Intergovernmental Oceanographic Commission

Workshop Report No. 65

Second IOC Workshop on Sardine/ Anchovy Recruitment Project (SARP) in the Southwest Atlantic

Montevideo, Uruguay, 21-23 August 1989

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IOC Workshop Reports

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No.	Title	Publishing Body	Languages
1	CCOP-IOC, 1974, Metallogenesis, Hydrocarbons and Tectonic Patterns in Eastern Asia (Report of the IDOE Workshop on); Bangkok, Thailand 24-29 September 1973 UNDP (CCOP), 138 pp.	Office of the Project Manager UNDP/CCOP c/o ESCAP Sala Santitham Bangkok 2, Thailand	English
2	CICAR Ichthyoplankton Workshop, Mexico City, 16-27 July 1974 (Unesco Technical Paper in Marine Sciences, No. 20).	Division of Marine Sciences, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock) Spanish (out of stock)
3	Report of the IOC/GFCM/ICSEM International Workshop on Marine Pollution in the Mediterranean, Monte Carlo, 9-14 September 1974.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish (out of stock)
4	Report of the Workshop on the Phenomenon known as "El Niño", Guayaquil, Ecuador, 4-12 December 1974.	FAO Via delle Terme di Caracalla 00100 Rome, Italy	English (out of stock) Spanish (out of stock)
5	IDOE International Workshop on Marine Geology and Geophysics of the Caribbean Region and its Resources, Kingston, Jamaica, 17-22 February 1975.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock) Spanish
6	Report of the CCOP/SOPAC-IOC IDOE International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific, Suva, Fiji, 1-6 September 1975.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
7	Report of the Scientific Workshop to Initiate Planning for a Co-operative Investigation in the North and Central Western Indian Ocean, organized within the IDOE under the sponsorship of IOC/FAO (IOFC)/Unesco/EAC, Nairobi, Kenya, 25 March-2 April 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
8	Joint IOC/FAO (IPFC)/UNEP International Workshop on Marine Pollution in East Asian Waters, Penang, 7-13 April 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock)
9	IOC/CMG/SCOR Second International Workshop on Marine Geoscience, Mauritius, 9-13 August 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
10	IOC/WMO Second Workshop on Marine Pollution (Petroleum) Monitoring, Monaco, 14-18 June 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish (out of stock) Russian
11	Report of the IOC/FAO/UNEP International Workshop on Marine Pollution in the Caribbean and Adjacent Regions, Port of Spain Trinidad, 13-17 December 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish (out of stock)
11 Suppl.	Collected contributions of invited lecturers and authors to the IOC/FAO/UNEP International Workshop on Marine Pollution in the Caribbean and Adjacent Regions, Port of Spain, Trinidad, 13-17 December 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
12	Report of the IOCARIBE Interdisciplinary Workshop on Scientific Programmes in Support of Fisheries Projects, Fort-de-France, Martinique 28 November-2 December 1977.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish
13	Report of the IOCARIBE Workshop on Environmental Geology of the Caribbean Coastal Area, Port of Spain, Trinidad, 16-18 January 1978.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
14	IOC/FAO/WHO/UNEP International Workshop on Marine Pollution in the Gulf of Guinea and Adjacent Areas, Abidjan, Ivory Coast, 2-9 May 1978.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French
15	CPPS/FAO/IOC/UNEP International Workshop on Marine Pollution in the South-East Pacific, Santiago de Chile, 6-10 November 1978	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock)
16	Workshop on the Western Pacific, Tokyo, 19-20 February 1979	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Russian
17	Joint IOC/WMO Workshop on Oceanographic Products and the IGOSS Data Processing and Services System (IDPSS), Moscow, 9-11 April 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
17 Suppl.	Papers submitted to the Joint IOC/WMO Seminar on Oceanographic Products and the IGOSS Data Processing and Services System, Moscow, 2-6 April 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
18	IOC/Unesco Workshop on Syllabus for Training Marine Technicians, Miami, 22-26 May 1978 (Unesco reports in marine sciences, No. 4)	Division of Marine Sciences, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock) French Spanish (out of stock) Russian
19	IOC Workshop on Marine Science Syllabus for Secondary Schools, Llantwit Major, Wales, U.K., 5-9 June 1978 (Unesco reports in marine sciences, No. 5).	Division of Marine Sciences, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian Arabic
20	Second CCOP-IOC Workshop on IDOE Studies of East Asia Tectonics and Resources, Bandung, Indonesia, 17-21 October 1978.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
21	Second IDOE Symposium on Turbulence in the Ocean, Liege, Belgium, 7-18 May 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
22	Third IOC/WMO Workshop on Marine Pollution Monitoring, New Delhi, 11-15 February 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
23	WESTPAC Workshop on the Marine Geology and Geophysics of the North-West Pacific, Tokyo, 27-31 March 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Russian
24	WESTPAC Workshop on Coastal Transport of Pollutants, Tokyo, 27-31 March 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock)
25	Workshop on the Intercalibration of Sampling Procedures of the IOC/WMO UNEP Pilot Project on Monitoring Background Levels of Selected Pollutants in Open-Ocean Waters, Bermuda, 11-26 January 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (superseded by IOC Technical Series No. 22)
26	IOC Workshop on Coastal Area Management in the Caribbean Region, Mexico City, 24 September-5 October 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
27	CCOP/SOPAC-IOC Second International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific, Nouméa, New Caledonia, 9-15 October 1980	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
28	FAO/IOC Workshop on the effects of environmental variation on the survival of larval pelagic fishes Lima, 20 April-5 May 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
29	WESTPAC Workshop on Marine biological methodology Tokyo, 9-14 February 1981.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
30	International Workshop on Marine Pollution in the South-West Atlantic Montevideo, 10-14 November 1980.	IOC, Unesco Place de Fontenoy, 75700 Paris, France	English (out of stock) Spanish
31	Third International Workshop on Marine Geoscience Heidelberg, 19-24 July 1982	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish
32	UNU/IOC/Unesco Workshop on International Co-operation in the Development of Marine Science and the Transfer of Technology in the context of the New Ocean Regime Paris, 27 September - 1 October 1982	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish
32 Suppl.	Papers submitted to the UNU/IOC/Unesco Workshop on International Co-operation in the Development of Marine Science and the Transfer of Technology in the Context of the New Ocean Regime Paris, 27 September-1 October 1982	IOC, Unesco Place de Fontenoy 75700 Paris, France	English

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1. INTRODUCTION

The Second Workshop on the Sardine/Anchovy Recruitment Project (SARP) in the Southwest Atlantic was opened on the 21 August 1989 in the Regional Office of Science and Technology for Latin America and the Caribbean (ROSTLAC) of Unesco in Montevideo, Uruguay. Dr. J. Alheit welcomed the participants on behalf of the Intergovernmental Oceanographic Commission (IOC) of Unesco and thanked Dr. G. Malek, Director of ROSTLAC, for hosting the Workshop.

The Workshop was attended by 18 scientists from 7 institutes of Argentina, Brazil and Uruguay. The List of Participants is in Annex II.

The Agenda for the Workshop was briefly discussed and adopted (Annex I). In the following, Dr. Alheit gave a brief review of the on-going activities of the IOC-FAO Ocean Science in Relation to Living Resources (OSLR) Programme and its organizational structure (Annex III). He particularly stressed the importance and recent advances on the regional level within the SARP project, pointed out that the SARP initiative of Argentina, Brazil and Uruguay is an essential new component for the global SARP and referred to the international co-operative nature of this initiative.

He recalled that first discussions with scientists from the region to initiate a Southwest Atlantic SARP took place during his first visit in March 1988 when it was suggested using the R.V. METEOR of the Federal Republic of Germany (FRG) to commence co-operative international studies on the recruitment of the Southwest Atlantic anchovy. He briefly reviewed the preparations and efforts made in Argentina, Brazil and Uruguay and by the Permanent Delegations of these three Member States to Unesco and acknowledged their efforts.

Dr. Alheit continued with a brief report on the First Workshop on SARP in the Southwest Atlantic in Montevideo, 23-25 November 1988, where the scientific goals of the studies on recruitment of Southwest Atlantic anchovy were discussed with scientists from Argentina, Brazil and Uruguay and mentioned that, in the meantime, 12 scientists from these 3 countries visited the FRG for training on special methods to be applied in the Southwest Atlantic recruitment studies. These scientists were funded by IOC and the FRG.

2. TECHNICAL DETAILS OF METEOR CRUISE

2.1 PARTICIPANTS

The R.V. METEOR provides space for 28 scientists. It was agreed that 15 South American scientists from different research disciplines should participate in the cruise. In addition, 11 German and 2 Swedish scientists were named. A list of participants of the METEOR cruise is in Annex IV.

2.2 DATES OF THE CRUISE

The R.V. METEOR will leave Rio de Janeiro on 17 November and arrive in Montevideo on 18 December 1989. The scientists had to board ship on 16 November and disembarked on 18 December. Two official receptions on the METEOR are planned on 16 November in Rio de Janeiro and 19 December in Montevideo.

2.3 RESEARCH PERMITS

The FRG has requested research permits to operate the R.V. METEOR in coastal waters of Argentina, Brazil and Uruguay. The requests are at present under consideration by the respective authorities of the three countries.

3. EARLY LIFE HISTORY AND REPRODUCTIVE BIOLOGY OF SOUTHWEST ATLANTIC ANCHOVY AND BRAZILIAN SARDINE

Each country presented a summary on the available information on the early life history and reproductive biology of *Engraulis anchoita*, the Southwest Atlantic anchovy. As there is some likelihood that *Sardinella brasiliensis*, the Brazilian sardine, also spawns in the Northern part of the area under investigation, a summary on this species was also prepared. In addition, the summaries provide information on the oceanographic setting, nutrients, phytoplankton and zooplankton in the region. All contributions are authored by different scientists and are presented in Annex V (*E. anchoita*, Argentina), Annex VI (*E. anchoita*, Uruguay) Annex VII (*E. anchoita*, Brazil) and Annex VIII (*S. brasiliensis*, Brazil). These presentations served as the basis for the discussion of the points of the Agenda.

4. PROPOSAL FOR STUDY OF RECRUITMENT VARIABILITY AND REPRODUCTIVE BIOLOGY OF SOUTHWEST ATLANTIC ANCHOVY WITH R.V. METEOR

When visiting the region in March 1988, Dr. Alheit, discussed with scientists and authorities of the 3 countries involved, a possible project to study recruitment variability and reproductive biology of the Southwest Atlantic anchovy using the R.V. METEOR. Based on these discussions, he prepared a proposal for such a project in August 1988 (Annex IX). This proposal was presented to and approved by the Senate's Commission for Oceanography (Senatskommission fuer Ozeanographie) of the German Research Association (DFG) which evaluates proposals for the R.V. METEOR. This proposal was presented and discussed thoroughly during the Workshop. In the following, additional suggestions and improvements resulting from the discussions during the Workshop are presented.

4.1 PHYSICAL OCEANOGRAPHY

The Acoustic Doppler Current Profiler (ADCP) is a ship-based system which uses the Doppler effect to determine currents at a series of discrete depths under the ship. In the context of recruitment studies, this data can be used to estimate the advective and, together with CTD data, the diffusive transport of planktonic food sources and spawning products of clupeoid fish. Taken together, these two types of information characterize the physical, dynamical environment of spawning areas. The use of the ADCP instead of GISMO was suggested by Dr. G. Shaffer, Department of Oceanography, Gothenburg University.

4.2 REMOTE SENSING

Remote sensing is rapidly developing into an essential tool for early life history studies. The Remote Sensing Group of the Division of Meteorology and Physical Oceanography in the Rosenstiel School of Marine and Atmospheric Science at Miami University (contact: Dr. G. Podestá) and the Servicio Meteorológico Nacional (SMN) in Buenos Aires (contact: First Lieutenant M. García) were approached to provide and analyze sea surface temperature data from satellites for the METEOR cruise.

The Remote Sensing Group at Miami University has been producing satellite-derived sea surface temperature images of the South Atlantic since 1984. It has an agreement with the SMN which records several passes per day of the NOAA polar orbiters. This co-operation resulted in the accumulation of the most comprehensive archive of satellite imagery over the South Atlantic. Three major areas of application of satellite data were suggested for the METEOR cruise:

(i) the study of historical data to identify oceanic features that are relevant for the design of the sampling strategy,

(ii) real-time support during the cruise, and

(iii) post-cruise analysis of imagery to interpret results.

Real-time satellite data support will result in greatly improving sampling efficiency by reducing expensive ship time lost for searching hydrographic features, such as fronts and upwelling plumes, which are relevant for the proposed studies.

Also, the sea surface temperature data can be used to establish mesoscale flow fields. Sea surface flow is derived from displacements of surface patterns in sequential satellite images. The results of this type of analysis provide synoptic flow patterns possibly revealing advective transport of fish spawn during the METEOR cruise. This kind of application of remote sensing data was developed by Dr. A. Vastano from the Department of Oceanography of Texas A & M University.

4.3 PHYTOPLANKTON

The phytoplankton studies aim at:

(i) establishing the relationship between the physical dynamics and phytoplankton distribution, and

(ii) determining composition, abundance and biomass of phytoplankton. Incident light and light penetration profiles will be measured using a quantimeter and submersible light sensors. Biomass will be estimated by analysis of the chlorophyll-a concentration.

4.4 ZOOPLANKTON

Zooplankton is the most important food source for anchovy larvae. Its distribution and abundance will be studied in conjunction with investigations on the food spectrum, feeding habits and diet feeding rhythms of larvae. Vertical distribution of the zooplankton will be studied using the Multinet (5 opening and closing nets, 64μ mess size) and the small scale distribution will be analyzed with the Longhurst-Hardy-Plankton Recorder (LHPR).

4.5 CRUISE PLAN

Three areas (boxes) of investigation were selected according to the proposal (Annex IX). Seven days sampling time are provided for each box. Sampling will proceed on transects. On each transect of about 30-60 nm length, oceanographic measurements (CTD, ADCP) will be taken first, together with an ichthyoplankton sample using the Helgolaender Larvennetz, at stations spaced 5nm apart. Based on the results, 5 or 6 stations will be selected on each transect for intensive biological sampling in different physical environments. Altogether, 45 biological stations will be established in each of the 3 boxes. A detailed cruise plan was designed for each box:

(i) Brazilian Box C: Upwelling area off Cape Santa Marta. Three transects, one of 60 nm and 2 of 30nm length, will be laid perpendicular to the coast (Figure 1).

(ii) Uruguayan Box B: Area under influence of fresh water discharge off estuary of La Plata river. Two transects, each one of 60nm length will be laid perpendicular to the coast (Figure 2).

(iii) Argentinian Box A: Area with tidal mixing fronts off the Peninsula Valdes. Four transects of different length will be laid across the frontal systems to the Southeast and South of the peninsula. Each transect should cut through the mixing, the transitional and stratified zone of the front (Figure 3).

It was agreed that the final position and length of the transects should be decided upon, when in the sampling area, based on the most recent information from remote sensing and CTD data, and on egg and larval abundance determined by vertical net tows.

4.6 EQUIPMENT AND SAMPLING DESIGN

A routine hydrographical station includes:

(i) CTD with attached fluorometer and rosette sampler for phytoplankton,
(ii) ADCP,
(iii) Vertical tow with Helgoland Net.

A routine biological station includes:

(i) as above;
(ii) as above;
(iii) MULTINET for zooplankton sampling (64μ) in 5 discrete depth strata;
(iv) MOCNESS sampler for ichthyoplankton collections in up to 9 discrete depth strata; samples to be preserved in formalin and alcohol;

(v) MOCNESS sampler for ichthyoplankton collections at discrete depth strata; samples are for histological and biochemical studies;
(vi) RMT Net for sampling large larvae and juveniles for age and growth studies (daily growth rings); and
(vii) LHPR on selected stations for study of small scale distribution of anchovy larvae and their food organisms.

In addition, 60 hauls will be carried out with the Pelagic Trawl to sample adult anchovy for reproductive studies.

5. WORKING GROUPS

Working Groups were formed according to the different lines of research. The responsible scientists from the different countries (A-Argentina, B-Brazil, G-Federal Republic of Germany, U-Uruguay) are mentioned in the following:

1. Distribution, abundance, etc. of ichthyoplankton (MOCNESS)
   Ciechomski (A), Matsuura (B), Andrick (G), Mantero (U).
2. Larval age and age structure of larval population (MOCNESS)
   Sánchez (A), Matsuura (B), Ekau (G), Pin (U).
3. Larval condition factor (MOCNESS)
   Sánchez (A).
4. Larval starvation, histology (MOCNESS)
   Sieg (G).
5. Larval starvation, RNA/DNA (MOCNESS)
   Sánchez (A), Wongtschowski (B), Clemmesen (G), Mantero (U).
6. Larval starvation, enzyme analysis (MOCNESS)
   Sánchez (A), Wongtschowski (B), Ueberschär (G), Mantero (U).
7. Larval feeding and micro-zooplankton (MULTINET)
   Ramírez (A), Janssen (G).
8. Macro-zooplankton (RMT) and zooplankton (MOCNESS)
   Ramírez (A), Janssen (G), Goberna (U).
9. Larval mortality (MOCNESS)
   Sánchez (A), Matsuura (B), Ekau (G), Mantero (U).
10. Predation on anchovy eggs and larvae (Pelagic Trawl, RMT)
    Mianzan (A), Alheit (G).
11. Micro-distribution of zooplankton (LHPR, large fraction)
    Ebel (G).
12. Micro-distribution of zooplankton (LHPR, small fraction)
    Ramírez (A).
13. Age and growth of juveniles (MOCNESS, RMT)
    Sánchez (A), Castello (B), Ekau (G), Pin (U).
14. Reproductive biology (Pelagic Trawl)
    Christiansen (A), Wongtschowski (B), Alheit (G), Bosch (U).

Additional Working Groups were formed for Physical Oceanography (Djurfeldt, Möller, Roldos, Shaffer) and Phytoplankton (Carreto, Elgue, López, Odebrecht).

6. POST-CRUISE ANALYSIS

The samples will be processed by bilateral co-operation between German scientists and scientists from Argentina, Brazil and Uruguay. Ctenophora sampled in the 3 boxes will be studied by Mianzan (A). Financial support for study visits of South American scientists to Germany, and German scientists to South America will be requested from IOC and the bilateral Argentinian-German and Brazilian-German funding programmes. Workshops will be organized to analyze data. It was agreed that all results should be published jointly in English in a journal with an international reputation.

7. CLOSURE

The Workshop was closed by Dr. Alheit, on 23 August 1989.

FIGURE 1

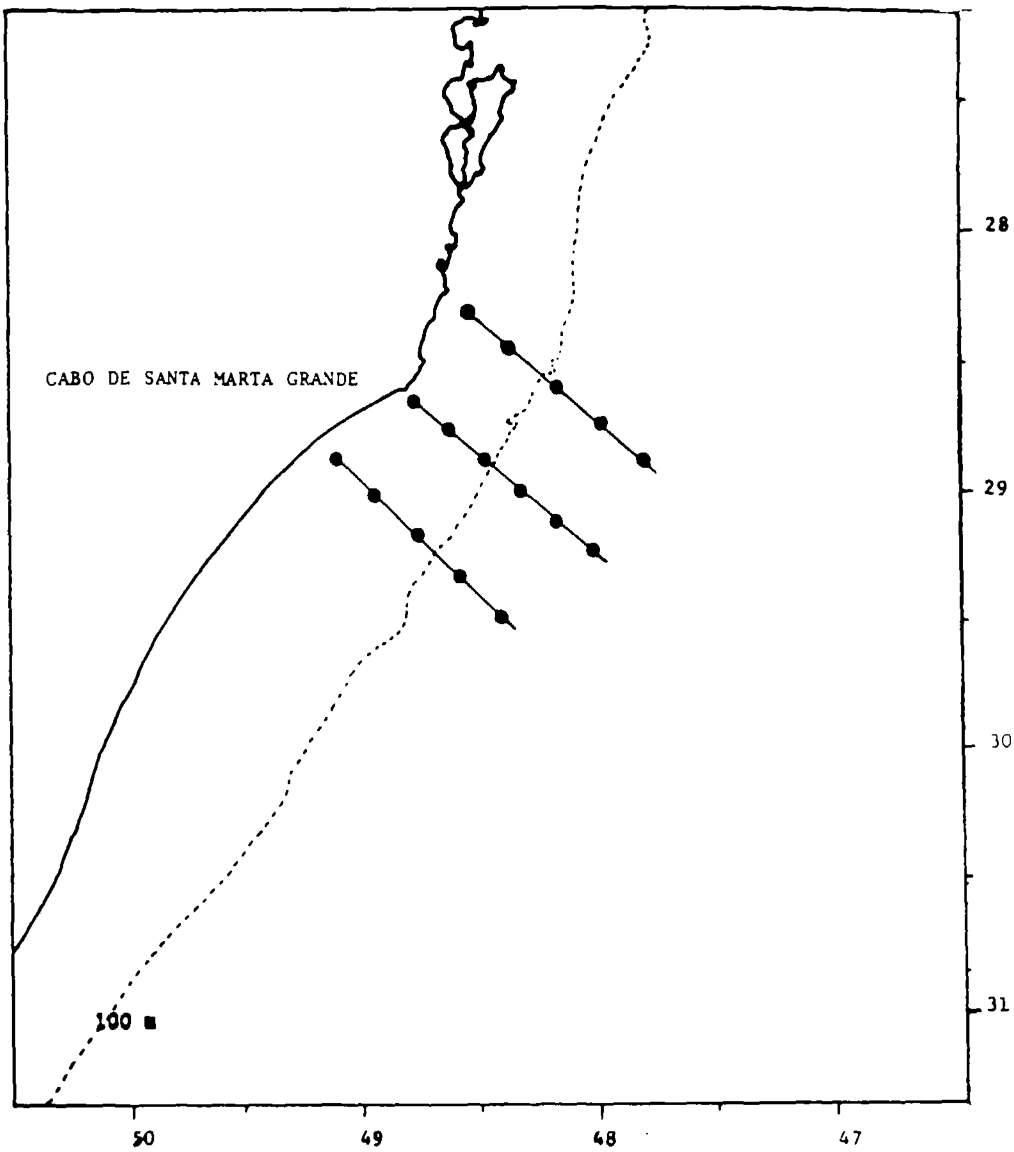

Fig. 1: Position of transects and stations in Brazilian Box C.

FIGURE 2

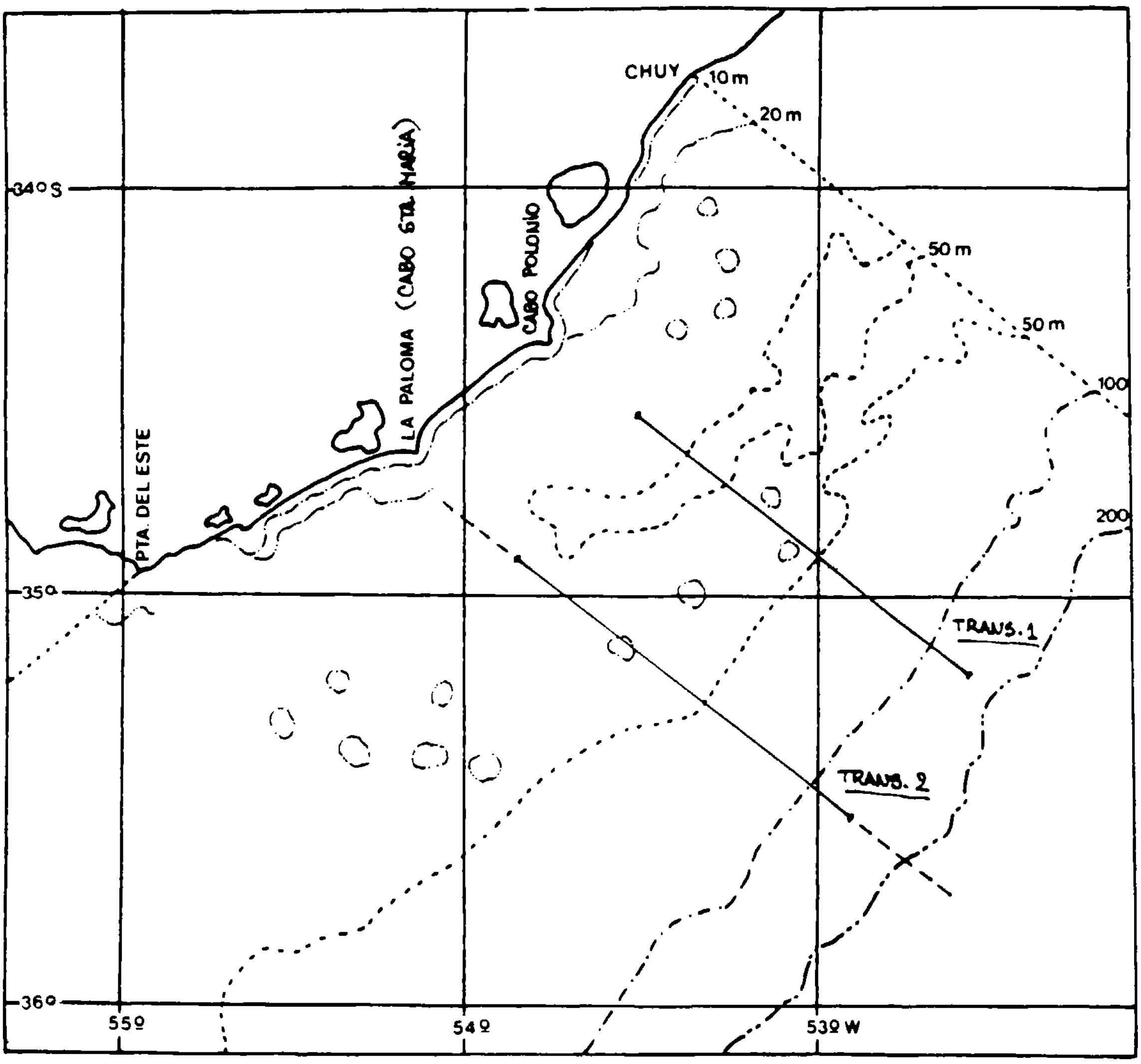

Fig. 2: Position of transects and stations in Uruguayan Box B.

FIGURE 3

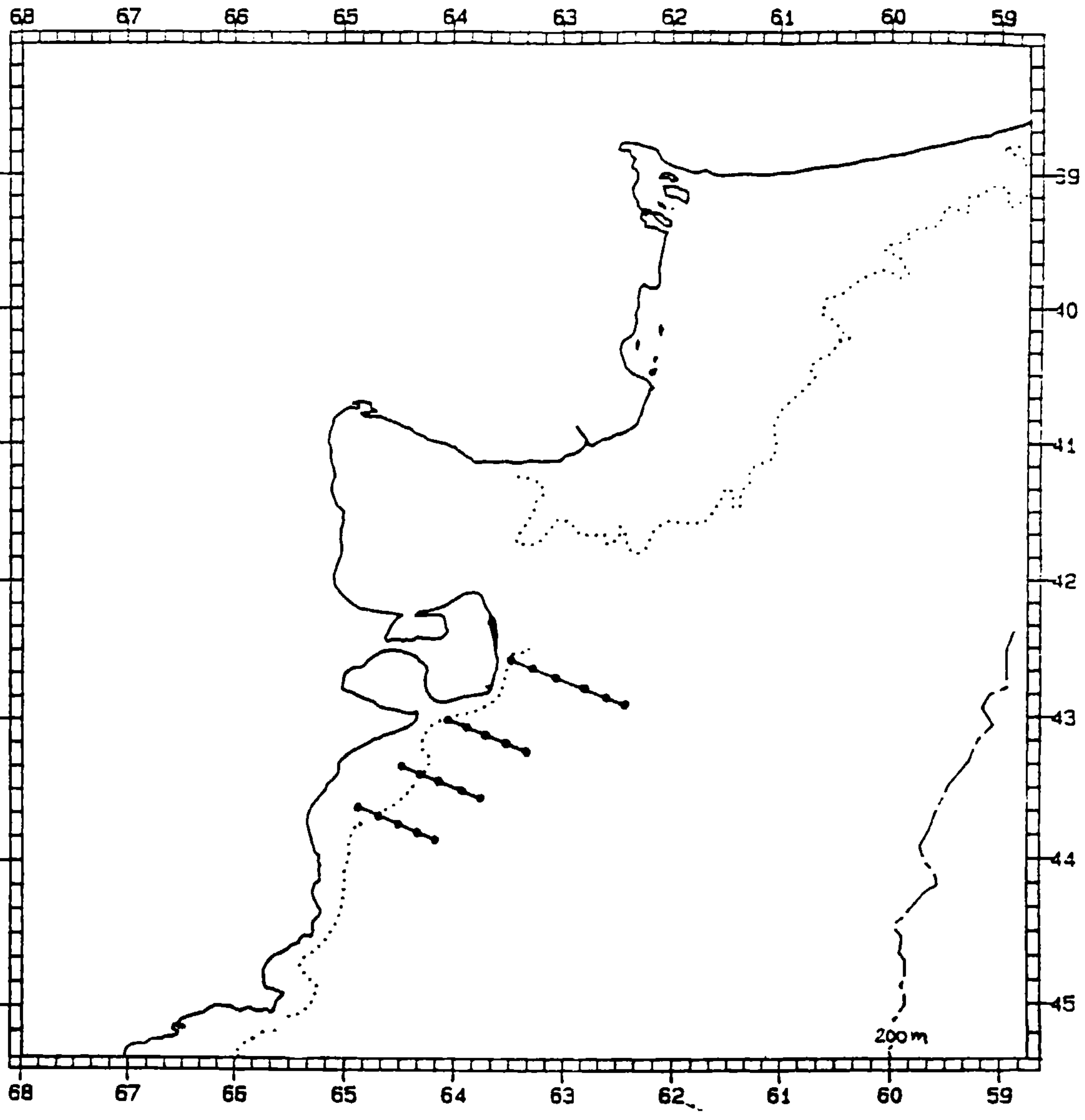

Fig. 3: Position of transects and stations in Argentinian Box A.

ANNEX I

AGENDA

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4. PROPOSAL FOR STUDY OF RECRUITMENT VARIABILITY AND REPRODUCTIVE BIOLOGY OF *E. anchoita* AND *S. brasiliensis* IN SOUTHWEST ATLANTIC WITH R.V. METEOR.

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   4.3 PHYSICAL OCEANOGRAPHY
   4.4 REMOTE SENSING
   4.5 PHYTOPLANKTON
   4.6 ZOOPLANKTON
   4.7 ICHTHYOPLANKTON
   4.8 REPRODUCTIVE BIOLOGY

5. WORKING GROUPS

6. POST-CRUISE ANALYSIS

7. CLOSURE

ANNEX II

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ANNEX III

OCEAN SCIENCE IN RELATION TO LIVING RESOURCES PROGRAMME (OSLR)

There is certainly a need to bring about a much closer interaction between oceanographic research and marine biology. Several recent national and international initiatives show that the time is ripe for coupling these 2 branches of marine science. One initiative towards this goal is the "Ocean Science in Relation to Living Resources" (OSLR) programme which is co-operatively sponsored and formulated by the Intergovernmental Oceanographic Commission (IOC) of Unesco and by the Food and Agriculture Organization of the United Nations (FAO). This programme was under discussion for several years in the early 1980's and was initiated officially in 1983 by an international workshop in Halifax, Canada. The formulation, development and implementation of the Programme is carried out and guided by the Guiding Group of Experts for OSLR, the members of which come from the fields of marine biology and physical oceanography. The Scientific Committee on Oceanic Research (SCOR), and the International Council for the Exploration of the Sea (ICES), have permanent representatives in this group. The Group reports to the governing bodies of IOC and FAO. The purpose of OSLR is to promote improvement in scientific understanding which will lead to more effective development, management and conservation of the marine living resources of coastal nations. So far, OSLR has concentrated its efforts in the field of fish recruitment.

The variability of fish recruitment is considered to be the most important unsolved problem in fishery population dynamics. To processes controlling the variability of fish recruitment are the subject of the "International Recruitment Project" (IREP) of OSLR. Fisheries management could be improved considerably if recruitment success or failure could be anticipated or if, at least, it be known if recruitment failure of a fish stock is due to natural or man-made causes, such as over-fishing or pollution. A variety of physical oceanographic phenomena on the macro- meso- and micro-scale, such as currents, upwelling, turbulence, Langmuir circulations, surface slicks, are known to affect fish at all life stages, particularly in the highly vulnerable larval or early juvenile phase. However, their net effect at the population level are poorly understood. The result is large unexplained inter-year variability in recruitment which, besides being a major source of uncertainty to those involved in fishing and associated industries, is typically so extreme as to largely obscure essential signals needed to foresee and manage the long-term effects of fishery exploitation, habitat alterations, global climate change and other vital concerns in a scientific manner. The need to develop the means to filter the interyear "noise" in order to resolve the crucial underlying signals is perhaps the most important argument for promoting research on the recruitment problem.

IREP has been initiated by 2 pilot projects, the "Sardine/Anchovy Recruitment Project" (SARP) and the "Tropical Demersal Recruitment Project" (TRODERP). Within the context of SARP, the principal biological and physical factors causing mortality of early life stages, including the early juvenile phase, are intensely studied, as it is commonly assumed that recruitment strength is determined at these stages.

Several regional SARP projects have been formed. Sprat recruitment in the North Sea is studied co-operatively by the UK, Denmark and the FRG. Sardine recruitment in Iberian waters is investigated in a bilateral project by Portugal and Spain with some US support. A multinational project on the recruitment of the Southwest Atlantic anchovy with scientists from Argentina, Uruguay, Brazil, FRG and Sweden will begin in November of this year. Similar studies will be initiated next year on anchovies and sardines in the upwelling region off the Chilean coast. A major aspect of the SARP scientific rationale involves application of the comparative method of science whereby the multiple expression of the problem afforded by various species groups inhabiting different regional ecosystems may facilitate the sorting out of the complex interacting mechanisms involved in recruitment variability.

Another growing sphere of activity within IREP focuses on the demersal resources of the tropical band through the "Tropical Demersal Recruitment Project" (TRODERP). TRODERP has been initiated in Southeast Asia in the form of a Penaeid Prawn Recruitment Project (PREP) involving Australia, Brunei, Indonesia, Malaysia, Papua New Guinea and the Philippines. In the western tropical Atlantic area, the IOCARIBE Sub-commission of IOC has defined 3 focal research areas under TRODERP:

(i) Fish Estuarine/Deltaic Recruitment (FEDERP);
(ii) Penacid Prawn Recruitment (PREP); and
(iii) Coral Reef Demersal Recruitment (CORDERP).

A schematic presentation of OSLR and its various regional components is given in Figure 1.

A second sub-programme of OSLR to be launched now will focus on Harmful Algal Blooms.

FIGURE 1

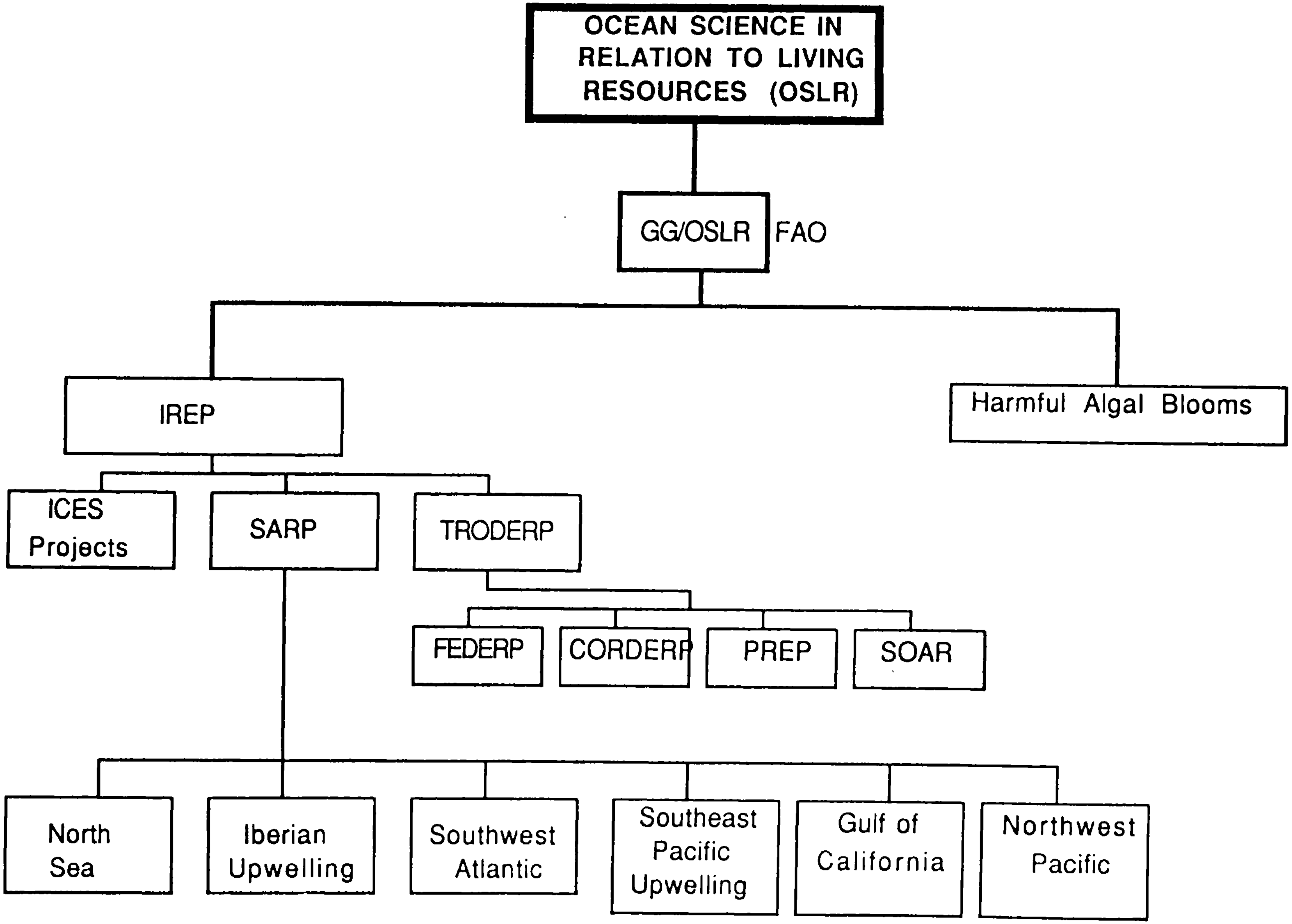


Figure 1: Organisational Scheme of OSLR

ANNEX IV

LIST OF SCIENTISTS PARTICIPATING IN THE METEOR CRUISE 11/3

Name	Country	Institute	Speciality
Alheit, Jurgen	FRG	IOC, Paris	Fisheries Biology
Andrick, Horst	FRG	Bremerhaven	Fisheries Biology
Carreto, Jose	ARGENTINA	Mar del Plata	Phytoplankton
Castello, Jorge	BRAZIL	Rio Grande	Fisheries Biology
Curtolo, Luis	ARGENTINA	San Antonio O.	Ichthyoplankton
Djurfeldt, Leif	SWEDEN	Gothenburg	Physical Oceanography
Ebel, Christian	FRG	Hamburg	Fisheries Biology
Ehrlich, Martin	ARGENTINA	Mar del Plata	Fisheries Biology
Ekau, Werner	FRG	Bremerhaven	Fisheries Biology
Elgue, Juan Carlos	URUGUAY	Montevideo	Phytoplankton
Janssen, Wilfried	FRG	Flensburg	Biology
Jarosch, Dirk	FRG	Kiel	Technician
Lopez, Cesar	URUGUAY	Montevideo	Phytoplankton
Mantero, Gabriela	URUGUAY	Montevideo	Fisheries Biology
Matsuura, Yasunobu	BRAZIL	Sao Paulo	Fisheries Biology
Mianzan, Hermes	ARGENTINA	Mar del Plata	Zooplankton
Moeller, Osmar	BRAZIL	Rio Grande	Physical Oceanography
Nellen, Walter	FRG	Hamburg	Fisheries Biology Chief Scientist
Odebrecht, Clarisse	BRAZIL	Rio Grande	Phytoplankton
Pin, Oscar	URUGUAY	Montevideo	Fisheries Biology
Roldos, Hugo	URUGUAY	Montevideo	Physical Oceanography
Sanchez, Ramiro	ARGENTINA	Mar del Plata	Fisheries Biology
Sieg, Andreas	FRG	Hamburg	Fisheries Biology
Trinkaus, Sabine	FRG	Hamburg	Zooplankton
Ueberschaer, Bernd	FRG	Kiel	Fisheries Biology
Wongtschowski, Carmen	BRAZIL	Sao Paulo	Fisheries Biology
Zangenberg, Norbert	FRG	Kiel	Physical Oceanography

ANNEX V

SYNOPSIS ON THE REPRODUCTIVE BIOLOGY AND EARLY LIFE HISTORY OF *Engraulis anchoita*, AND RELATED ENVIRONMENTAL CONDITIONS IN ARGENTINE WATERS

1. ANALYSIS OF ENVIRONMENTAL CONDITIONS

1.1 THE PHYSICAL ENVIRONMENT (by Patricia Martos)

1.1.1 Oceanographic Setting

The general surface circulation of the Southwestern Atlantic is characterized by the Brazil current flowing poleward along the continental margin of South America and the Malvinas current flowing northward at the edge of the Argentinian shelf (Garzoli & Bianchi, 1987). Both currents are restricted to depths of less than 1500 m (Reid et al., 1977). The Brazil and Malvinas currents meet on the continental slope of the Argentine basin, near 38°S, creating a strong frontal zone (Deacon, 1937; Gordon, 1981; Legeckis & Gordon, 1982). This frontal zone marks the division between Sub-Antarctic and Subtropical waters. The horizontal temperature gradient reaches values up to 1°C/250 m. After the Malvinas current (cold, lower salinity sub-antarctic water) meets the Brazil current (warm and saline waters), they turn seaward (Figure 1). Then the Brazil current separates from the shelf break and penetrates the South Atlantic in a series of large amplitude meanders (Olson et al., 1988).

A poleward extension of warm water, composed of warm eddies, filaments and meanders, is almost always present, within the longitudes 50°-55°W, and latitudes 38°-46°S (Gordon, 1981). These features have typical lifetimes of about 2 months (Figure 1).

The Malvinas current dominates adjacent shelf waters (Blanc et al., 1983). Intrusions of sub-antarctic water over the continental shelf produce significant vertical gradients of temperature and salinity (Lusquiños & Schrott, 1983). The presence of Intermediate Antarctic Waters (nucleus of the Malvinas current) on the shelf is documented by the existence of a low salinity layer immediately below the thermocline (a common characteristic of the 3 Southern Hemisphere Oceans (Deacon, 1933, 1937; Sverdrup, 1934, 1940; Piola & Gordon, 1989)).

Martos & Piccolo (1988) studied the hydrological conditions between 38° and 42°S, dividing the Argentine continental shelf in 2 domains with different physical and morphological characteristics: a coastal region (H<40 m), where the mixing due to the wind and tides produces vertically homogeneous waters all year round and an outer shelf region (40 m<H<90 m) which has a warm surface layer (approximately 30 m depth) from spring to autumn. Below the warm layer shelf waters are strongly stratified to the bottom. A permanent shelf break front forms the limit of the outer shelf region near the 90-100 m isobath (Figure 2).

Studies in the Argentine shelf waters south of 45°S, show the presence of 3 main water masses: Malvinas, coastal and shelf waters. The latter is a result of the mixing between Malvinas and coastal waters (Bianchi et al., 1982; Krepper, 1977; Krepper & Rivas, 1979). These studies show the existence of a low salinity water coastal tongue (33.4 °/oo) originating from the Magellan Strait and extending until 45°S (Figure 3). Apart from the shelf break front, Argentine exhibits 2 other important fronts: an estuary and a tidal front. The former originates from the discharge of the La Plata river at 35°S. The river receives its water from the Paraná and Uruguay rivers, which drain the second largest basin in South America after the Amazonas River with an average flux of about 20,000 m3/s (Urien & Ewing, 1971). The tidal front is located in the vicinity of Valdes Peninsula (42°S) separating well mixed coastal waters from oceanic stratified waters (Carreto et al., 1981, 1986; Glorioso, 1987). There are few observations of the mean current pattern over the continental shelf in this region. The few current measurements available are for short time periods. The Atlas of Pilot Charts (US Hydrographic Office, 1958) shows drift currents with a magnitude of 25 cm/s and general direction towards the NNE. Theoretical models also predict currents towards NNE, with magnitudes between 10 to 20 cm/s (Lusquiños & Schrott, 1983; Forbes & Garrafo, 1988).

1.1.2 Topography

The Argentine Continental Shelf is one of the largest and flattest in the world. Its width varies between a few km at 55°S and 850 km along 51°S. The area between 34° and 56°S is approximately 1,000,000 km^2, About 70% of the total area is deeper than 75 m. Locally, the sea bottom is remarkably level and regionally it deepens gradually toward the south and seaward. The range of depths at which the shelf break takes place is relatively broad: between 100 m and 150 m. The average depth of this interval coincides with the world-wide average value of 130 m. The flattest areas of the shelf are located between 38° and 42°S at 82 m average and between 43° 30'S and 48°S at 100 m average. North of the 38°S the width of the shelf decreases and near the shelf break bottom gradients exceed 1:500. In the south, isobaths are aggregated near the land, while in the north, they are close to the shelf edge, the medium depth decreases south to north.

1.1.3 Fresh water discharge

From north to south, the most important rivers are: La Plata (35°S), Colorado (40°S), Negro (41°S), and Santa Cruz (50°S). Of much lesser volume are Chubut (43° 20'S), Deseado (47° 50'S) and Gallegos (51°S). Available basic data for the Argentine rivers are given in Table 1. The exchange of Rio de la Plata with the shelf depends on tidal and meteorological conditions whereby winds play the major role (Balay, 1961; Ottman & Urien, 1966).

1.2 PHYTOPLANKTON (by Jose I. Carreto & Hugo R. Benavides)

1.2.1 Nutrients - Fertilization mechanisms

1.2.1.1 The maritime front of the La Plata River

Distributions of temperature, salinity, nutrient concentration and photosynthetic pigments were studied at the maritime front of the La Plata River during a survey in spring 1982 (11-27 October) (Carreto et al., 1986a) (Figure 4).

Three different systems were identified within this front, based on their nutrient ratios ($NO3^{-1}$: $PO4^{-3}$: $SiO3^{-1}$):

(i) ESTUARINE (2.5:1:139);
(ii) COASTAL (0.1:1:1,4), and
(iii) SUB-ANTARCTIC (12:1:2.2).

These systems correspond to the:

(i) Estuarine waters of the La Plata river,
(ii) Coastal waters of Sub-Antarctic origin, and
(iii) Continental shelf Sub-Antarctic waters.

The strong influence of the La Plata river which is flowing into a NNE direction becomes evident by the high chlorophyll-a concentrations in the Northwestern part of the Estuarine System. High chlorophyll-a concentrations (7.7mg/m3) were recorded in this region which occurred together with a marked thermo/saline stratification. Phytoplankton production in this system is assumed to be regulated by the availability of nitrogen and by light penetration while silicate and phosphate are in excess. Silicate concentrations are very high (>40M) and can be fairly well correlated with salinity values. Phosphate concentrations (0.4-0.7M) are lower than would be expected from an estuarine system which is in physico-chemical equilibrium.

The Sub-Antarctic System is characterized by relatively high nitrate concentrations. Its center is at the Southeastern part of the front and it is the main source of nitrogen. In Spring, this system has a high availability of nitrate (>12.0M) and phosphate (>1.0M) whereas that of silicate (<5.0M) is much lower. The highest chlorophyll-a concentrations are not encountered at the center of the system, but rather at its northern limit, at the transition zone with the Coastal System, where a concentration of 10.0 mg/m3 was recorded on the surface. The low water temperatures and the instability of the water column seem to indicate a temporary delay in the phytoplankton bloom.

The Coastal System covers the largest part of the front and has the lowest nutrient levels. The lowest absolute and relative nitrogen concentration is <1.0M. However, chlorophyll-a concentration is relatively high at intermediate latitudes and deeper layers (10.0 mg/m^3), where a large percentage of the Sub-Antarctic type could be detected (2.3:1:2,4), which may be assumed to be in the final stage of phytoplankton blooming. Sub-tropical coastal waters were encountered only in one station and could therefore not be characterized further. Low chlorophyll-a concentrations, scarce concentrations of nutrients and high Margalef index values were recorded.

1.2.1.2 The tidal frontal system of Valdes Peninsula

Growth of phytoplankton in this area seems to be mostly determined by nitrogen availability (Carreto et al., 1974; Charpy et al., 1982). High tidal dissipation rates in this area, enhanced by coastal headlands such as Peninsula Valdes, generate zones of intensified vertical mixing in the near-shore waters. The mixing is focused at shelf-sea fronts which separate well-mixed areas from areas with stratified water structures (Carreto et al., 1981, 1985, 1986b; Glorioso, 1987). Formation of the front begins in Spring as seasonal thermoclines become established in shelf waters far from the coast. However, waters around the Peninsula Valdes remain well-mixed throughout the year. The structure of the front is maintained until Autumn when the thermoclines are eroded. During Summer, fronts are clearly recognized in infra-red satellite images, due to the difference in sea surface temperature between the mixed and stratified parts (Figure 5). The average position of the front during summer can be adequately predicted by means of the Simpson-Hunter (1976) parameter h/u^3. This prediction corresponds well to the infra-red images (Glorioso, pers. com.). Surface advection of warmer waters of northern origin, spring-cycle neaps, and wind induced mixing (for depths less than 50 m) may account for the variations observed in the shape and position of the front (Carreto et al., unpubl. results).

An almost constant characteristic during the 4-5 months lifetime of the front, is the greater availability of nitrates in the mixed side, as compared to the euphotic zone of the stratified part, where nutrient concentrations in summer are less than 0.2 μM. Observed concentrations in the mixed part (Figure 6), show a marked space-time variability, that cannot be explained on the basis of the model suggested by Pingree et al. (1975) and Holligan (1981). This variability, the occurrence of large amounts of detritus in oil-like surface spots (Carreto et al., 1981) and the presence of resting cysts in the plankton of the mixed side (Carreto et al., 1985) indicate the existence of up-welling processes, produced in some areas of the front as a consequence of alternating periods of mixing and stratification (Carreto et al., 1986b). These mechanisms, surface convergence and the formation of frontal eddies, described for similar frontal systems (Simpson, 1981), may explain the high phytoplankton biomass observed in the area (Carreto et al., Benavides et al., unpublished data). The existence of the front was discovered during the first studies of the bloom of the toxic dinophlagellate *A. excavatum* in 1980 (Carreto et al., 1981).

1.2.2 Species composition

1.2.2.1 Phytoplankton species distribution at the maritime front of the La Plata river

Negri et al. (1988) applying numerical analysis could determine the existence of 4 floristic regions: Estuarine, Coastal, Transition-Coastal and Sub-Antarctic. Seven significant associations of species with taxonomic and ecological affinities were identified in relation with the above mentioned regions, 6 of them mainly encountered in the coastal area with a certain overlap in space among some of them. One of those associations was also related to the estuarine region. The seventh association was distributed over the shelf-break thus coinciding with the Sub-Antarctic region (Figure 7).

1.2.2.2 Phytoplankton species distribution at the frontal system of Patagonia

In this system, the distribution of phytoplankton species presents a well-marked regularity, which seems to be related to 2 basic factors: nutrient availability and turbulence (Margalef, 1978). In the mixed side chain-forming diatoms are predominant (*Asterionella glacialis, Thalassiosira allienii, Paralia sulcata,* etc.). The importance of vertical mixing, is evidenced by the presence of typically benthic species in the plankton (*P. sulcata, Pleurosigma normanii* and *Coscinodiscus spp.*) (Carreto et al., 1986b). In well mixed waters, the classic species succession which is characteristic of temperate seas is not observed and diatoms are predominant throughout the year (Benavides et al., unpubl.). In the transition zone, the situation is more complex, as it has the highest biomass values.

In this zone diversity is very poor and the alternating predominance of red tide dinoflagellates *A. excavatum* and *Prorocentrum micans* and the *Prymnesiophyta Phaeocystis poucetti*, is the outstanding characteristic. The competition between these 2 species is probably determined by the variability in the hydrographic system. Occasionally one of these species predominates over the whole transition area, whereas in other cases, specially segregated blooms are observed simultaneously. On the stratified side, the scarce phytoplankton biomass is represented by heterotrophic dinoflagellates such as *Dinophysis spp.*, *Ceratium lineatum*, etc. (Benavides et al., unpubl.).

The described scenario may be compared to 3 characteristic stages of the successional sequence described for temperate seas (Margalef, 1978), which occur simultaneously in the front system, due to the hydrographic dynamics.

1.2.3 Size structure.

No information

1.2.4 Distribution and abundance of phytoplankton in relation to hydrographic structures

In the tidal system of Patagonia, biomass maxima on the surface are formed in the transition zone. The distribution of chlorophyll-a is very similar to that which is considered typical for tidal fronts in Europe (Pingree et al., 1975), where maxima are recorded at the surface of the frontal zone and at the sub-surface in relation with the pycnocline in the stratified side of the front (Figure 8). However, there are some important differences in the patterns of distribution, which seem to be related both to latitudinal hydrographic differences in the front, and to the species which make up the biomass maximum. In general terms, mucilaginous colonies of *Phaeocystis* are found in the transition zone in closer relation to the mixed side whereas *P. micans* and *A. excavatum* are also found in the transition zone but more related to the stratified side.

1.2.5 Levels of primary production

The available data are insufficient to assess the relative importance of redistribution by water motion versus *in situ* growth of the phytoplankton population during the formation of the biomass maxima. But clearly, nutrient fertilization, and the exchange of properties across pycnoclines and fronts are important in the initiation and maintenance of phytoplankton growth and the determination of phytoplankton species composition.

1.3 ZOOPLANKTON (by Fernando C. Ramirez, Hermes W. Mianzan, Betina Santos & Maria D. Viñas)

1.3.1 Qualitative and quantitative composition of zooplankton

The distribution of zooplankton organisms in the Argentine sea may be analyzed in terms of 3 water masses: coastal, middle shelf and outer shelf waters influenced by the Malvinas current.

The dominant copepoda species in the coastal waters from the North to Peninsula Valdes are *Paracalanus parvus, Centropages brachiatus, Acartia tonsa, Oithona nana* and *Euterpina acutifrons* (Ramírez, 1969, 1971a). The cladocerans *Podon intermedius, P. leuckarti, P. polyphemoides, Evadne nordmanni* and the medusae *Liriope tetraphylla, Phialidium simplex, Mitrocomella frigida, Proboscidactyla sp.* and *Obelia sp.* occur also in this region (Ramírez & Zamponi, 1980, 1981). Although the discharge of the La Plata river builds up a kind of barrier of low salinity, a close similarity exists between zooplankton communities from South-Brazilian and Uruguayan waters on one hand and those from the Buenos Aires province on the other hand. In Summer, warm water euryhaline species seem to occur frequently, such as the copepods *Labidocera fluviatilis, Corycaeus amazonicus, Eucalanus pileatus, Temora stylifera, Clytemnestra rostrata, Paracalanus crassirostris* (Ramirez 1969) and the scyphomedusae *Chrysaora lactea, Aurelia aurita, Stomolophus meleagris, Lichnorhiza lucerna* and *Drymonema gorgo* (Mianzan, 1986 and Mianzan, in Press).

In middle shelf waters, small sized copepods are abundant, such as *Clausocalanus brevipes, Ctenocalanus vanus, Calanoides carinatus, Oithona helgolandica* and *O. atlantica* and the distribution of some of them extends even to the shelf break. Ostracods (*Conchoecia serrulata*) and young stages of oceanic copepods, euphausiids and amphipods are also found commonly throughout this region. The amphipod *Themisto gaudichaudii* has been widely found at all latitudes in middle shelf and oceanic waters (Ramirez & Viñas 1985).

Hydrographical studies in the outer shelf region show the displacement of cold waters to deeper layers as they flow northwards. As a consequence, species which occur in subcoastal and middle shelf waters in the Patagonian region are commonly found near the shelf break off Buenos Aires province (Figure 9). Among these species are the copepods *Aetideus armatus, Rhincalanus gigas, Clausocalanus laticeps, Haloptilus oxicephalus, Euchirella rostrata, Heterorhabdus austrinus, Eucalanus elongatus, Pleuromamma robusta, P. gracilis* (Ramírez 1970, 1977), the polychaetes *Tomopteris septentrionalis*, the amphipod *Primno macropa*, and the euphausiids *Euphausia similis, E.lucens, E. vallentini, Thysanoessa gregaria* and *Nematoscelis megalops* (Ramírez 1971b). Mianzan (1988) also mentions the scyphomedusae *Desmonema chierchianum* and *Phacellopora camtschatica*.

The seasonal fluctuations of plankton in Argentinian shelf waters show the cycle which is typical for temperate cold latitudes where the maxima occur after the spring bloom (Carreto et al., 1981). Total numbers of copepods per m^2 can reach up 15,000 individual, with some exceptional values of 50,000. The total average biomass (dry weight) seems to be less than 500 mg/m^2, however, sometimes values of 2,000 mg/m^2 were recorded. These high values are due to the influence of sub-antarctic waters which extend onto the shelf and have characteristically larger sized organisms such as young forms of *Calanus, Eucalanus* and *Rhincalanus, eupahysiid furciliae* and post-larvae, and juvenile amphipods. Starting in Spring, a strong increase in zooplankton abundance can be observed. Off the Buenos Aires area, numbers of copepods surpass 500,000 individuals per m^2 and the biomass can reach up to $13g/m^2$. Transects run over the shelf off Buenos Aires showed increased total chlorophyll values during mid-Spring, while copepods reach their maximum at the end of Spring. Young stages of copepods are predominant at mid-Spring (Figure 10).

The Patagonian region has generally lower biomass values than the district of Buenos Aires (Figure 11).

Three faunistic zones can be separated within the common fishing zone of Argentina and Uruguay (Fernández Aráoz et al. MS):

(i) Coastal Waters under the influence of the La Plata river; in these waters, copepods, such as *Calanoides carinatus* and *Paracalanus parvus*, and cladocerans, such as *Evadne nordmanni* and *Podon intermedius*, can be found;

(ii) the Transitional Zone of the shelf waters for which a typical species association has not been identified; and

(iii) waters under sub-antarctic influence with oceanic species, such as the copepods *Rhincalanus nasutus, Metridia sp., Scolecithricella sp*, the ostracod *Conchoecia serrulata* and the euphausiid *Thysanoessa gregaria*. Several species, the copepods *Calanus propinquus* and *Clausocalanus brevipes*, the amphipod *Themisto gaudichaudii* and the euphausiiid *Euphausia lucens* are widely distributed over all 3 faunistic zones.

1.3.2 Distribution and abundance of zooplankton in relation to hydrographical structures

High concentrations of phyto- and zoo-plankton are usually found at frontal systems elsewhere. However, results from several cruises carried out in the frontal system off the Peninsula Valdes in November 1981, and 1984 and January 1986 showed very low concentrations of copepods during high blooms of phytoplankton (Carreto et al., 1986b). In December 1988, although a high number of copepods was found in the area, their density, however, decreased at the front (Ramírez & Santos, unpubl. data).

1.3.3 Levels of secondary production.

No information.

1.3.4 Predation on anchovy eggs and larvae

Among the potential predators, ctenophores were the most abundant group in zooplankton samples collected off Peninsula Valdes during the spawning season of 1988, surpassing hydromedusae and chaetognats. The dominant species were *Mnemiopsis leidyi* Agassiz, 1865 and *Pleurobrachia sp. cf. P. pileus*. High numbers of ctenophores were found in samples with few or no *E. anchoita* eggs and larvae. Spearman rank correlation co-efficients were negative and significant for the former ctenophores species and negative and highly significant for the latter. The reasons for this apparent lack of co-occurrence between ctenophores and the early life history stages of anchovy (predation, trophic competition, etc.) are yet to be determined (Mianzan, unpubl. data).

2. AVAILABLE INFORMATION ON SPAWNING GROUPS (by Ramiro P. Sanchez)

A synoptic review of information on the reproductive biology and early life history of *E. anchoita* up to 1988, in Argentina (Table 2) was presented by Sánchez (in press).

2.1 KNOWN NUMBER OF SPAWNING GROUPS

At least 2 populations of adult anchovy inhabit the sea off Uruguay and Argentina in Spring and Summer, a northern one not exceeding the 41°S latitude, and a southern one in the Patagonian region from 41° to 47°S (Brandhorst et al., 1974; Hansen et al., 1984; Ratti, 1986; Hansen, MS). On the basis of meristic counts and the analysis of otoliths structure, the existence of 3 sub-populations within the northern area, corresponding to the Spring, Autumn and Winter spawners, has been postulated (Fuster de Plaza & Boschi, 1958; Fuster de Plaza, 1964; Castello & Cousseau, 1969a).

2.2 BIOMASS ESTIMATES OF SPAWNING GROUPS

Ciechomski & Sánchez (1988) presented a comparative analysis of different biomass estimates of the species carried out in different years by means of acoustic and ichthyoplankton surveys, and developed a model in order to obtain biomass estimates of the 2 spring spawning groups, from a historical data base. Estimates were obtained for the period 1966-1985 (Table 3 which are in good agreement with previously published results (Ciechomski et al., 1979; 1986a; Sánchez & Ciechomski, 1984) using classic methods for stock size appraisals from egg surveys. The yearly fluctuations of the species biomasss calculated on the basis of the derived model, showed a well-marked stability, compared to other *Engraulis* species. The relation between the smallest and largest biomass estimates was 1:2,6 for the northern group and 1:2.1 for the Patagonian stock.

2.3 SPAWNING SEASONS AND GROUNDS

Anchovy eggs and larvae were collected in the sea off Argentina throughout the year (Figures 12 to 15) with different intensities and geographical coverage. Areal extension of the spawning grounds is minimum in September (34,397 km2) and maximum in November (265,348 km2) which corresponds to over one quarter of the Argentine shelf. Percentage of positive station for anchovy eggs within the potential spawning habitat of the species, defined on the basis of temperature and salinity tolerance ranges of the embryonic stages (Ciechomski, 1967b; Ciechomski & Sánchez, 1984) reaches highest (84%) and lowest (17%) values in October and September, respectively.

In September, 80% of the spawning takes place north of 36°S, with only one major spawning center located near the coast of Uruguay at 34.5°S. Larvae show similar patterns of distribution and abundance, with minor occurrences in the shelf-break and south of 39°S in the vicinity of El Rincón. In October and November the reproductive activity expands southward to include the Patagonian spawning grounds. In November, larvae were collected outside the spawning area in the northern extreme of the distributional range and in some areas influenced by the La Plata river estuary. In December, spawning reaches San Jorge's Gulf, the southern extreme reported for the genus *Engraulis* (47°S), and spreads as Summer progresses over the shelf and shelf break. There is no spawning in the intensely mixed area to the north of the Valdes Peninsula, a region were gelatinous plankton, mostly ctenophores, are encountered during that season (Brandhorst & Castello, 1971; see also 1.3.4.).

There is a northerly progression of reproductive activity from April to August. No spawning has been detected, during these months to the south of 41°S. Throughout the Winter months, two spawning centers off Buenos Aires province, a major one north of Mar del Plata, and a minor one between 38° and 41°S tend to separate.

Distributions of anchovy eggs and larvae in the areas off Uruguay and Argentina to be occupied during the METEOR cruise are presented in Figures 16 and 17. Off Uruguay, eggs and all larval sizes (2-24mm SL) may be found, whereas in the Patagonian region only eggs and larvae up to 10 mm SL were collected.

2.4 KNOWN NURSERY GROUNDS

Available information seems to indicate that anchovy larvae are subject to different processes of drift and retention, according to the area and time of the year (Sánchez & Ciechosmki, 1989b). Latitudinal variation of larval size distribution (Figure 18), and occurrence of pre- and post-metamorphosis specimens (Figure 19) confirms the existence of two individual populations during Spring and Summer. Post-larvae born in Spring and early Summer off the Buenos aires province, are retained within the area, with a latitudinal shift in the length frequency distribution throughout the season, in accordance with the advance and retreat of warm waters over the continental shelf. In March, larger post-larvae are found only in the northern part of the Buenos Aires region, whereas south of 39° only newly born larvae were collected. South of 41°S, the occurrence of anchovy eggs and larvae is related to the existence of frontal systems (the tidal front off the Valdes Peninsula and the hydrological front to the south of San Jorge Gulf), but post-larvae and juveniles are retained in the region even after the tidal front has been eroded by the end of Summer. Larvae and post-larvae were collected in the Patagonian region from April to July in the vicinity of Isla Escondida (43°S) and Mazarredo's Bank (47°S), 2 important spawning and nursery grounds of shrimp and several fish species. Larval collections made in April in this region, consisted of specimens of sizes over 4 mm SL (mode 10 mm). In May, no larvae less than 7 mm SL were collected (mode 15 mm). During June and July all larvae collected in the area were larger than 20 mm SL.

At least part of the Autumn-Winter born larvae seem to drift towards lower latitudes, according to larval length frequencies distributions (Hubold, 1982), and the presence of large amounts of juveniles in Winter and Spring (Castello & Pérez Habiaga, 1983). Transport is favoured by the higher intensity of the Sub-antarctic waters and by the outflow of La Plata water along the Brazilian coast.

The presence of metamorphosed specimens in October and November in the shallow protected area of EL Rincón, could indicate that there is an individual spawning group south of 38°S, in Winter.

2.5 REPRODUCTION

2.5.1 Sex ratio

Monthly fluctuations in the proportion of males to females in the catches have been reported by Castello & Cousseau (1969b) and Cousseau et al. (1981). The observed trends indicate that females are predominant during inactive reproductive periods, whereas, during the spawning season, sex ratios come close to 1:1. Eventually, males may become predominant (1:0.67) as observed by Hansen (pers. comm.) in an extended survey during the Spring spawning peak, off Buenos Aires province, in November 1988. There is no available information as to variations in the proportion of males to females in relation to age or length.

2.5.2 Length at first maturity

There are statistical differences in the size at first maturity of the 2 populations inhabiting the Argentine Sea during Spring and Summer (Hansen, MS). In the Northern group, 50% of the individuals mature at 116 mm (one year old), whereas in the Patagonian region, 50% first maturity corresponds to specimens of length 132 mm (2-year old).

2.5.3 Frequency of reproduction

Based on the percentage of post-ovulatory follicles of female anchovies of the Northern stock, which were collected during the Spring spawning peak, Christiansen & Cousseau (1985) estimated the frequency of reproduction at 12-17 days. These results were confirmed (Ibid.) by an analysis of the evolution of gonad maturity during the spawning season, determined by ova growth measured with an integrating eye-piece, which yielded an independent estimate of about 15 days between consecutive batches of eggs.

There is no information available on the frequency of reproduction of the southern stock during Spring and Summer, and of the northern stock(s) in Autumn and Winter.

2.5.4 Fecundity

Estimates of relative fecundity determined gravimetrically on the basis of oocyte counts of the most advanced mode, are given by Fuster de Plaza (1964) (RF = 558-666 oocytes/gram of female weight) and Ciechomski & Weiss (1973) (RF = 404-678 oocytes/gram of female weight). Olivieri estimated the relative fecundity of females at pre-spawning (Mean RF = 672 oocytes/g) and full maturity stages (Mean RF = 422 oocytes/g) stereometrically. Louge & Christiansen (MS) estimated, by the same method, the batch fecundity of 23 females caught in coastal waters off Mar del Plata, reporting a mean value of 355 ± 190 oocytes per female gram.

2.5.5 Spawning time

Peak spawning takes place around 2100 h (Ciechomski & Sánchez, 1984) though there is evidence of reproduction activity taking place from 2000 h to 0200 h.

3. EARLY LIFE HISTORY (by Ramiro P. Sanchez)

3.1 DEVELOPMENTAL STAGES

The embryonic and larval development of *E. anchoita* has been described by Ciechomski (1965a). Anchovy eggs show the characteristics typical of the genus *Engraulis* (Figure 20). Eggs are pelagic and elliptical (long axis: 1.15-1.53 mm; short axis: 0.66-0.78 mm), with smooth, transparent chorion, segmented yolk, a narrow perivitelline space and have no oil globule. Anchovy embryos hatch at an early stage of development, without pigmentation, with mouth and pectoral fins undeveloped, and their size is approximately 2.7-3.1 mm TL. At 15°C, yolk-absorption takes about 3-4 days. Pectoral fin buds, formation of the swimming bladder and pigmentation are evident in 3.8 mm larvae. Metamorphosis takes place at about 33-34 mm TL (Figure 21).

In order to estimate the influence of temperature on the rates of development of anchovy eggs, they were classified according to a scale of 9 stages by Ciechomski & Sánchez (1984). Developmental stages used for *E. anchoita* are listed in Table 4.

3.2 EGG STAGE DURATION

Tables 5 and 6 and Figures 22 and 23 summarize the methods used by Ciechomski & Sánchez (1984) to calculate the duration of the 9 developmental stages of anchovy eggs at different experimental temperatures. The estimated relation between the incubation time until hatching (t) and temperature (T), was t = 2.449 - 0.042T (r = -0.985). Calculated values of the critical thermal increment (μ = 15.48) and Van't Hoff coefficient (Q10 = 2.68) (Sánchez, 1986) show that the decrease of developmental duration with rising temperature is less pronounced for *E. anchoita* than for other related species.

3.3 LARVAL GROWTH

Pre-hatch and post-hatch growth of Southwest Atlantic anchovy, have been described by Sánchez (1986) by fitting a double cycle Laird-Gompertz model to several sets of experimental data. Obtained values for the first cycle of the model, which corresponds to the stage of endogenous feeding, are very similar to those reported by Zweifel & Lasker (1976) for *E. mordax*.

3.4 EMBRYONIC MORTALITY

Mortality from fertilization to hatching has been calculated by Ciechomski & Sánchez (1984) and Sánchez & Ciechomski (1989b) from age frequency distributions of anchovy eggs collected in different months and areas (Table 6). Embryonic mortality was also calculated from 2 cohort tracing experiments, carried out during the reproductive peak in the spawning grounds off southern Buenos Aires province, (Ciechomski & Sánchez, 1984; Sánchez MS) which showed lower daily loss rates (Z= 0.54-0.56).

3.5 LARVAL MORTALITY

Maximum likelihood estimates of larval mortality were reported by Sánchez & Ciechomski (1989b) from the decline in catches of successive length classes (2-20 mm SL, preserved size), derived from the seasonal census method in the regions off Buenos Aires (Z= 0.62) and Patagonia (Z= 0.25). Similar results were obtained from estimates of larval abundance calculated during the months of peak spawning in each region (November and January, respectively). Sánchez (1986) on the basis of a combined growth curve, estimated mortality with age, for the 1981 spawning peak off Buenos Aires. Instantaneous coefficients of mortality (Z) were 0.56 for the embryonic period (days 0-3), 0.23 for the larval and post-larval stages (days 3-26) and 0.35 for the first 26 days of life.

3.6 DISTRIBUTIONAL PATTERNS OF EGGS AND LARVAE

Monthly distributional patterns of anchovy eggs and larvae have been studied by Sánchez & Ciechomski (1989a), both in the colloquial sense, as synonym with temporal and geographic arrangement, and in the statistical sense, that is in reference to the way in which variate values (variate: number of organisms/sea surface unit) are apportioned with different frequencies in a number of possible classes.

3.6.1 Patterns in relation to environmental factors

Sánchez & Ciechomski (1989a) analyzed a historical data series (1966-1988) in order to produce monthly estimates of reproductive intensity and larval abundance (Figures 12 to 15) and to study the influence of different environmental factors on anchovy spawning activity. Figure 24 represents the monthly variation of average values of daily egg production, which correspond to different intervals within the encountered ranges of temperature and distance from shore. Temperature of maximum spawning incidence decreases from 18.5°C in February to 13.0°C in September. The widest thermal range is observed in November (8.8°-23.2°C), whereas the narrowest one was found in September (9.3°-13.2°C). Although some reproduction takes place as far as 400 km from the coast during Summer, in all other months, more than 95% of the spawning takes place at distances not exceeding 150 km from shore, and at bottom depths above 75 m. Seasonal reproductive activity south of 34°S, as represented in T-S charts (Figure 25), shows that there is no spawning in any of the 3 main water masses found in the area (Malvinas, Subtropical, and Estuarine waters of the La Plata River) in their pure form, but rather in waters characterized by different mixing proportions of the 3 water masses, which due to the hydrodynamic conditions prevailing in the region, can be detected as far south as 39°S. The percentage of each water type in every positive station located between 34°S and 39°S was calculated by means of Meincke's (1972) equations. Inserts in Figure 25 show the percent seasonal abundance of anchovy eggs, collected in different fractions of each water mass.

Spawning south of 41°S is related to the formation of a tidal mixing front off the Valdes Peninsula, and a hydrological front in the southern part of the San Jorge's Gulf. The occurrence of anchovy eggs and larvae smaller than 10 mm SL in the 3 water types of the tidal front (mixed, transition and stratified) has been shown to vary throughout the reproductive season (Sánchez & Ciechomski 1989b). Figure 26 shows the relation between the presence of anchovy eggs and larvae and Simpson's (1981) parameter, a measure of the degree of stratification of the water column. The black bar under the x-axis indicates the values of the parameter in the transition zone, which seem to accumulate most eggs and larvae at the beginning (December) and end (April) of the reproductive season. In February, however, most eggs and larvae are found in the stratified region.

3.6.2 Sample frequency distribution

Analysis of sample frequency distributions and fitting of theoretical models to observed data on anchovy eggs and larvae have been carried out in order to estimate population parameters and then calculate abundance and confidence intervals (Ciechomski et al., 1983), to determine the intensity of sampling effort (Sánchez, 1986) and to interpret larval behaviour and ecology (Sánchez, 1986; Sánchez & Ciechomski, 1989a; Sánchez, MS).

To facilitate comparison with results reported on related species, the Peruvian and Californian anchovies, egg sample frequency distributions were analyzed in accordance with Smith et al. (1983), grouping historical data into base-4 logarithmic categories and calculating the proportion corresponding to each of them. The frequency distribution obtained for the Southwest Atlantic anchovy, from the analysis of a total of 4898 samples (Sánchez & Ciechomski, 1989a) resembles that reported for the Californian species. Egg densities (N/m2) ranged from 0.06 to 14200, with the highest probability corresponding to the 64-256 sample size category. The complete range of density intervals is attained only in October and November. In spite of an 8-fold increase in the regional abundance of eggs from September to January, there is no statistically significant difference between the sample frequency distributions of these 2 months. Evolution of larval aggregation patterns was studied following the methodology proposed by Hewitt (1981), which includes the fitting of the weighted negative binomial series and the application of indexes of patchiness and mean crowding. Details of the different steps followed are given by Sánchez (1986). Patchiness indexes calculated for the Southwest Atlantic anchovy larvae from 2-15 mm SL, are higher than those of the corresponding size classes of the Californian anchovy. Moreover, differences are observed in the relative occurrence of the size categories studied, in the observed divergence between the mean numbers per station within the larval habitat and the mean number per positive station which correspond to each size class, considered as an indicator of the beginning of patch formation, and also in the effect of dispersal, which in the case of *E. anchoita* seems limited to the egg and prelarval stages (Sánchez & Ciechomski, 1989a).

3.7 LARVAL FEEDING BEHAVIOUR

E. anchoita seems to be an almost exclusively zooplanktophagous species from its earlier life stages. According to Ciechomski (1967a) the different developmental stages of calanoid copepods are the principal component of the diet of both larval and juvenile anchovy. Higher percentages of feeding individuals were reported (Ibid.) for first-feeding (52%) and post-metamorphosis (57-78%) stages. The size range of food items of first-feeding larvae goes from 60 to 150μ (Ciechomski 1967a; Ciechomski & Weiss, 1974). At about 40 mm length, the development of the gill raker apparatus is completed, and as a result of increased filtering capacity, phytoplankton items are found in the gut contents. As shown by Ciechomski & Weiss (1975), the development of the filtering apparatus (i.e., length and number of gill rakers) is correlated to temperature.

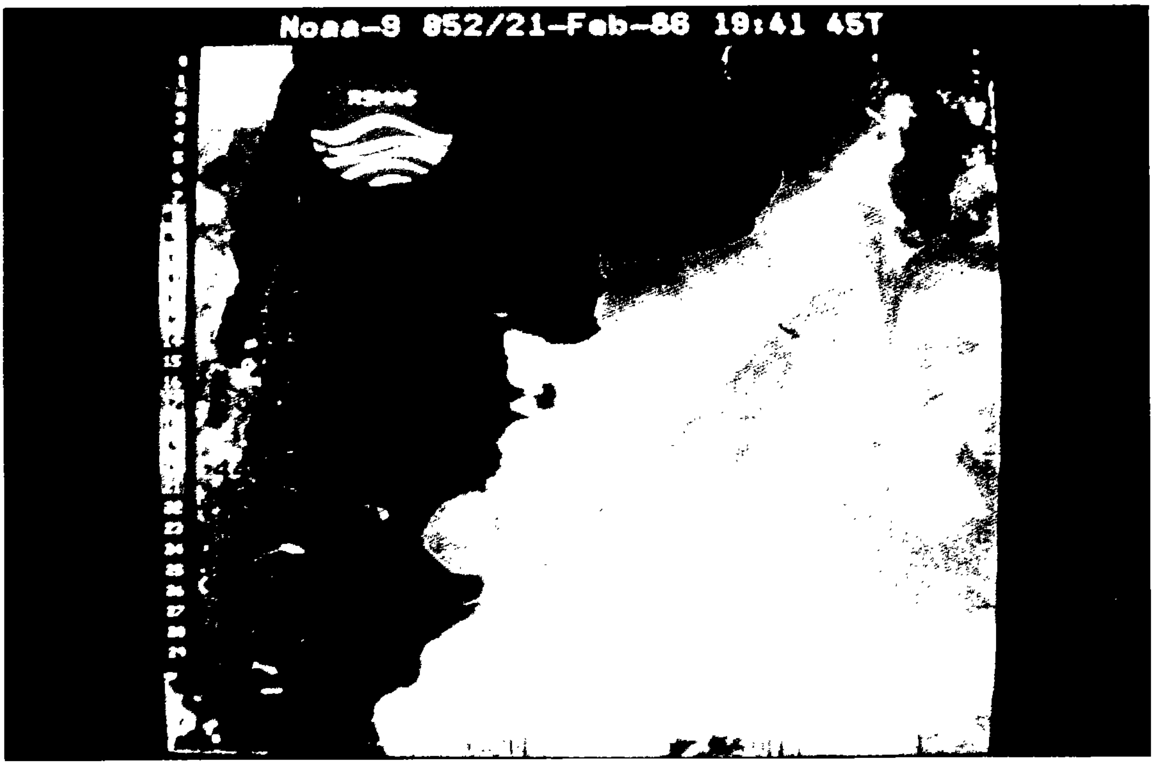
A 14-hour feeding period was estimated by Sánchez (MS) on the basis of the percentage of larvae with undigested gut contents, caught during Spring and Summer at 3 depth intervals (0-10m; 11-20; 21-35m). Feeding starts after sunrise (0700h), mostly in the thermocline or immediately below. Before and after sunset, feeding activity was detected in all the 3-depth intervals sampled whereby larger feeding larvae were found in the lowest level. All larvae with food remnants after nightfall, were caught in the upper water layer.

Sánchez & Ciechomski (1989b) compared the percentages of first-feeding larvae in different areas and regions. The Patagonian area showed higher incidence not only of positive samples (i.e., samples containing at least one larvae with at least one food item), but also of number of feeding larvae in each positive sample, and number of food items in their digestive tube, as compared to the area off Buenos Aires province. Within the latter area, higher percentages of positive samples were collected in the coastal region, up to 50 m and in the outer shelf and shelf break (100-200 m bottom depth).

3.8 PREDATION

See 1.3.4

A



B

Figure 1. Satellite derived Seasonal SST fields. A) Summer B) Winter; Provided by Servicio Meteorologico Nacional (Argentina) and Rosenstiel School of Marine Science; University of Miami.

FIGURE 2

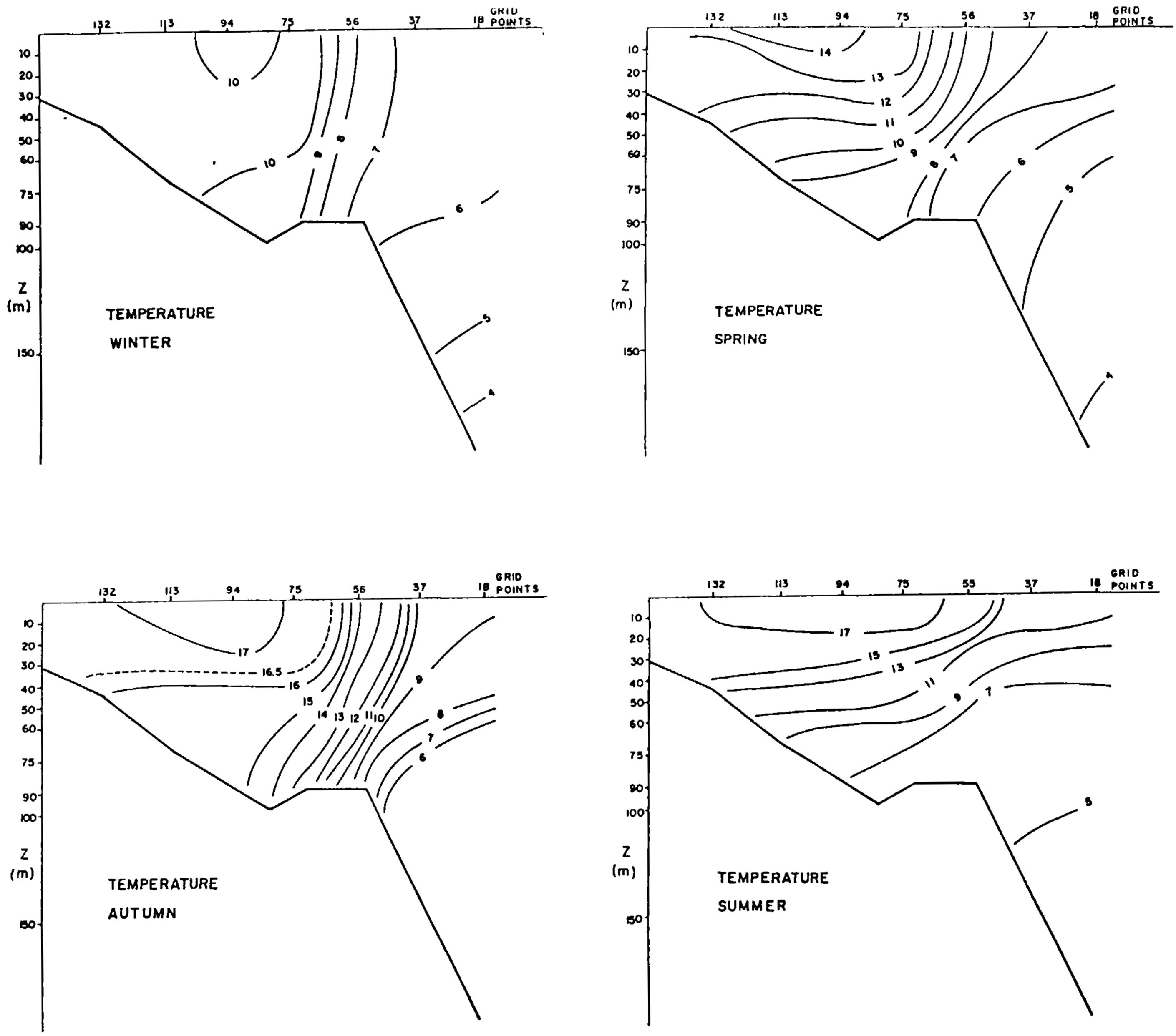


Fig. 2 - Seasonal mean cross-shelf temperature profiles.
From: Martos & Piccolo (1988)

FIGURE 3

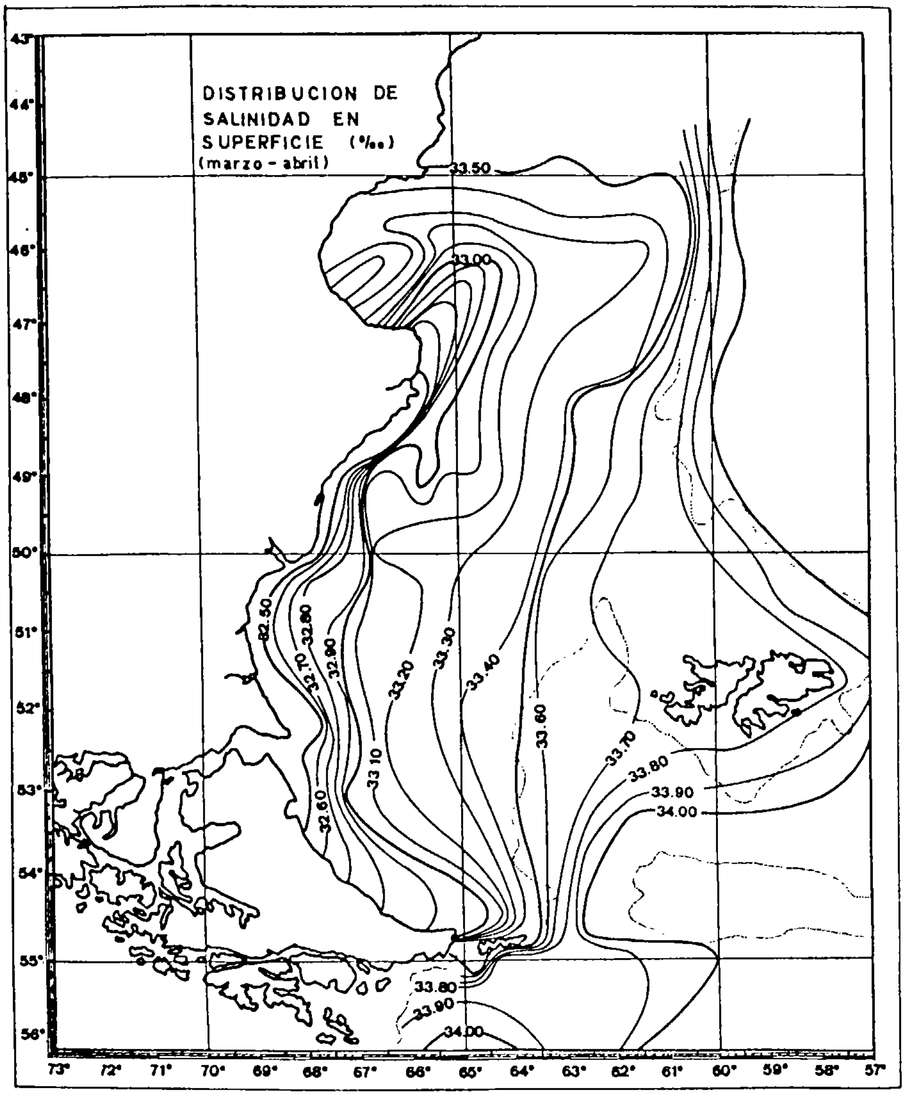


Fig. 3 - Surface Salinity Distribution (March-April).
From: Krepper & Rivas (1979).

FIGURE 4

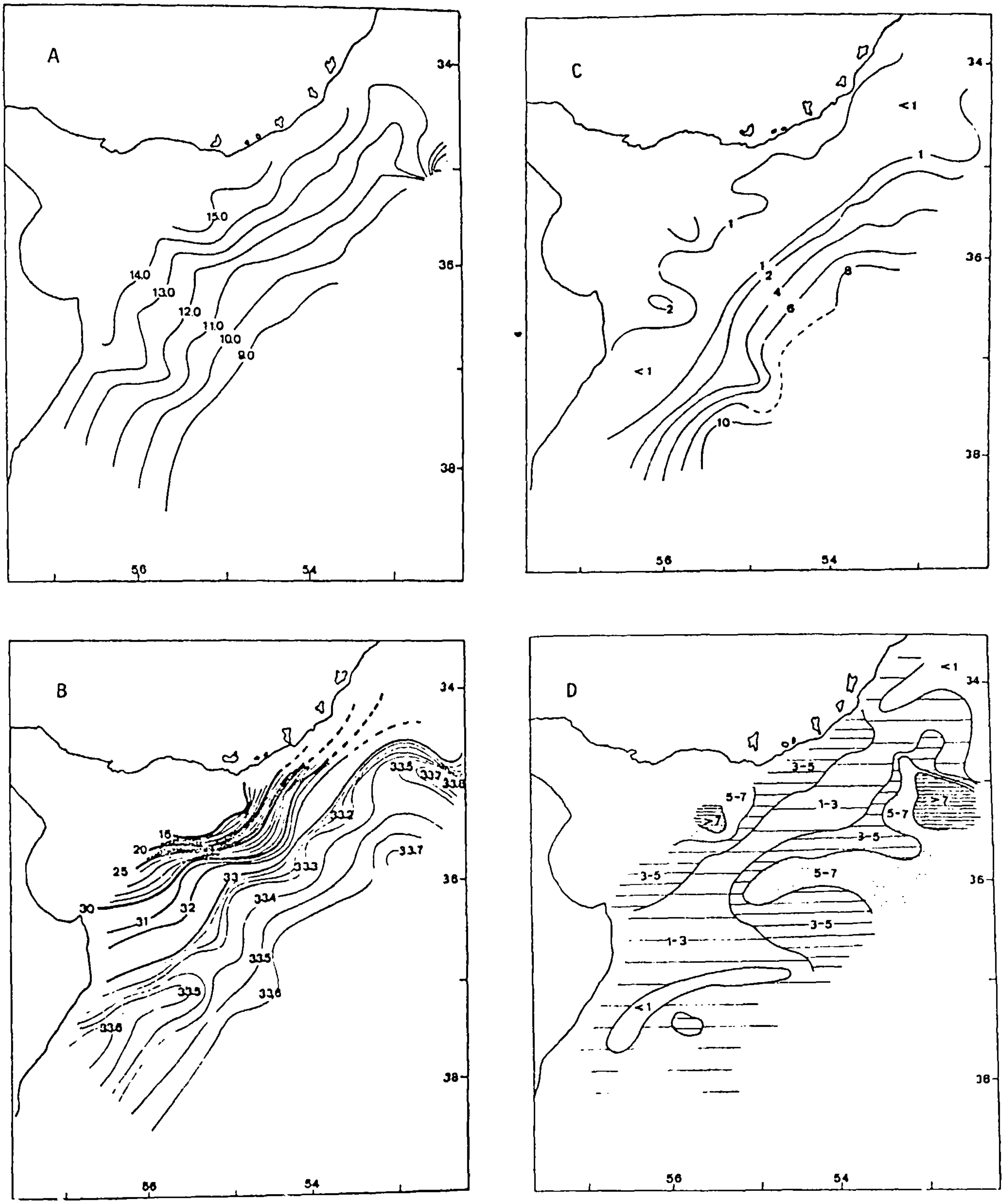


FIGURE 4: Surface distributions of temperature (A) salinity (B), nitrates (C) and chlorophyll a (D), from a spring cruise at the La Plata river maritime front. (from Carreto et al., 1986)

FIGURE 5

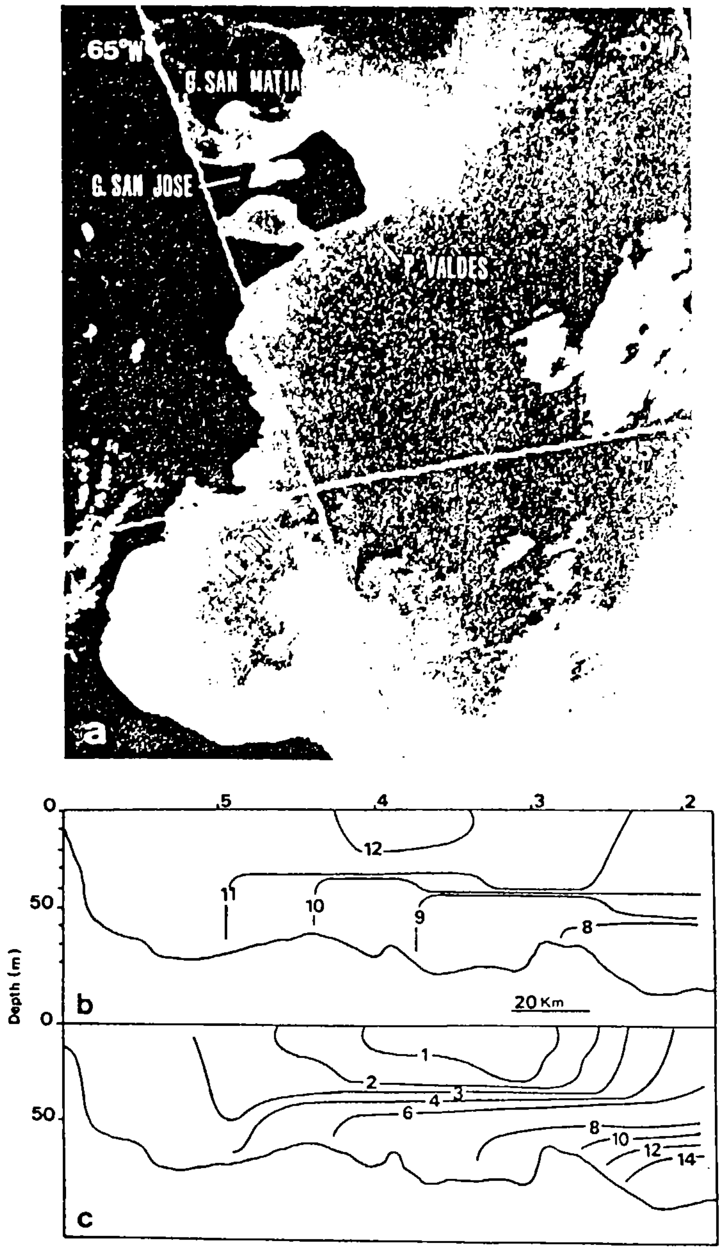


FIG. 5 a) Infrared satellite image (AVHRR) of an Argentine coast sector. b) Sections for temperature (C), and c) nitrate (uM) across the Peninsula Valdes front on November 1981. Station 2: Lat. 44°20' Long. 62°30'; Station 3: Lat. 44°03' Long. 62°52'; Station 4: Lat. 43° 33', Long. 63°29'; 5: Lat. 43°08', Long. 63°32'.
(from Carreto et al., 1985).

FIGURE 6

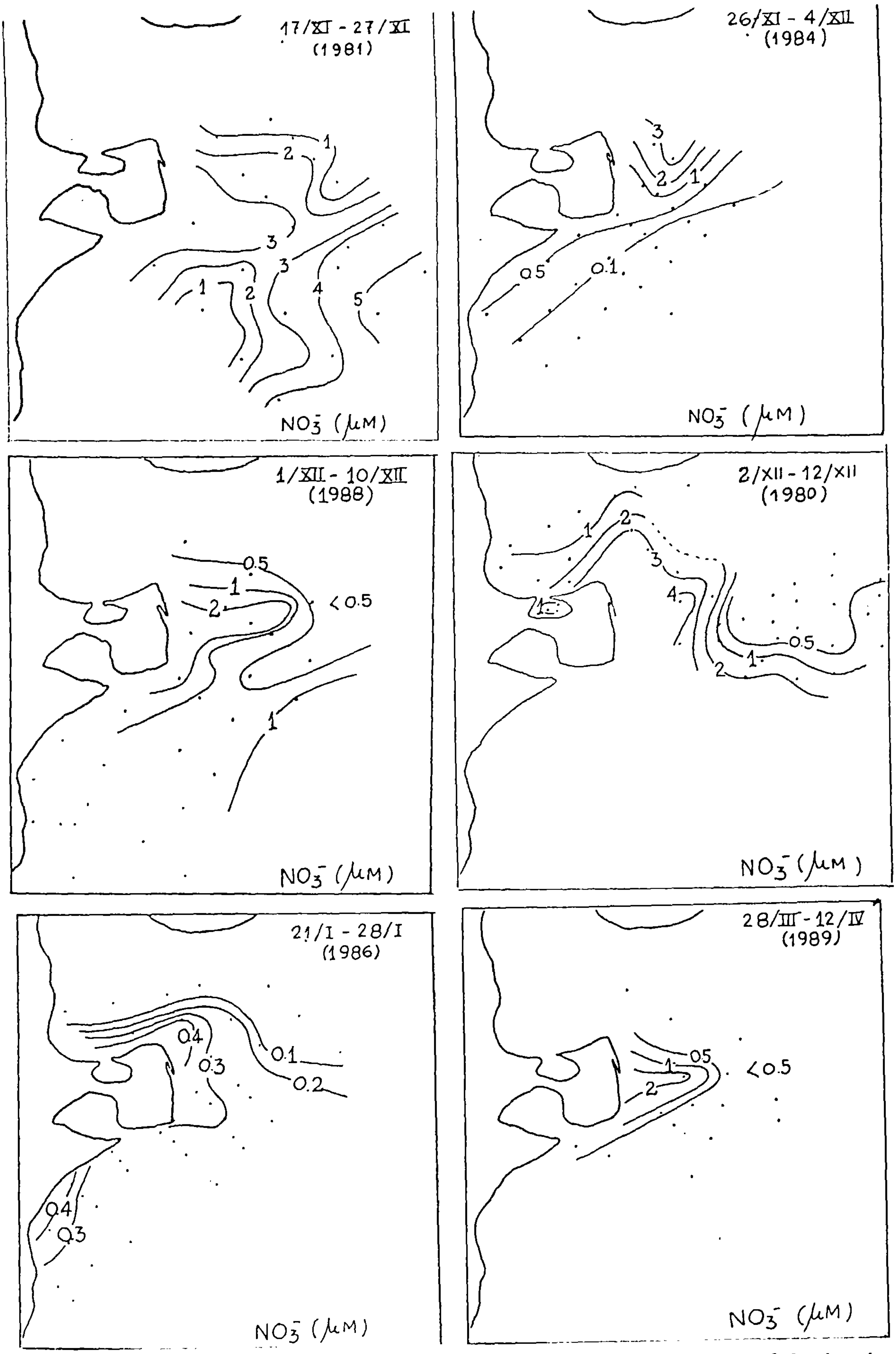


FIGURE 6: Nitrates (uM) surface distribution in the frontal zone of Peninsula Valdés (original).

FIGURE 7

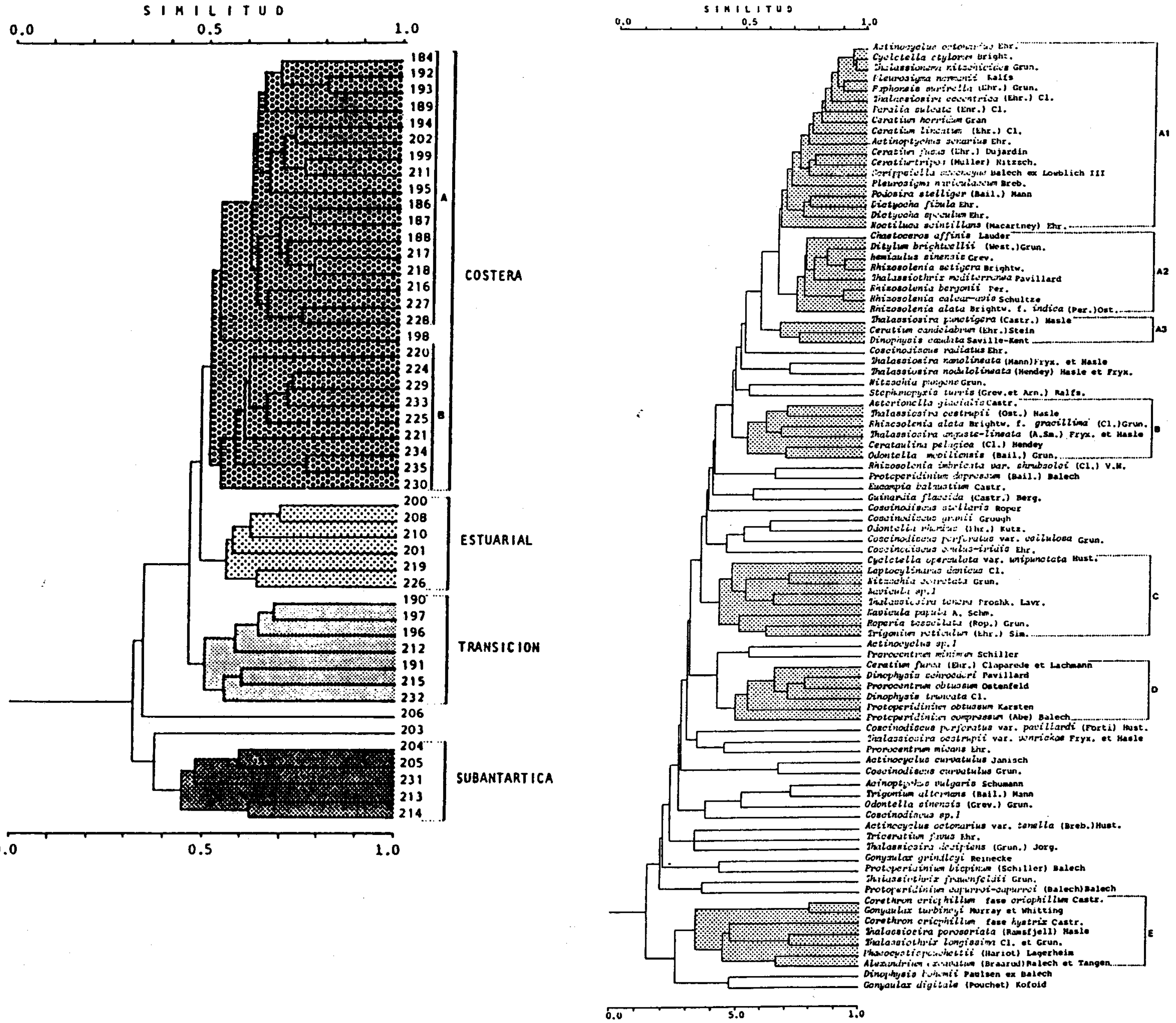


FIGURE 7: Dendrograms grouping stations (left) and phytoplankton species (right) from a spring cruise at La Plata river maritime front.(from Negri et al, 1988).

FIGURE 8

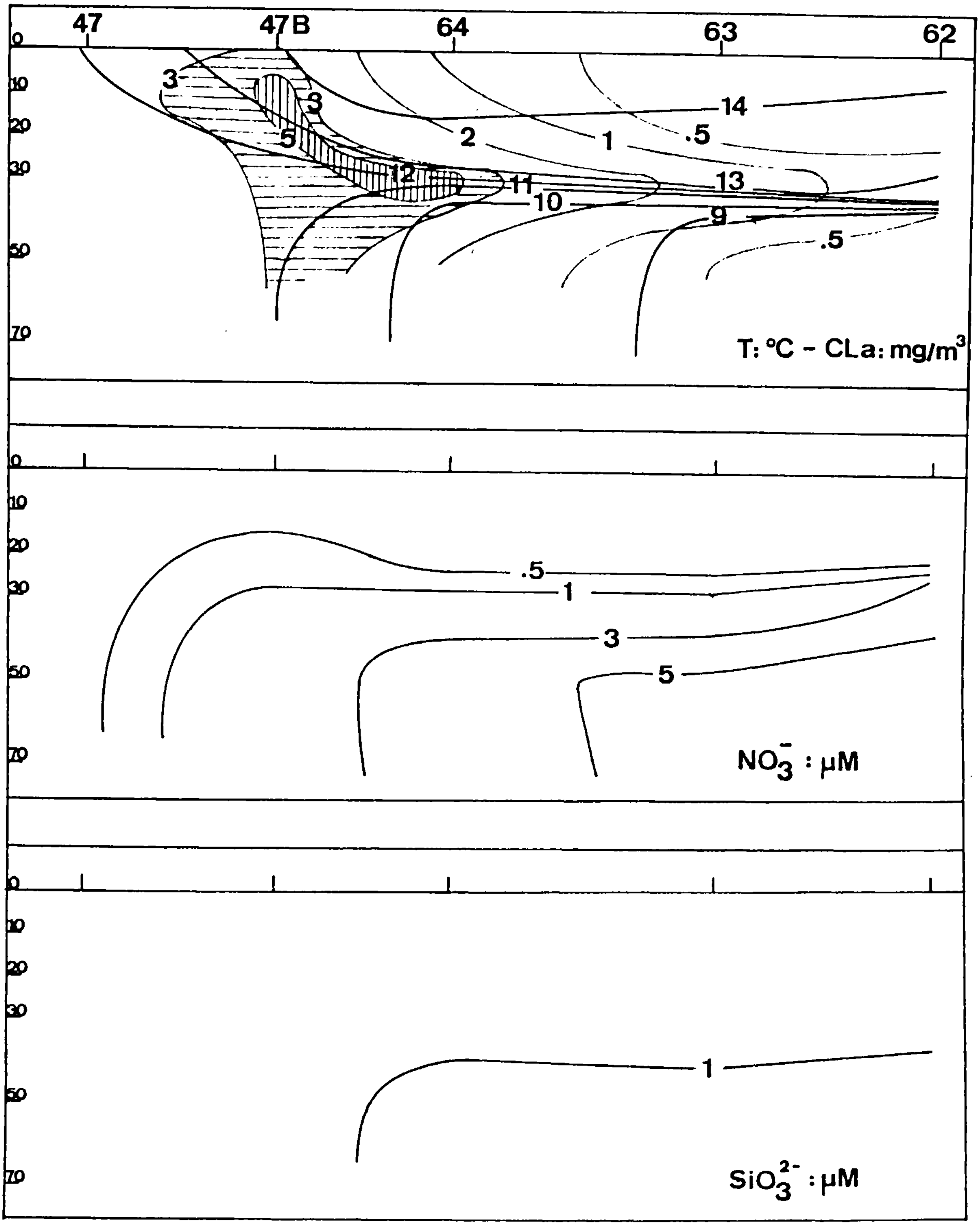


FIGURE 8: SECTIONS FOR TEMPERATURE (ºC). CHLOROPHYLL *a* (mg m^{-3}), NITRATE (µM) AND SILICATE (µM) ACROSS THE PENINSULA VALDES FRONT ON DECEMBER 1984. (ORIGINAL).

FIGURE 9

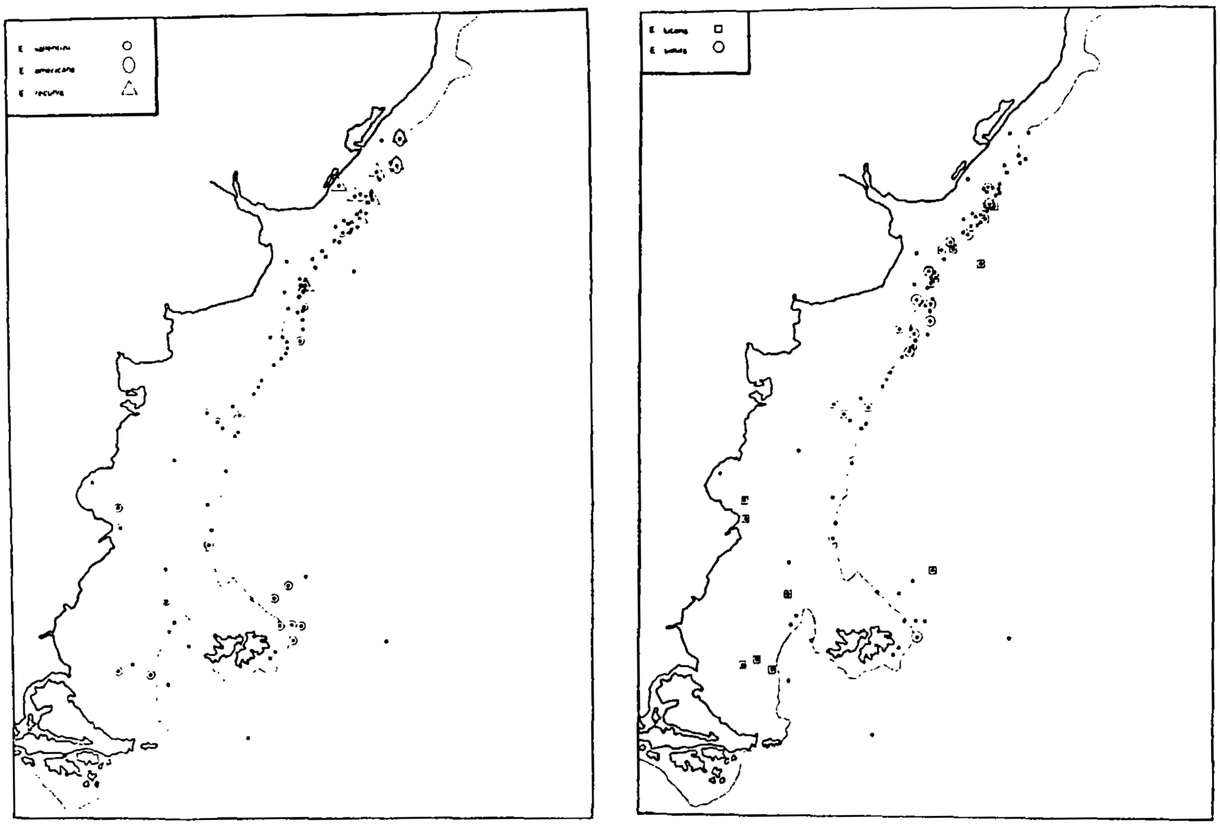


FIGURE 9: Distribution of the Euphausia species in Argentine shelf waters and adjacences: left, E. lucens and E. similis; right, E. vallentini, E. americana and E. recurva. (from Ramírez, 1973).

FIGURE 10

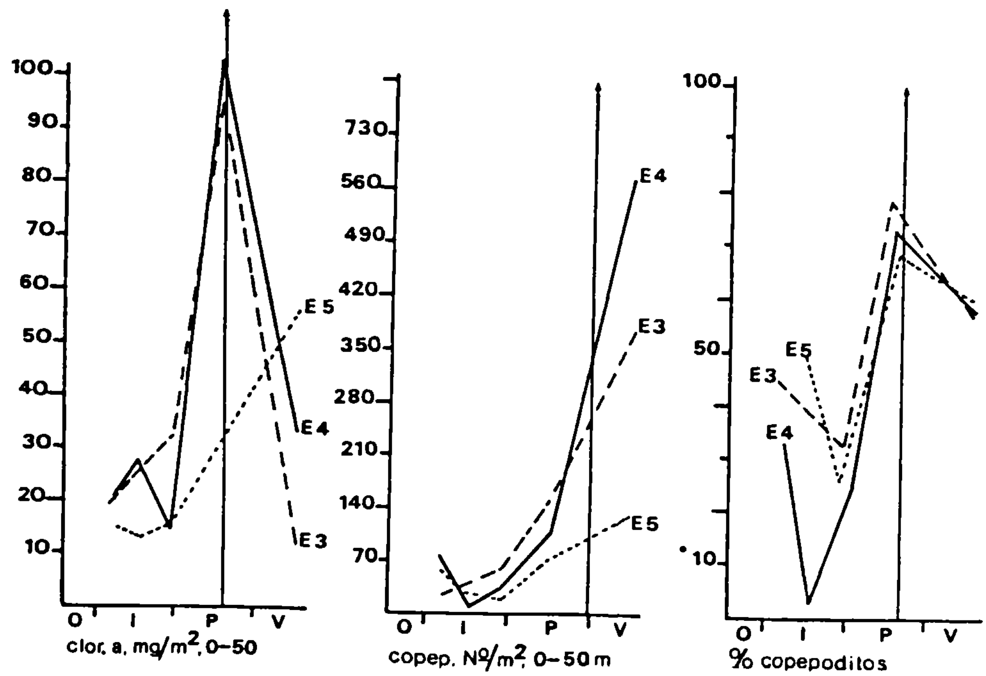


FIGURE 10: Seasonal variations of the planktonic abundance off Mar del Plata at three oceanographic stations (E3 to E5). O: Autumn, I: Winter, P: Spring, V: Summer (from Carreto et al., 1971).

FIGURE 11

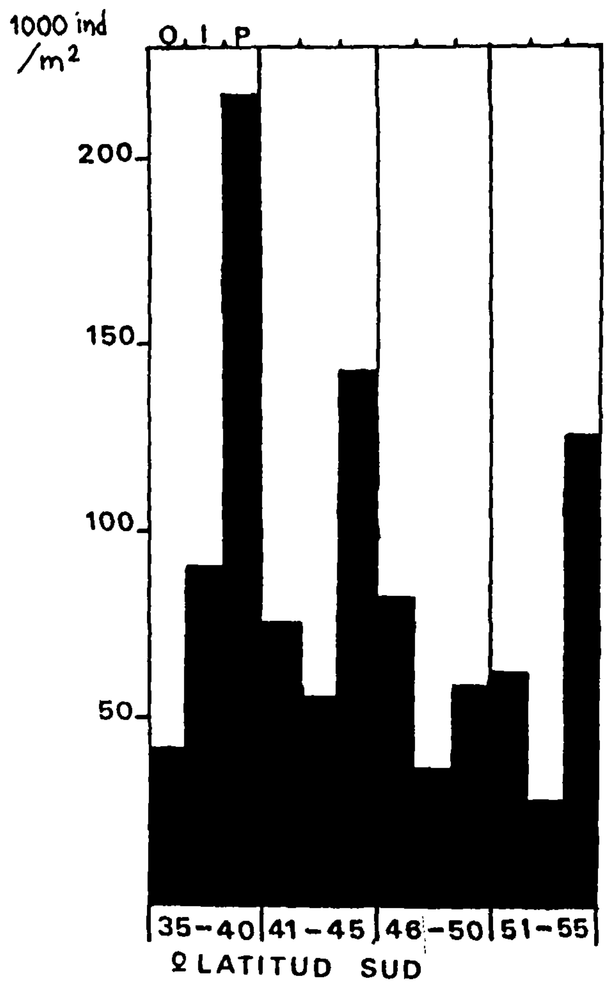


FIGURE 11: Mean seasonal abundances of copepods at different latitudes of the Argentine shelf waters. O: Autumn, I: Winter, P: Spring (results from W. Hervig and S. Maru expeditions 1978/79. Ramírez, MS).

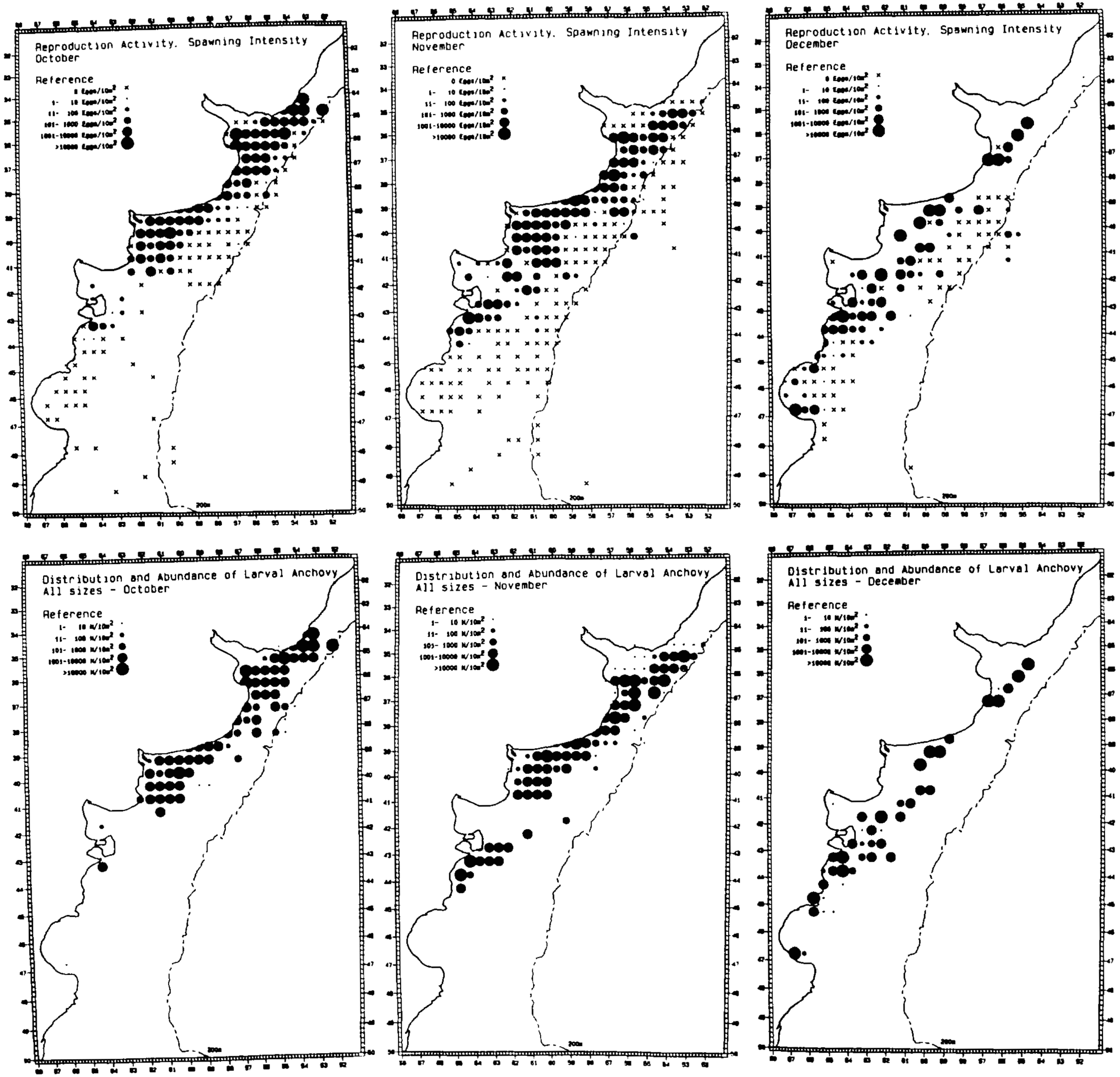


FIGURE 12: Average distributional patterns of eggs and larvae in spring (from Sánchez & Ciechomski 1989a)

FIGURE 13

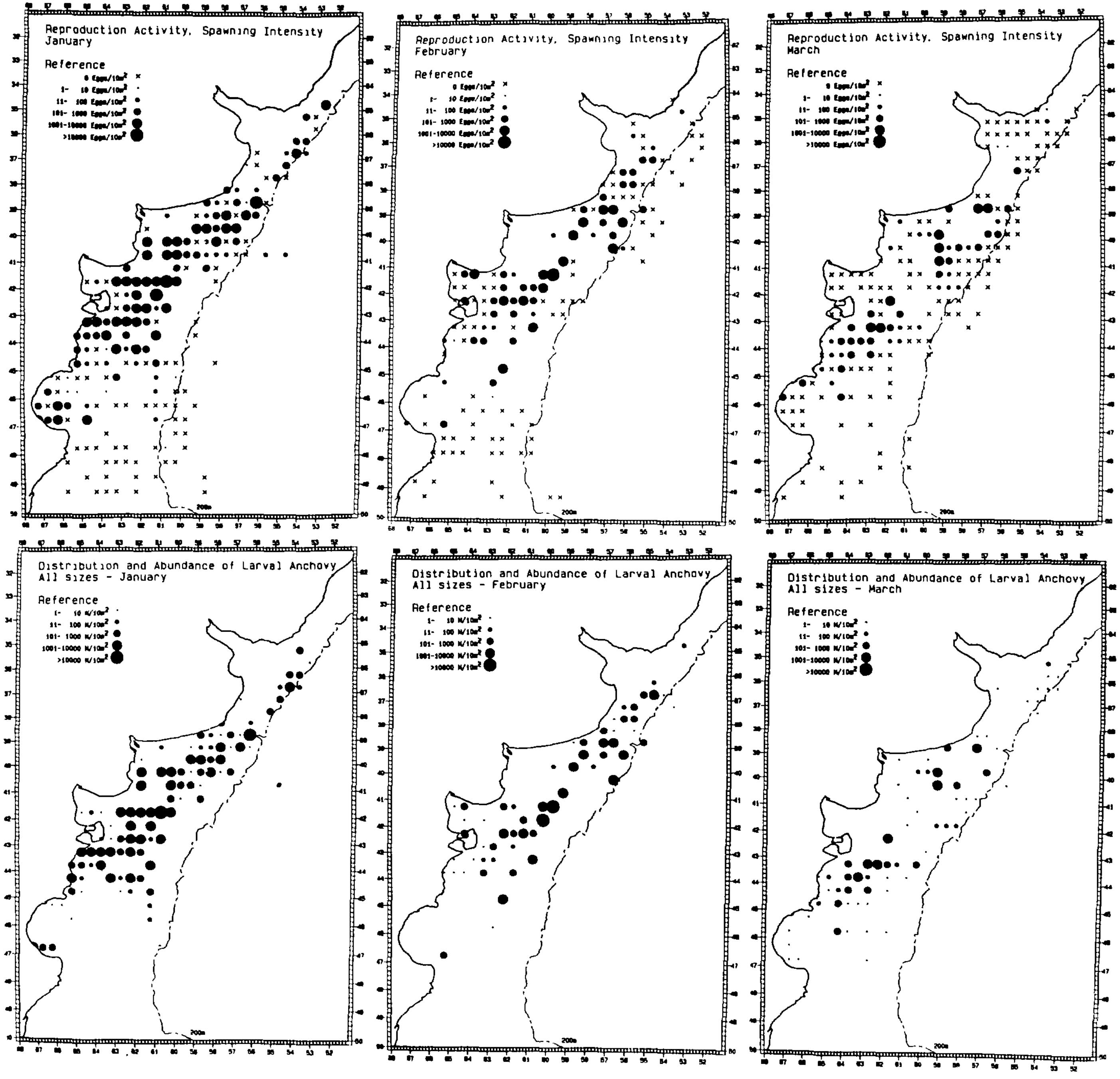


FIGURE 13: Average distributional patterns of anchovy eggs and larvae in summer (from Sánchez & Ciechomski 1989a)

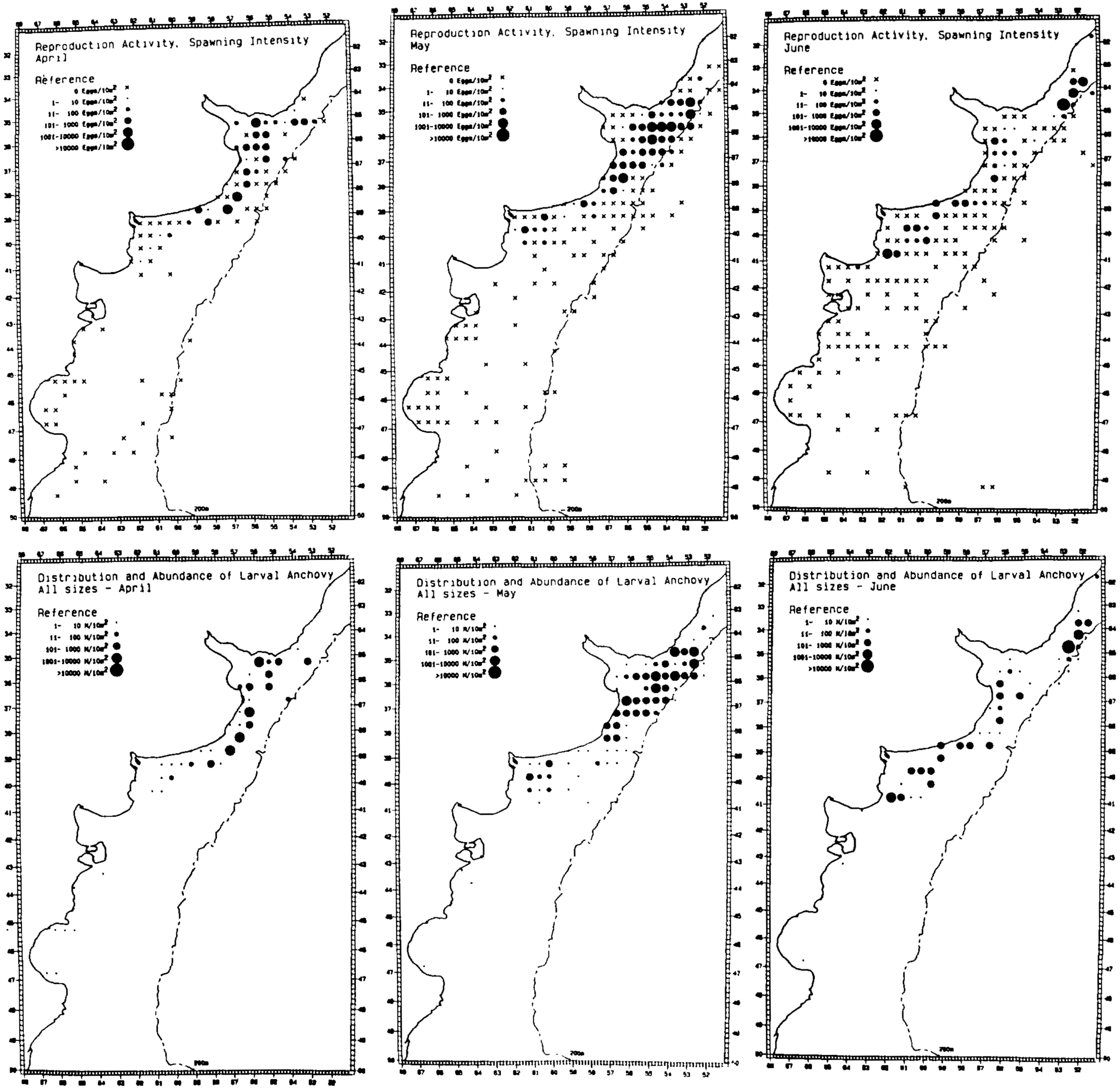


FIGURE 14:Average distributional patterns of anchovy eggs and larvae in autumn (from Sánchez & Ciechomski,1989a)

FIGURE 15

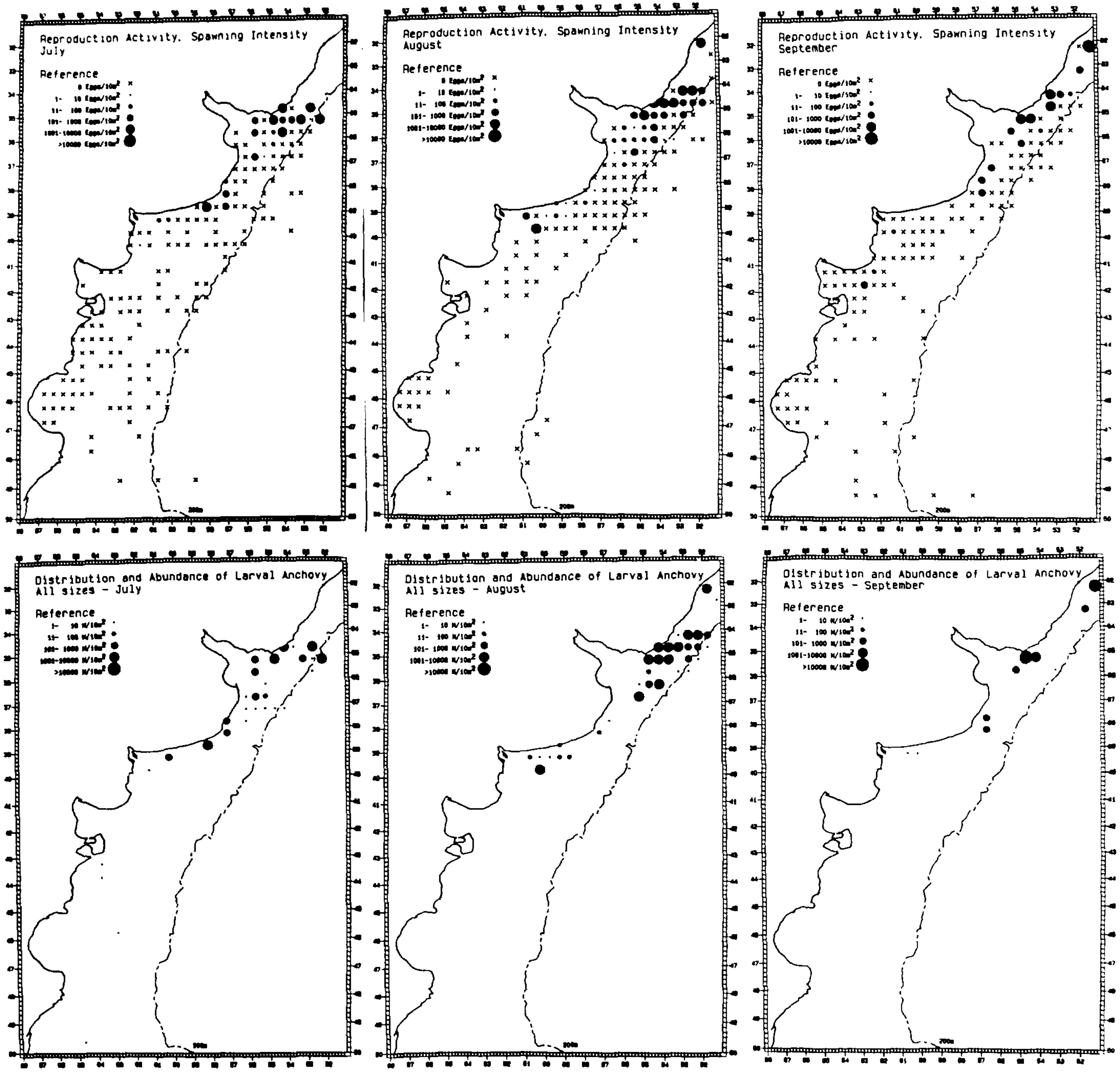


FIGURE 15: Average distributional patterns of anchovy eggs and larvae in winter (from Sánchez & Ciechomski, 1989a)

FIGURE 16

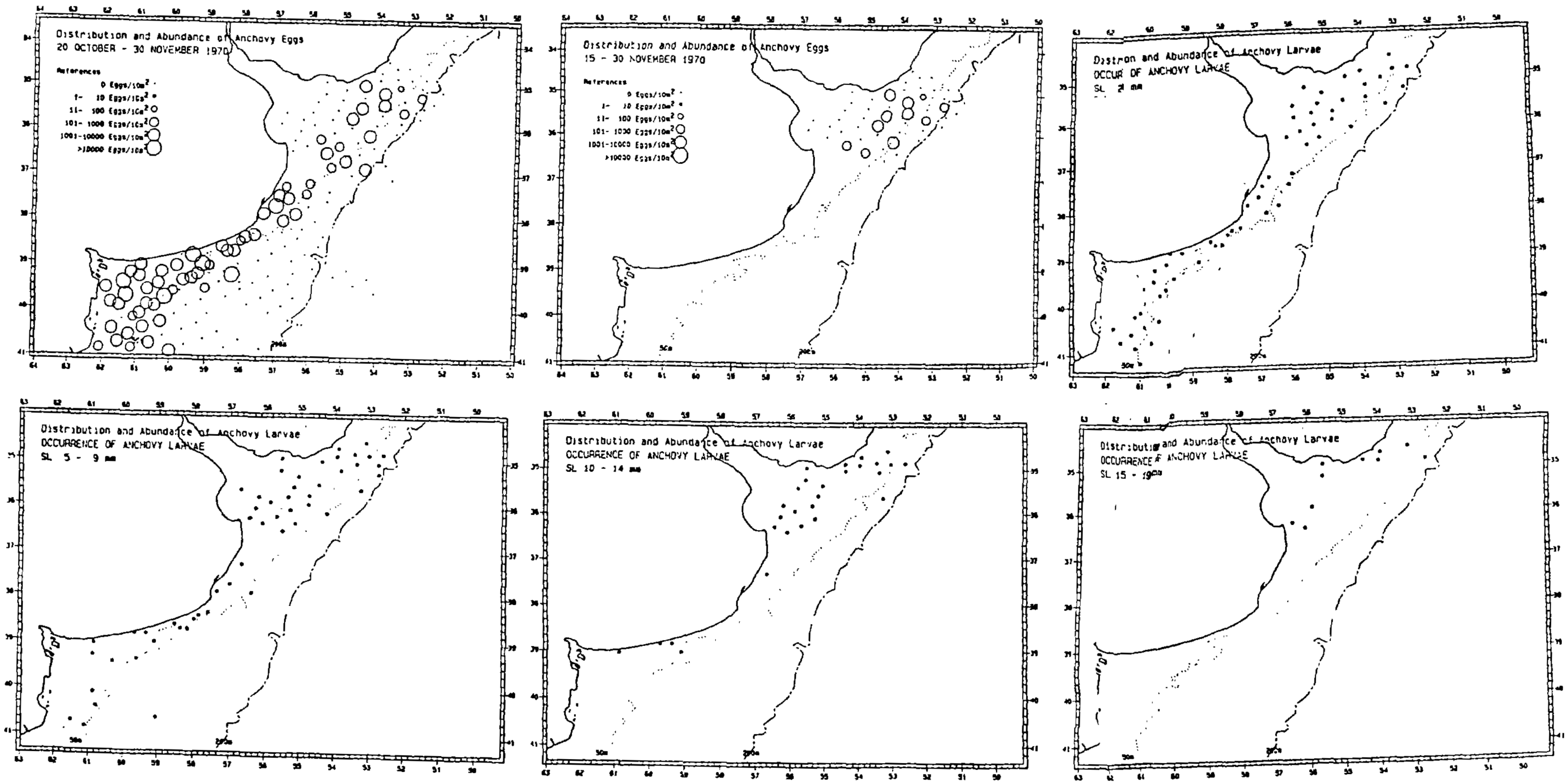


FIGURE 16: Distribution and abundance of anchovy eggs and occurrence of different larval sizes in spring, off Buenos Aires and Uruguay (Sánchez, MS).

FIGURE 17

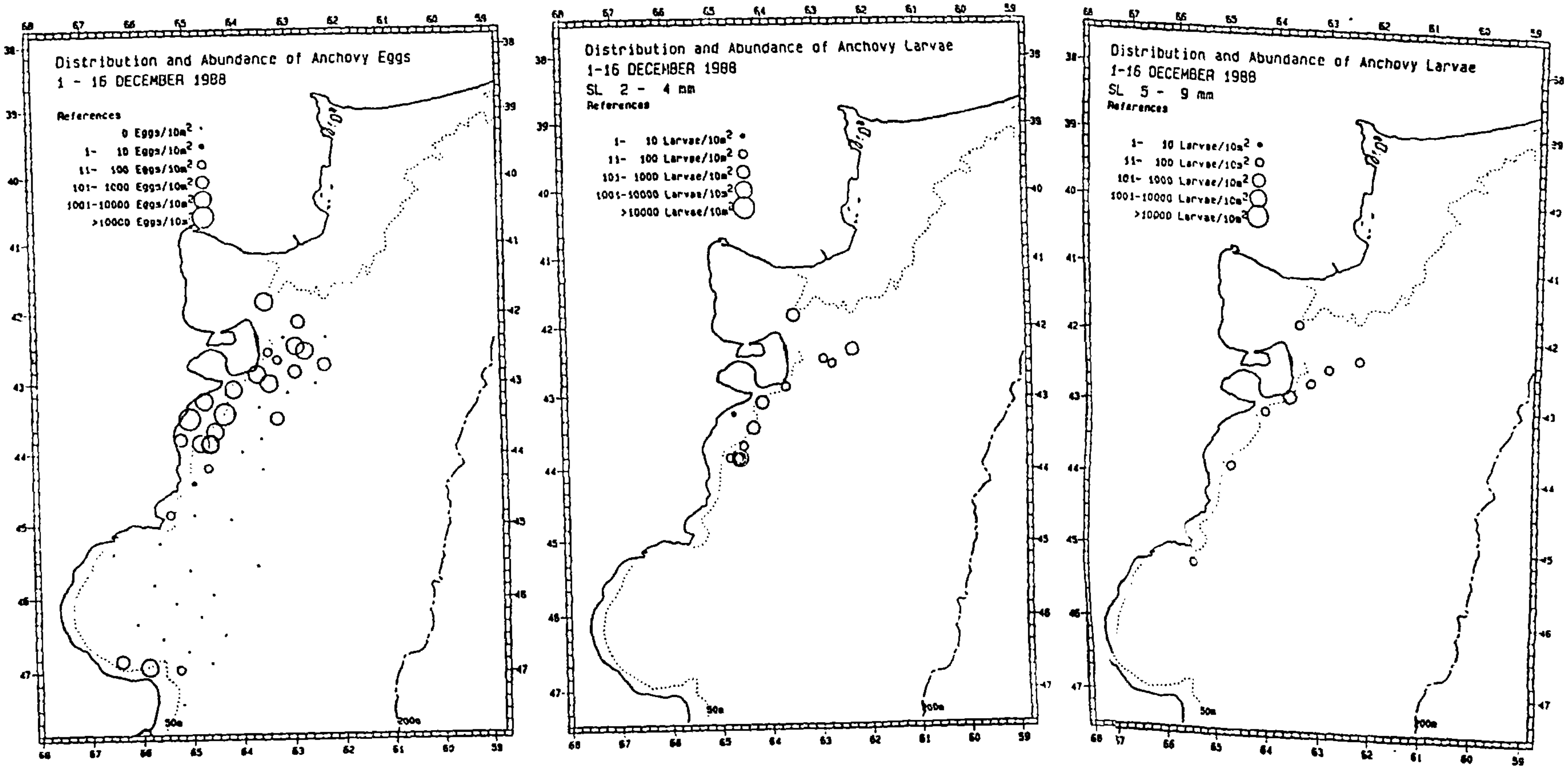


FIGURE 17; Distribution and abundance of anchovy eggs and different larvaizes in spring off Patagoniia (from Sánchez, MS).

FIGURE 18

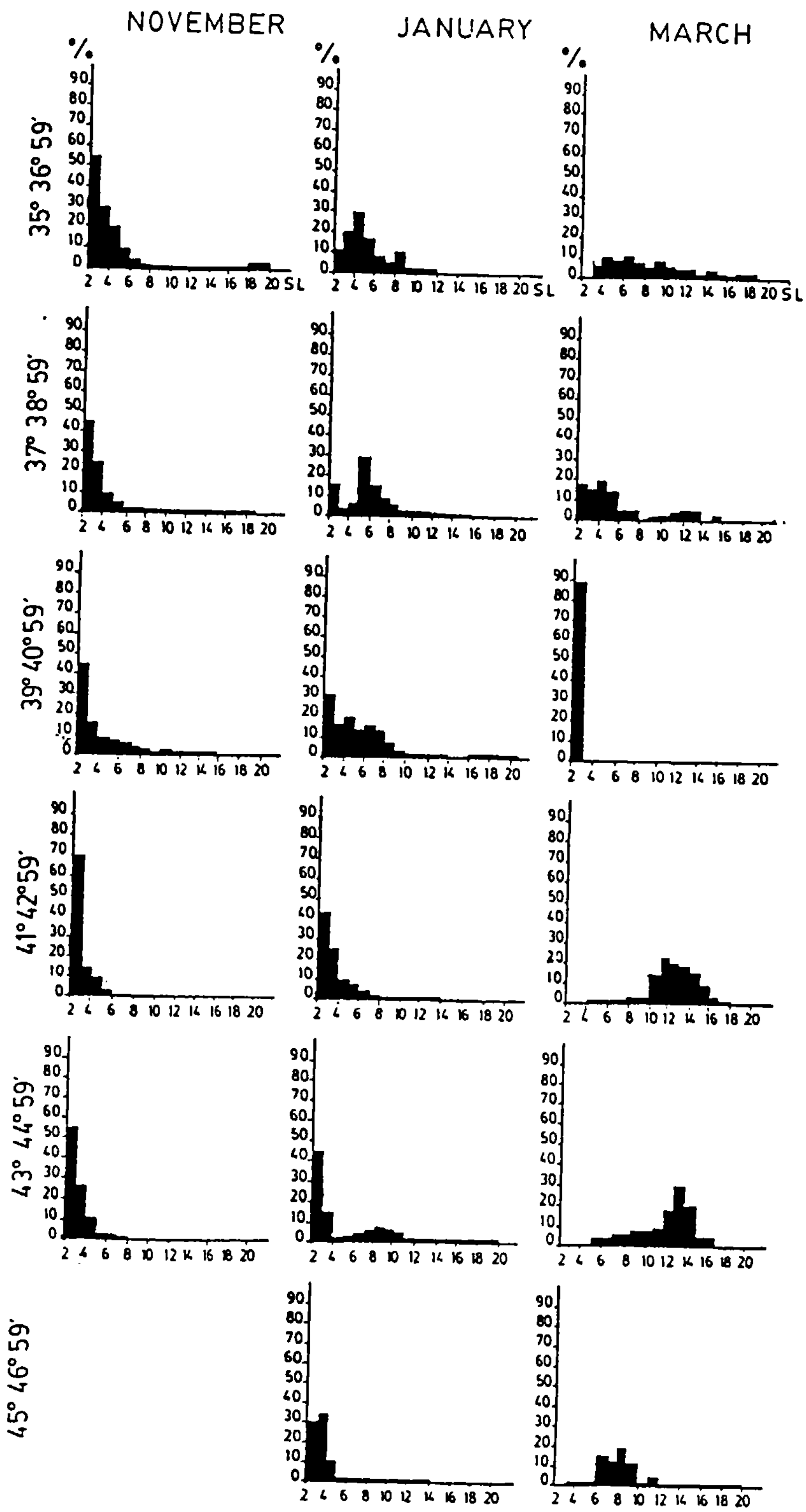


FIGURE 18; Latitudinal variation in larval size frequency distributions during spring and summer. (from Sánchez & Ciechomski, 1989 a)

FIGURE 19

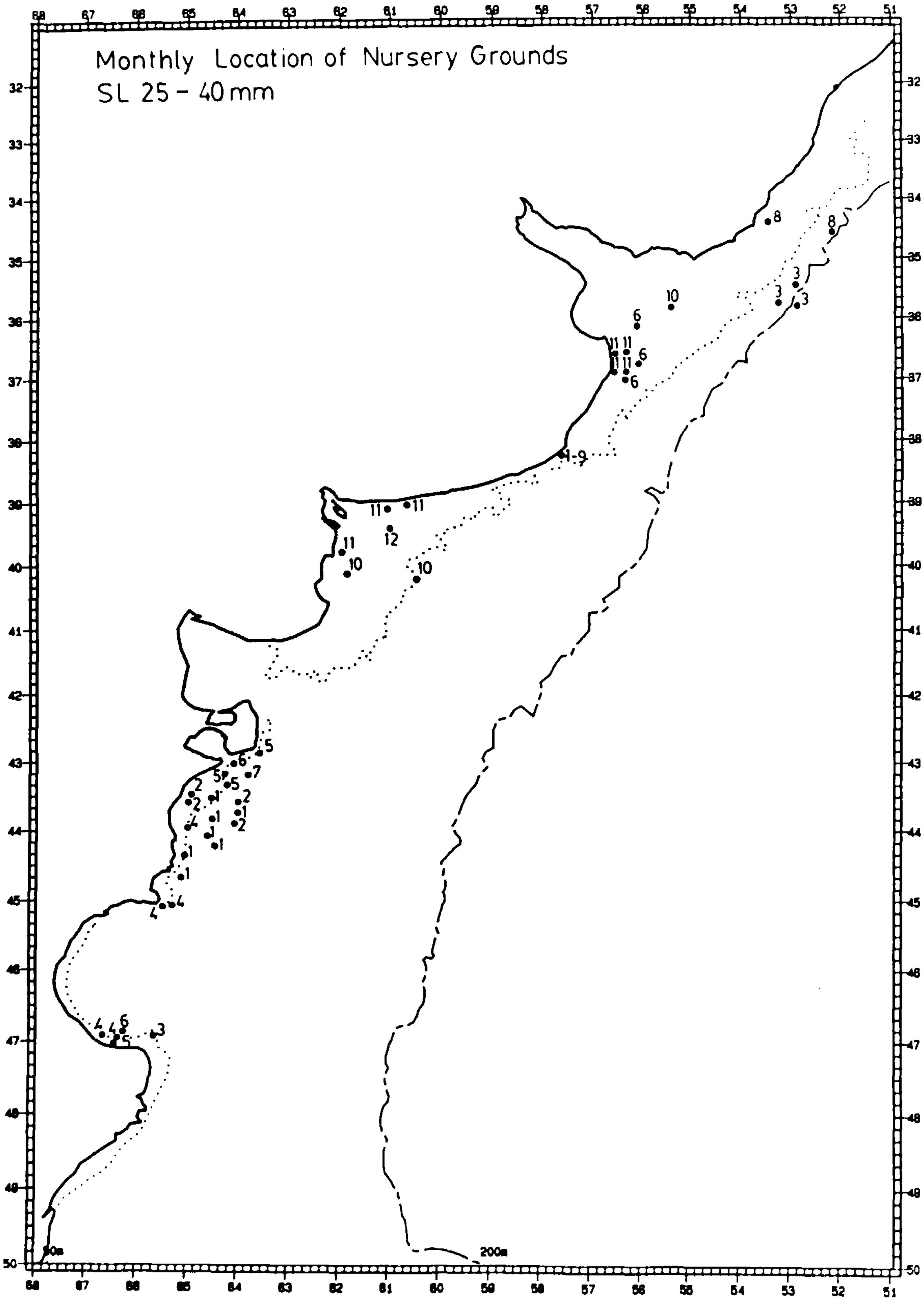


FIGURE 19: Occurrence of post-larvae and early juveniles. Numbers refer to months (1= January, etc.) (from Sánchez & Ciechomski, 1989 b).

FIGURE 20

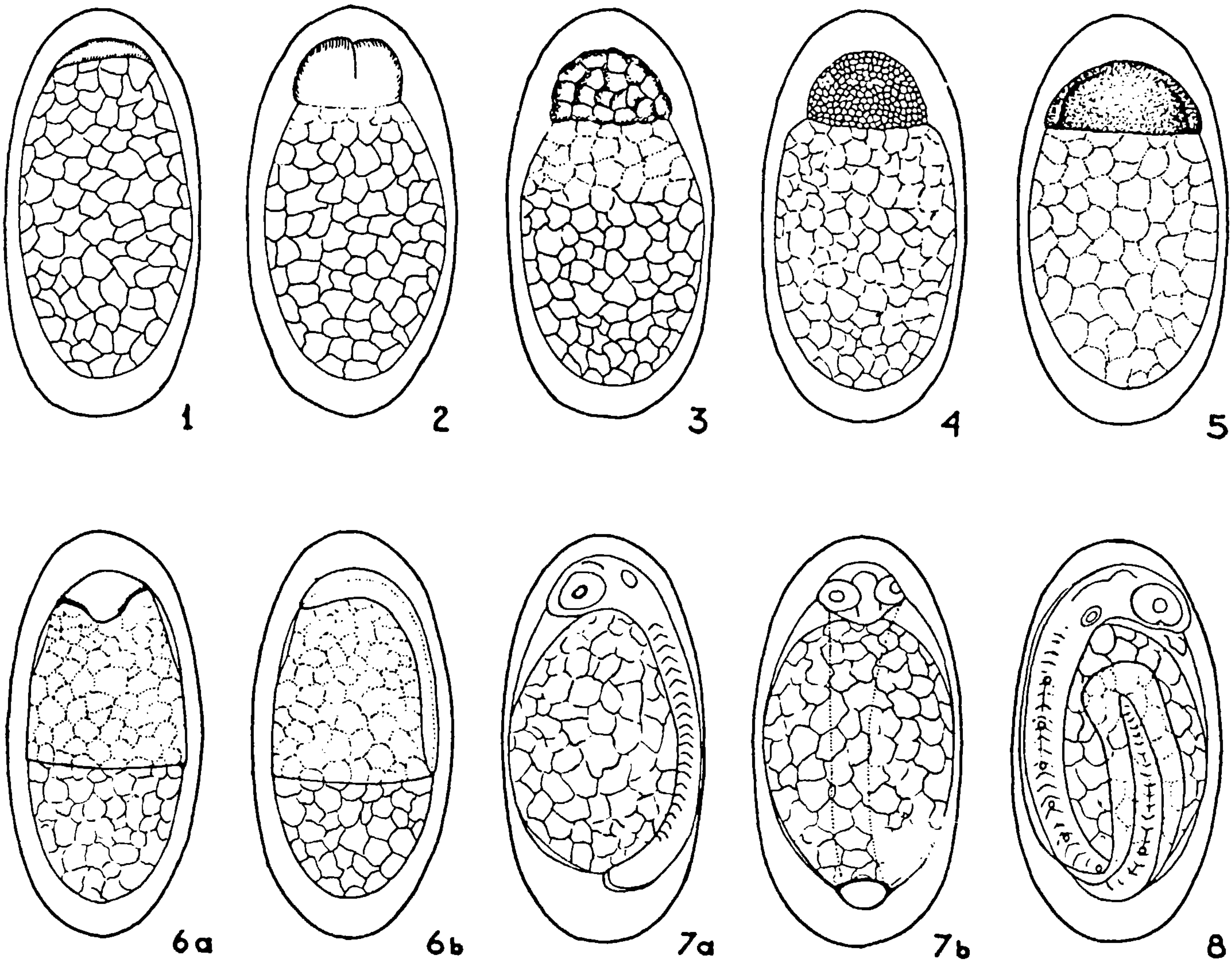


FIGURE 20: Embryonic development of the anchovy. 1. Formation of the first cell. 2. Two-blastomere stage. 3. Formation of the blastula. 4. Blastula. 5. Gastrulation.6. Neurula a)frontal and b) lateral view of same. 7. Commencement of the separation of the caudal region from the vitelline sac. 8. Embryo immediately prio to hatching. (from Ciechomski, 1965).

FIGURE 21

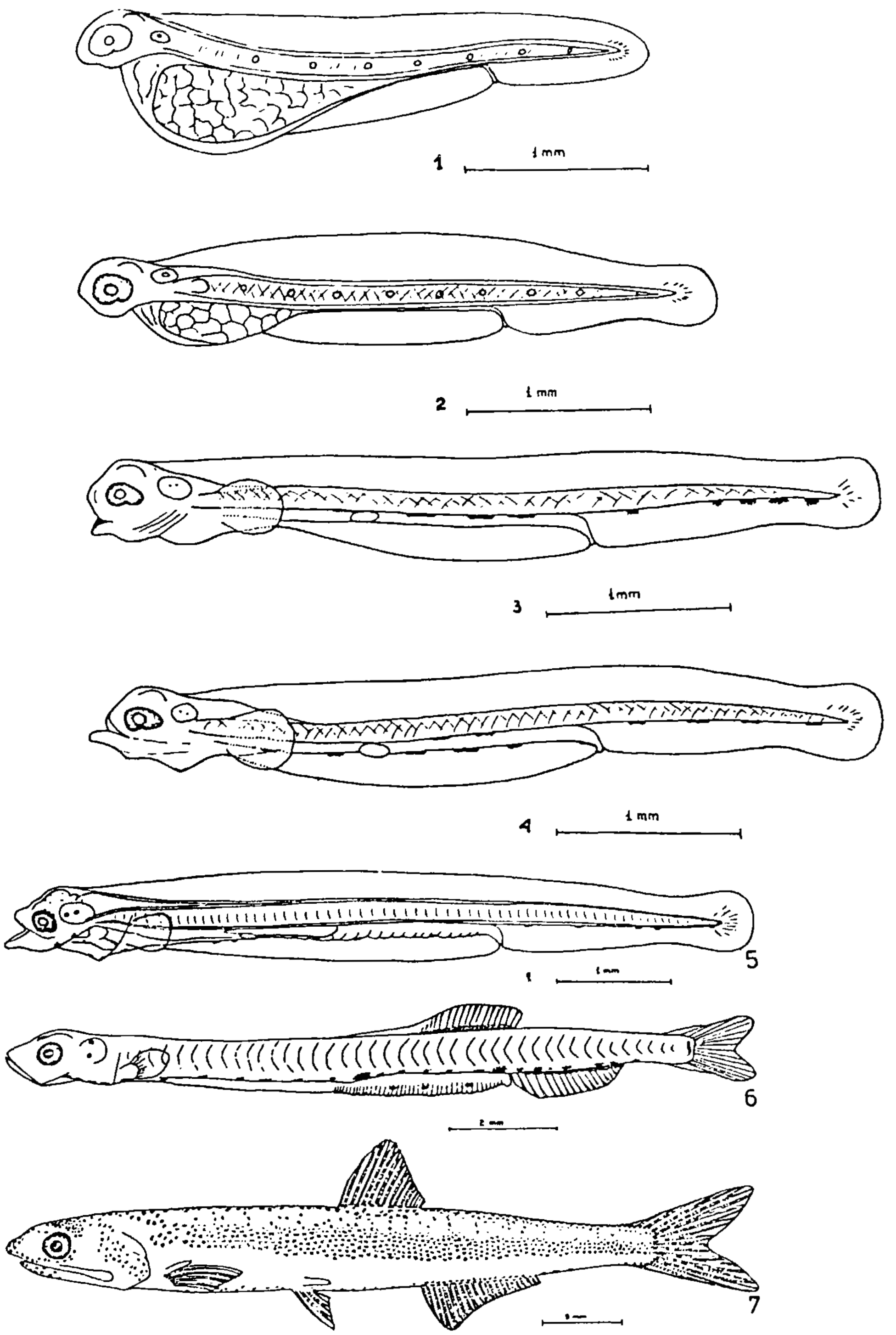
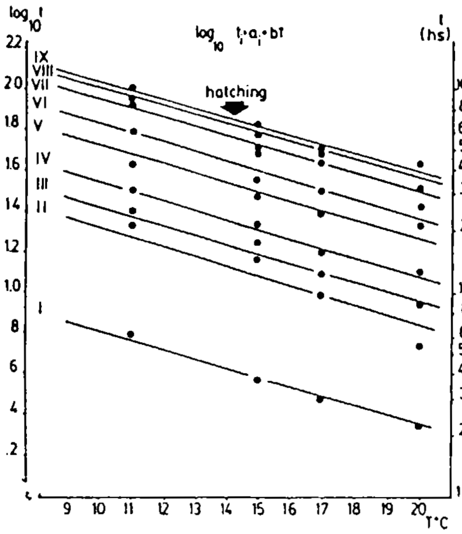


FIGURE 21: Larval development of E. anchoita (from Ciechomski, 1965) 1.Recently hatched larva. 2. 2.5 days larva. 3. 3-4 days larva. 4. 10-days larva. 5. 6mm larva. 6. 13.5 larva.7. juvenile of 44 mm.

FIGURE 22



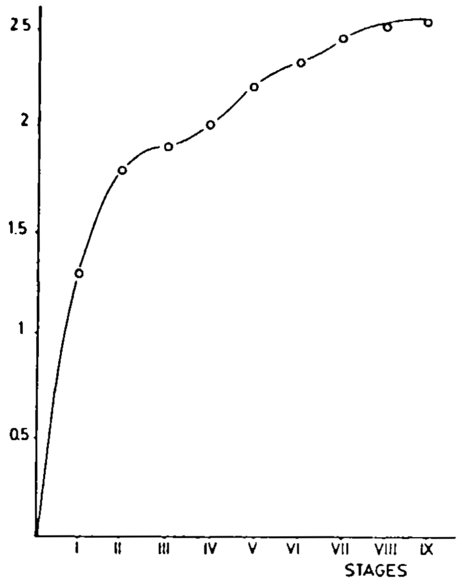


FIGURE 22: Left. Relationship between incubation temperatures and time to reach the end of each stage of embryonic development. Regression statistics of the lines fitted to each set of data are given in Table 6 (from Ciechomski & Sánchez, 1984).

FIGURE 23: Right. Curve for the calculation of the ordinate intercept in the incubation times vs. temperature equations corresponding to intermediate stages. Circles represent the values of a_i ($\log_{10}$ of age at 0°C) for each stage of embryonic development. Equations and coefficients of the curve are

$$a_{S_i} = \alpha_1 S_i + \alpha_2 S_i^2 + \ldots + \alpha_9 S_i^9$$

$\alpha_1 =$ 2.55260039493 $\quad \alpha_4 = -1.2429796839 \quad \alpha_7 =$ 0.00891812166204

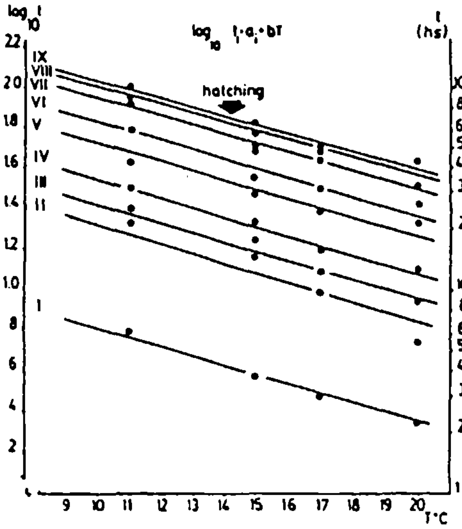
$\alpha_2 = -2.64434473670 \quad \alpha_5 =$ 0.405101271908 $\quad \alpha_8 = -0.00054536210112$

$\alpha_3 =$ 2.27386631890 $\quad \alpha_6 = -0.0786302080776 \quad \alpha_9 =$ 0.0000138833773681

(from Ciechomski & Sánchez, 1984).

FIGURE 22

AND FIGURE 23



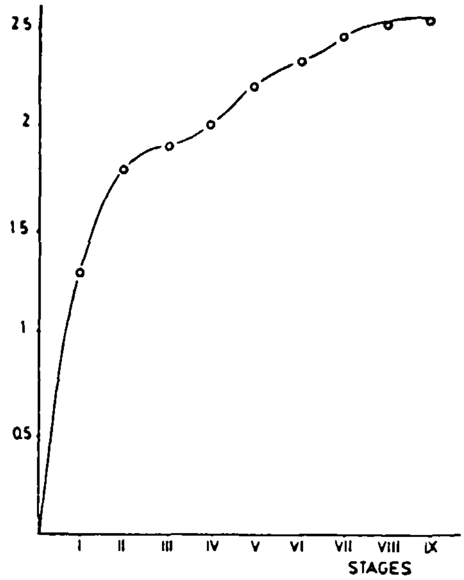


FIGURE 22: Left. Relationship between incubation temperatures and time to reach the end of each stage of embryonic development. Regression statistics of the lines fitted to each set of data are given in Table 6 (from Ciechomski & Sánchez, 1984).

FIGURE 23: Right. Curve for the calculation of the ordinate intercept in the incubation times vs. temperature equations corresponding to intermediate stages. Circles represent the values of a_i ($\log_{10}$ of age at 0°C) for each stage of embryonic development. Equations and coefficients of the curve are

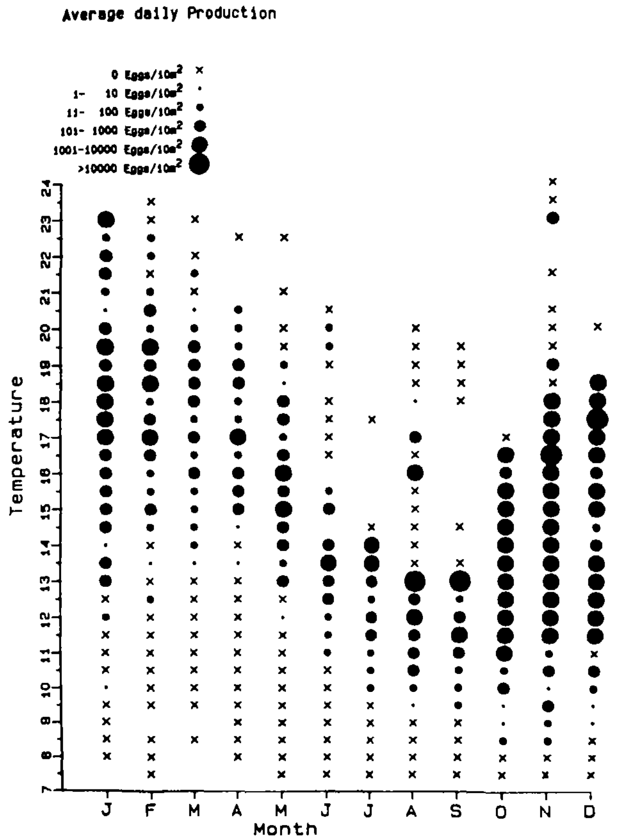
$$a_{S_i} = \alpha_1 S_i + \alpha_2 S_i^2 + \ldots + \alpha_9 S_i^9$$

$\alpha_1 = 2.55260039493$	$\alpha_4 = -1.2429796839$	$\alpha_7 = 0.00891812166204$
$\alpha_2 = -2.64434473670$	$\alpha_5 = 0.405101271908$	$\alpha_8 = -0.00054536210112$
$\alpha_3 = 2.27386631890$	$\alpha_6 = -0.0786302080776$	$\alpha_9 = 0.0000138833773681$

(from Ciechomski & Sánchez, 1984).

NB: Please note that page 34 of Annex V is not missing. It simply does not exist.

FIGURE 24



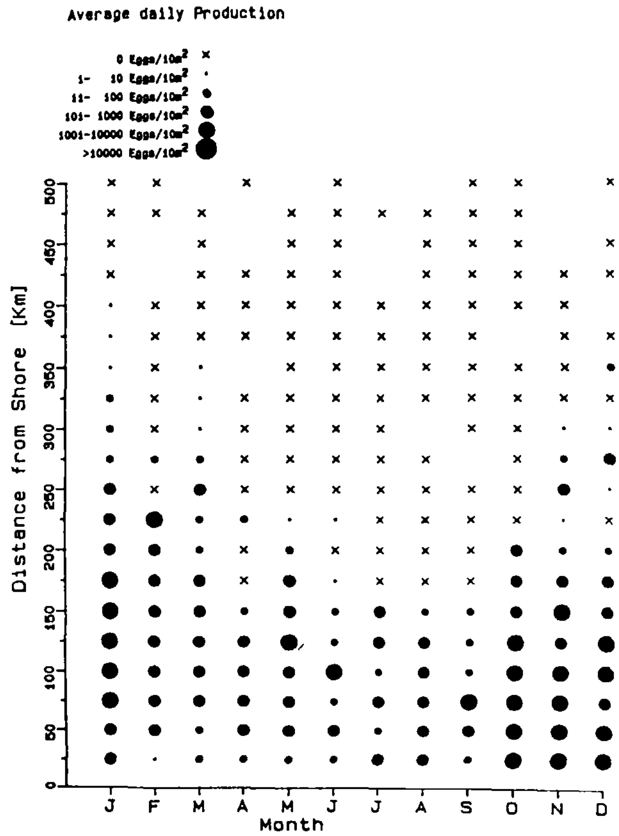


FIGURE 24: Monthly variations of daily production averages in relation to temperature (left) and distance from shore (right) (from Sánchez & Ciechomski, 1989a).

FIGURE 25

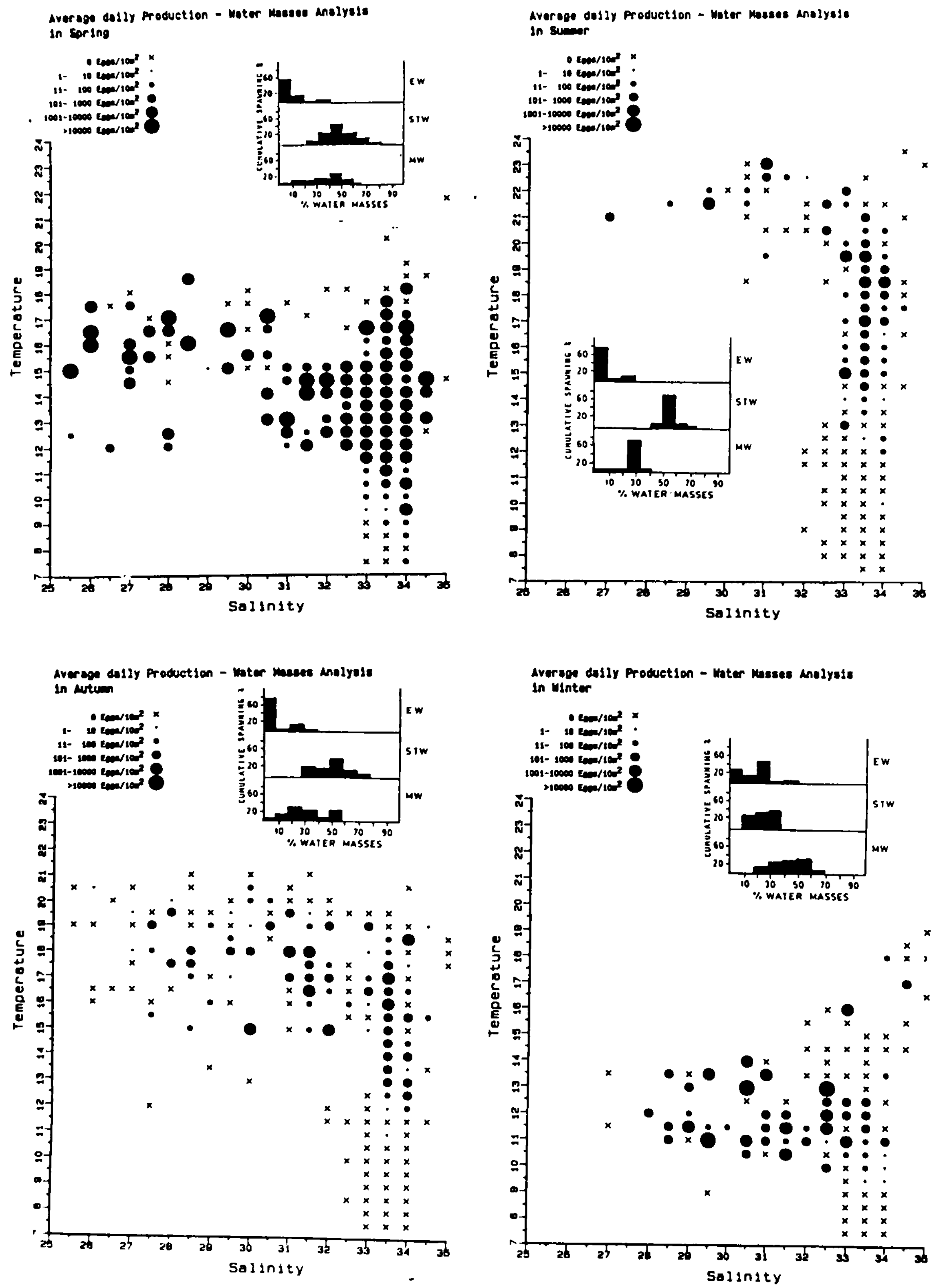


FIGURE 25: T-S chart representation of seasonal reproductive activity of the anchovy between 34°S-39°S. Inserts show the cumulative relative abundance of anchovy eggs collected over the season in different fractions of estuarine, subtropical and Malvinas water.(from Sánchez & Ciechomski, 1989a)

FIGURE 26

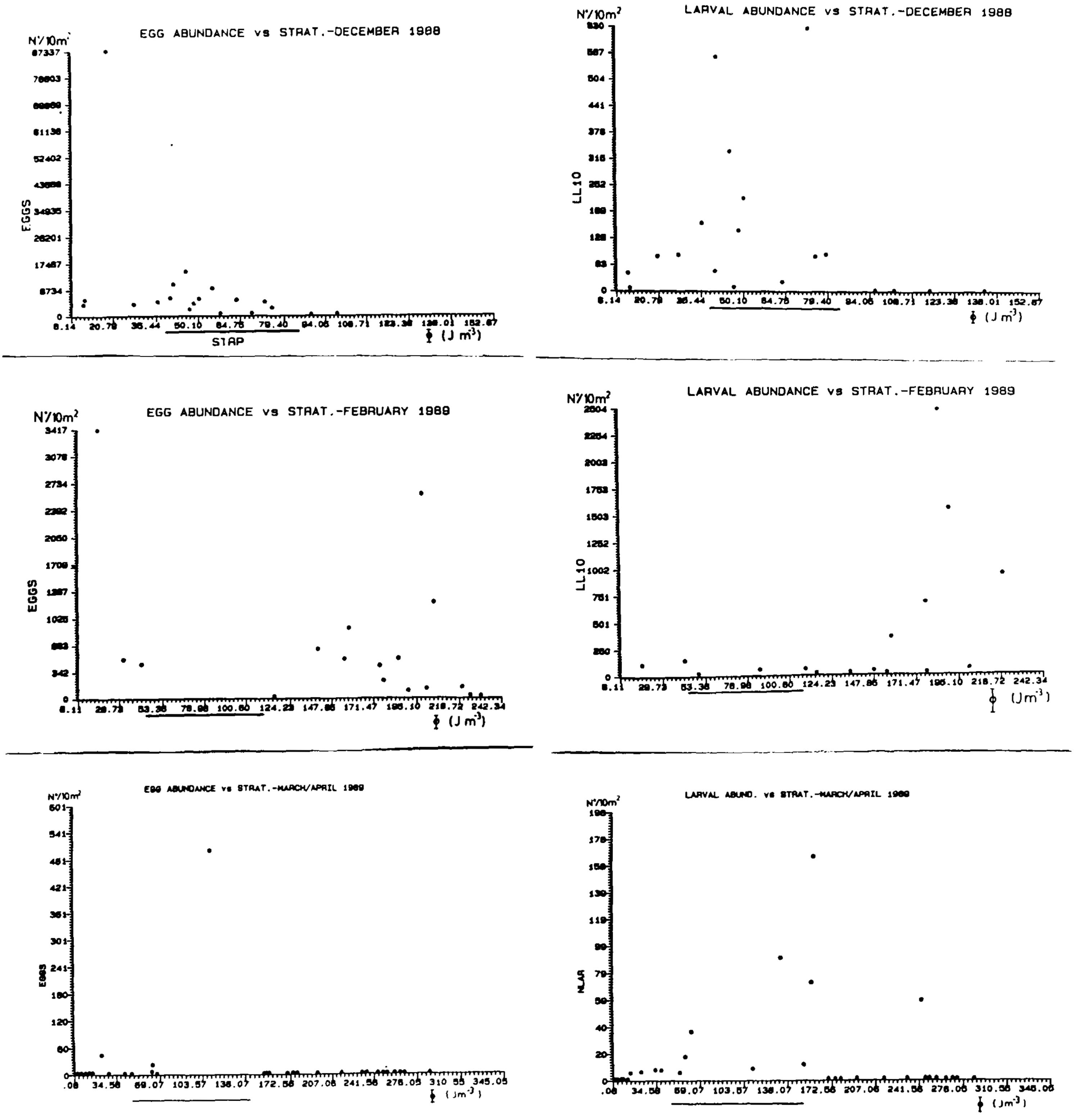


FIGURE 26: Relation between anchovy egg and larval abundances and Simpson's (1981) stratification parameter, through the spawning season in the Patagonian tidal system. The black bar under the x-axis indicates the values of the parameter in the transition zone.

TABLE 1: Discharge of the most important rivers over the Argentine shelf (from Lonari & Ewing, 1971).

RIVER	ANNUAL WATER DISCHARGE 10m	ANNUAL SEDIMENTS DISCHARGE 10tons	MAX. WATER DISCHARGE m/sec	MIN. WATER DISCHARGE m/sec	REFERENCE
Río de La Plata	730	73	23,000	-	Ottman & Urien (1966)
Río Negro	29.5	13.6	1,346	508	Secretaria de Agua y Energía Eléctrica Argentina
Río Santa Cruz	21.3	---	905	342	Idem
Río Colorado	4.2	6.9	252	55	Idem
Río Chubut	1.5	---	89	34	Idem

TABLE 2: List of available information on the reproduction and early life history of E. anchoita in Argentina (from Sánchez, in press).

I. ESTUDIOS EN EL AMBIENTE MARINO

1. Distribución y abundancia de huevos y larvas

   Ciechomski (1968a)
   Ciechomski (1969a)
   Ciechomski (1970)
   Ciechomski (1971)
   Ciechomski et al. (1975)
   Ciechomski et al. (1979)
   Ciechomski & Booman (1983)
   Sánchez & Ciechomski (1984)
   Ciechomski et al. (1986a)
   Ciechomski & Sánchez (1988)

2. Distribución vertical de huevos y larvas

   Ciechomski et al. (1986a)

3. Relación entre áreas de desove y abundancia de zooplancton

   Weiss (1972)
   Ciechomski & Sánchez (1983)

4. Relación entre áreas y épocas de desove y tamaño de huevos

   Ciechomski (1973a)
   Ciechomski et al. (1983)

5. Relación entre la temperatura y el número de vertebras

   Ciechomski & Weiss (1971)

6. Relación entre la temperatura y el desarrollo branquial

   Ciechomski & Weiss (1975)

7. Crecimiento y características de los otolitos en distintas épocas

   Ciechomski (1973b)

8. Mortalidad embrionaria

   Ciechomski & Capezzani (1973)
   Ciechomski & Sánchez (1984)

9. Mortalidad larval

   Sánchez (1986)

10. Crecimiento larval y factor de condición

    Ciechomski et al. (1986b)
    Sánchez et al. (1988)

11. Alimentación larval

    Ciechomski (1967a)
    Ciechomski & Weiss (1974)

II. METODOLOGIA DE MUESTREO DE HUEVOS Y LARVAS

1. Determinación del esfuerzo de muestreo

   Sánchez (1986)

2. Error asociado al muestreo y sub-muestreo

   Ciechomski & Capezzani (1973)
   Sánchez & Ciechomski (1984)
   Ciechomski & Sánchez (1986)

3. Selectividad de las redes de plancton

   Sánchez & Ciechomski (1984)
   Ciechomski & Sánchez (1986)
   Sánchez (1986)

III. METODOLOGIA PARA EL MANEJO DE DATOS DE ICTIOPLANCTON

   Ciechomski et al. (1983)
   Sánchez (1986)
   Ciechomski & Sánchez (1989)

IV. ESTUDIOS SOBRE LA ACTIVIDAD REPRODUCTIVA

1. Modalidad reproductiva

   Christiansen & Brodsky (1975)
   Brodsky & Cousseau (1979)
   Christiansen & Cousseau (1985)

2. Fecundidad

   Fuster de Plata (1964)
   Ciechomski & Weiss (1973)

V. EVALUACIONES DE ADULTOS DESOVANTES

   Ciechomski & Capezzani (1973)
   Ciechomski et al. (1983)
   Sánchez & Ciechomski (1984)
   Ciechomski et al. (1986a)
   Ciechomski & Sánchez (1988)
   Ciechomski & Sánchez (1989)

VI. ESTUDIOS EXPERIMENTALES

1. Desarrollo embrionario y larval

   Ciechomski (1965a)

2. Desarrollo embrionario en un medio no acuoso

   Ciechomski (1965b)

3. Relación entre tamaño del huevo y desarrollo larval

   Ciechomski (1966)

4. Influencia de factores ambientales sobre el desarrollo

   Ciechomski (1967b)
   Ciechomski & Sánchez (1984)

5. Crecimiento larval en condiciones experimentales

   Sánchez (1986)

TABLE 2

TABLE 3

A

Año	Area Norte 35° - 41° S Biomasa en toneladas métricas	Area Sur 41° - 46° S Biomasa en toneladas métricas
1966	1.987.259	
1967	4.440.192	1.111.013
1968	3.347.403	1.328.725
1969	5.155.017	1.113.106
1970	2.984.938	1.589.287
1973		1.020.100
1978	3.259.033	1.892.045
1980	2.166.845	
1981	2.317.542	2.151.767
1982	2.771.217	1.285.930
1983	3.885.640	1.188.776
1984		1.203.181
1985		1.480.093

B

Fecha	Area	Biomasa en t.	Error mínimo calculado	Límites de confianza	Autores
22 oct.-5 nov. 1969	35°00'-41°00'S	9.928.152	± 59%	4.070.542	Ciechomski y Capezzani, 1973
Invierno/primavera Agost.-nov. 1977	25°00'-40°00'S	1.500.000			Hubolt, 1982
Otoño Abril-junio 1978	25°00'-40°00'S	130.000			Hubolt, 1982
10 nov.-5 dic. 1978	36°00'-42°30'S	3.327.660	- 26%	2.462.468	Ciechomski *et al.*, 1979
			+ 35%	4.192.851	
6 dic.1978-2 ene.1979	42°30'-45°30'S	2.564.697	- 29%	1.820.935	Ciechomski *et al.*, 1979
			+ 10%	3.308.460	
3 oct.-1 nov. 1981	35°30'-40°49'S	2.161.704	- 13%	1.880.685	Sánchez y Ciechomski, 1984
			+ 15%	2.485.936	
13 oct.-2 dic. 1982	34°00'-41°00'S	2.514.970	+ 40%	4.325.749	Ciechomski *et al.*, 1986

TABLE 3: Spawning biomass estimates of E. anchoita (from Ciechomski & Sánchez, 1988)

A.- Estimates obtained from application of the areal expansion method.

B.- Estimates obtained from egg counting method.

TABLES 4, 5, 6

TABLE 4: Developmental stages used for *E. anchoita* (from Ciechomski & Sánchez, 1984)

I.	From fertilization to 16-cell stage
II.	Sixteen-cell stage to first appearance of segmentation cavity
III.	First appearance of segmentation cavity to first sign of primitive streak
IV.	First sign of primitive streak to germ ring halfway round the egg
V.	Germ ring halfway round the egg until blastopore closure
VI.	Blastopore closure until tail bud starts to separate from the yolk
VII.	Tail bud separation until caudal one-eighth of the body is free from the yolk
VIII.	Caudal one-eighth of the body free from the caudal one-quarter of the body is free from the yolk
IX.	From rotation of the tail portion of the embryo out of the embryonic plane to hatching

TABLE 5: Adjusted data on the embryonic development of *E. anchoita* at four constant experimental temperatures (from Ciechomski & Sánchez, 1984).

Stage	Temperature			
	11°C	15°C	17°C	20°C
I	6.25 h	3.75 h	3.00 h	2.25 h
II	21.25	14.50	9.50	5.50
III	24.75	17.50	12.00	8.50
IV	31.50	20.50	15.75	12.50
V	42.25	29.50	24.50	21.50
VI	60.50	35.50	31.50	26.50
VII	84.00	47.50	43.50	32.50
VIII	90.25	59.50	47.50	39.50
IX	99.00	65.50	49.00	42.50

TABLE 6: Regression equations for the prediction of stage duration at different temperatures, t=hours of develpment, T=temperature in °C (from Ciechomski & Sánchez, 1984)

Stage I	$\log_{10} t = 1.274 - 0.046\,T$	$(r = -0.923)$
Stage II	$\log_{10} t = 1.778 - 0.046\,T$	$(r = -0.993)$
Stage III	$\log_{10} t = 1.889 - 0.046\,T$	$(r = -0.871)$
Stage IV	$\log_{10} t = 1.993 - 0.046\,T$	$(r = -1.000)$
Stage V	$\log_{10} t = 2.182 - 0.046\,T$	$(r = -0.811)$
Stage VI	$\log_{10} t = 2.286 - 0.046\,T$	$(r = -0.973)$
Stage VII	$\log_{10} t = 2.406 - 0.046\,T$	$(r = -0.999)$
Stage VIII	$\log_{10} t = 2.473 - 0.046\,T$	$(r = -0.982)$
Stage IX	$\log_{10} t = 2.503 - 0.046\,T$	$(r = -0.994)$

TABLE 7

TABLE 7: Abundance estimation of age groups and mortality coefficients during the embryonic development of *E. anchoita* (from Sánchez & Ciechomski 1989b)

AREA	YEAR	MONTH	AGE	ABUNDANCE (eggs/10m²)	C (hours)	T (°C)	D (hours)	Z	%L	ECM
N	1967	NOV.	0	6830	13.79	13.42	76.86	0.99	62.6	95.80
			1	2526	39.99					
			2	951	61.69					
N	1968	NOV.	0	6049	10.10	13.94	72.74	1.01	63.6	95.31
			1	2721	36.28					
			2	680	62.53					
N	1969	OCT.	0	8048	12.26	12.56	84.18	0.81	55.6	94.16
			1	3706	38.49					
			2	1379	61.44					
			3	943	78.10					
N	1970	NOV.	0	4263	8.53	13.87	73.28	1.05	65.0	95.95
			1	1086	35.37					
			2	438	60.72					
N	1982	OCT.	0	3900	9.12	11.76	90.17	0.69	49.34	92.44
			1	2437	39.12					
			2	1987	57.12					
			3	389	89.04					
N	1986	NOV.	0	5190	15.12	13.76	74.33	0.82	55.96	90.38
			1	2169	39.84					
			2	1337	66.96					
			3	360	88.08					
S	1983	JAN.	0	2204	10.08	17.37	52.41	0.31	26.31	48.73
			1	1618	34.08					
			2	1193	58.32					
S	1984	NOV-DEC	0	2808	16.80	13.23	78.22	0.27	23.64	59.67
			1	1592	44.16					
			2	2209	50.40					
			3	1240	85.92					
S	1986	JAN.	0	2863	15.60	17.05	54.06	0.44	35.60	59.01
			1	2109	40.56					
			2	1053	70.56					
S	1986	DEC.	0	1091	11.04	13.84	73.74	0.53	41.34	70.16
			1	575	34.80					
			2	765	57.12					
			3	172	84.24					
S	1988	DEC.	0	1955	15.84	12.88	80.91	0.54	41.73	74.68
			1	1395	40.08					
			2	1067	63.84					
			3	348	89.76					

References:

A = Northern area (34°- 40°59'S)
B = Southern area (41°- 46°59'S)
Age 0 = Embryos up to 24 hours from fertilization
Age 1 = Embryos from 24 up to 48 hs. from fertilization
Age 2 = Embryos from 48 up to 72 hs. from fertilization
Age 3 = Embryos from 72 up to 90 hs. from fertilization
C = Weighted estimate of the class age
T = Weighted average of sea-water temperature during the cruise
D = Theoretical hatching age according to T
Z = Instantaneous mortality rate per day
%L = Percent loss per day
ECM = Cumulative mortality during the embryonic period from Z and D.

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ANNEX VI

SYNOPSIS ON THE REPRODUCTIVE BIOLOGY AND EARLY LIFE HISTORY OF *Engraulis anchoita*, AND RELATED ENVIRONMENTAL CONDITIONS IN URUGUAYAN WATERS

1. ANALYSIS OF ENVIRONMENTAL CONDITIONS

1.1 THE PHYSICAL ENVIRONMENT (by Juan C. Elgue)

The study area comprises a highly dynamic hydrographic system, characterized by the confluence of water masses of different origins: the Malvinas and Brazil currents, coastal and shelf waters and the continental discharge of the La Plata river (Thomsen, 1962) giving rise to frontal systems of high space and time variability and biological productivity (Carreto et al., 1986; Elgue et al., in press; Baysse et al., 1986 & in press).

The influence of continental discharge is evident along the coastal region, where salinity values less than 20 °/oo have been reported (Elgue & Parietti, 1985, 1987; Elgue et al., 1986c).

1.2 PHYTOPLANKTON (by Juan C. Elgue)

1.2.1 Species composition

Baysse et al. (1986; in press) have described the phytoplankton species composition in the area.

Among the dinoflagellates, small size naked forms are predominant. The prevailing species are *Ceratium candelabrum* and *C. tripos*, with maximum densities of about 0.0001 cells/liter.

The presence of silicoflagellates has been observed in areas outside the influence of the La Plata river, with maximum countings of 1,000 cells/liter. Predominant species are *Dyctiocha fibula* and *Distephanus speculum*.

Centric diatoms are by far, the most important group in the area. Several spatial associations have been described, the most important of which is related to the La Plata river mouth, with maximum densities of 79,000 cells/l, and a predominance of the genus *Thalassiosira*. Another important association is located to the west of that area, with a predominance of *Skeletonema costatum* and *Chaetoceros spp*. Important associations have also been observed over the Uruguayan coast to the north, and over the Argentine coast to the south.

The pattern of distribution of pennate diatoms is similar to that of the centric species, but densities are lower. In the Rio de la Plata area, maximum densities reach 10,000 cells/l, with predominance of *Cylindrotheca closterium*, *Thalassionema nitzschioides* and *Nitzschia spp*.

1.2.2 Distribution of phytoplankton in the maritime front of the La Plata river

The distribution of phytoplankton in the area has been described on the basis of values of the diversity index (H') (Margalef, 1974), ranging from 1.0 to above 3 bits.cell/liter. Values are higher in the coastal zone, decreasing towards the open sea, in relation to the above mentioned specific variation: centric and pennate diatoms prevailing near the coast, and dinoflagellates being predominant in more off shore waters. However it should be noted that all groups coexist, with the sole exception of silicoflagellates over the Rio de la Plata mouth.

A study of spatial succession (Elgue et al., in press) shows a predominance of the stage I (opportunistic species), particularly in areas near the coast and under the influence of the La Plata river, a transition zone (stage II species), and an off-shore area where dinoflagellates and small forms prevail (stage III). Other studies based on the application of different techniques of numerical analysis (Elgue et al., 1986 a & b; 1987), show the existence of several ecologically significant associations, according to the predominance of the different forms.

1.3 ZOOPLANKTON (by Eduardo Goberna and Gabriela Mantero)

1.3.1 Qualitative and quantitative composition of zoo-plankton

The densities and percent incidence of different zooplankton groups on the shelf border, of the northern part of the Argentine-Uruguayan Common Fishing Zone (AUCFZ), during winter 1981, was reported by Goberna (1983). The distribution and specific composition of adult and larval stages of euphausiids showed important differences in relation to the water masses of the shelf and slope.

On the basis of zooplankton surveys carried out in Summer 1981 and Winter 1983, 69 copepoda species could be identified. Their distribution and seasonal fluctuations in relation to the prevailing water masses were analyzed by Goberna (1986). Seasonal changes in the distribution of euphausiids and chaetognats, were also reported.

1.3.2 Distribution and abundance of zooplankton in relation to hydrographic structures

Differences in the zooplankton communities composition and abundance between shelf waters and those corresponding to the slope (bottom depth >100 m) with surface temperatures ranging from 10-16°C and salinities from 33-36°/oo, and seasonal fluctuations, were reported by Goberna (1986). The structure of copepoda communities in relation to temperature was studied by Goberna (1988). The 10°C isotherm is considered as a dynamic limit between the northern community, which is influenced by the Subtropical current and shows a high specific diversity, and the less diversified southern community. In winter the limit is located at 37°S latitude, moving southward in Summer.

1.3.3 Levels of secondary production

No information.

2. AVAILABLE INFORMATION ON SPAWNING GROUPS (by Oscar Pin)

The AUCFZ comprises only a fraction of the wide latitudinal range of the species distribution. Results reported here, although sometimes partial in nature, must be considered as complementary and in relation to those presented in Argentinian and Brazilian publications.

2.1 KNOWN NUMBER OF SPAWNING GROUPS IN THE AREA

Refer to Annexes V and VII.

2.2 BIOMASS ESTIMATES OF SPAWNING GROUPS

The abundance of the anchovy adult stock in the area, was estimated by acoustic surveys by Ehrhardt et al. (1977, 1978) and Nion et al. (1980), showing marked seasonal fluctuations which should be mainly attributed to seasonal migrations. A clear stratification in spatially segregated length groups was also observed (Figure 1).

Peak abundance corresponds to winter when the stock distributes near the Uruguayan coast and the La Plata river sea front. Winter stock biomass was estimated at 374,000 t (1979), 460,000 t (1977) and 1,207,000 t (1976). In Spring the stock spreads over the continental shelf. Spring biomass estimates range from 369,000 t to 1,049,000 t. Lower abundances were observed in Summer 1976 and 1978 (267,000-460,000t, respectively) whereas in Autumn 1978, the assessed biomass was 1,700,000 t.

On the basis of egg surveys, Matsuura (1981) estimated the anchovy spawning biomass in the region at 886,000 t.

2.3 SPAWNING SEASONS AND GROUNDS

Refer to Annexes V and VII.

2.4 KNOWN NURSERY GROUNDS

The distribution of anchovy juveniles off the Uruguayan coast has been studied since 1975. In Summer and Autumn, juveniles were found from the coast up to 50 miles offshore. Smaller individuals (50-60 mm TL) were caught in coastal waters, whereas larger specimens (70-75 mm TL) were further offshore (Nion et al., 1986). Pin (1989) reports anchovy juveniles of 70 mm TL, in an area between the 20 n mi from shore contour and the 50 m isobath (Fig.2).

2.5 REPRODUCTION

Refer to Annexes V and VII.

3. **EARLY LIFE HISTORY** (by Gabriela Mantero)

3.1 DEVELOPMENTAL STAGES

Refer to Annexes V and VII.

3.2 EGG STAGE DURATION

Refer to Annex V.

3.3 LARVAL GROWTH

Development stages and morphological changes during growth of anchovy larvae caught in the AUCFZ were studied by Mantero (1986). Morphometric analysis showed changes in body proportions. In the course of larval development there is an increase of the head length/SL and body depth/SL ratios, and a decrease of predorsal and preanal distances. The forward migration of dorsal and anal fins and the backward migration of ventral fins, relative to myomere counts is illustrated in Figure 3. Meristic characters of anchovy larvae were studied and the sequence of ossification was determined. The ossification of the spine begins in the 20th vertebra of 13 mm SL specimens. Vertebral ossification is completed at 17 mm SL, last vertebrae to be ossified are those adjacent to the urostyle. Caudal fin rays are completely ossified at 22 mm SL, dorsal and anal fin rays at 19 mm SL and ventral fin rays at 21 mm SL (Figure 4). The development of the caudal skeleton and maxillary bones was also described.

Changes in the patterns of pigmentation were determined and an increasing number of melanophores along the ventral part of the body was observed.

3.4 EMBRYONIC MORTALITY

Refer to Annex V.

3.5 LARVAL MORTALITY

Refer to Annex V.

3.6 DISTRIBUTIONAL PATTERNS OF EGGS AND LARVAE

Available data from the area refer almost exclusively to the winter season (July-August-September). During this period the highest densities of anchovy eggs are located in the northern part of the AUCFZ and represent over 90% of all fish eggs collected. Mantero (1983) confirms the existence of a Winter spawning of the species between latitudes 34° and 36°S, which is part of the spawning registered in southern Brazilian waters during the same period. The percentages of anchovy larvae in relation to the total number of fish larvae, were more variable (11.7% in 1979; 13.7% in 1980; 70.9% in 1981; and 77.8% in 1982) depending mainly on the changing environmental conditions and the date the surveys were carried out.

The only available information on the spring spawning, corresponds to a cruise carried out in December 1979 in the northern part of the AUCFZ (Figure 5). Anchovy eggs represented 77.7% of total fish eggs, higher densities were observed in the north of the surveyed area (1232 eggs/m2). Anchovy larvae, on the other hand, represented 47.2% of total fish larvae, higher densities were found in the south (1291 larvae/m^2).

Length classes of larvae caught at day and night were examined by Matsuura (1981). The night-day ratio increased rapidly for larvae bigger than 7.5 mm SL, and the corresponding proportion between night and day caught larvae was 12.4:1. Length frequency distribution of larvae caught at night was clearly bimodal, proving that they belonged to more than one spawning pulse (Figure 6).

In order to study the relation between larval sizes and the spawning area, percent length frequencies were plotted by latitude (Matsuura, 1981). Smaller larvae were captured in the northern part of the study area at the beginning of the cruise, whereas larger larvae were caught some 20 days later, in the southern part of the surveyed region (Figure 7). As a possible explanation to the observed pattern, it could be assumed, that larger larvae, caught in the south, correspond to the spawning that was taking place in the north when the survey began. A similar larval distributional pattern was observed by Mantero (1983) in Winter 1979, 1980 and 1982.

3.6.1 Patterns in relation to environmental factors

The distribution of anchovy eggs and larvae in Winter and Spring has been studied in relation to such environmental factors as sea surface water temperature and salinity and zooplankton abundance.

In Winter, surface temperature ranges from 5° to 16°C, but anchovy eggs are only found between 8° and 16°C (Figure 8). The salinity range is wider (22°/oo-35°/oo), so it seems that the spawning area is principally determined by temperature (Matsuura, 1981). Similar values were obtained for anchovy larvae (Figure 9). Maximum densities during Winter time, were reported by Mantero (1983) at temperatures between 10° and 14°C and salinities between 23°/oo and 35°/oo. Matsuura (1981) reported higher zooplankton concentrations in the south of the study area, in colder waters (6°-11°C), whereas higher egg abundance were observed in the north. He concluded that high productivity waters coming from the south are to cold to allow anchovy to spawn.

In Spring, surface temperatures range between 14° and 23°C. In December 1979 (Figure 5 a-d) the higher densities of eggs were found in the north, at temperatures between 17° and 19°C, whereas larvae were more abundant to the south, at temperatures about 18°C. The distribution of zooplankton was quite different to that of anchovy eggs. Peak zooplankton densities were observed in the south at surface temperatures of 15-16°C.

3.6.2 Sample frequency distribution

Refer to Annex V.

3.7 LARVAL FEEDING BEHAVIOUR

Refer to Annex V.

3.8 PREDATION

No Information.

FIGURE 1

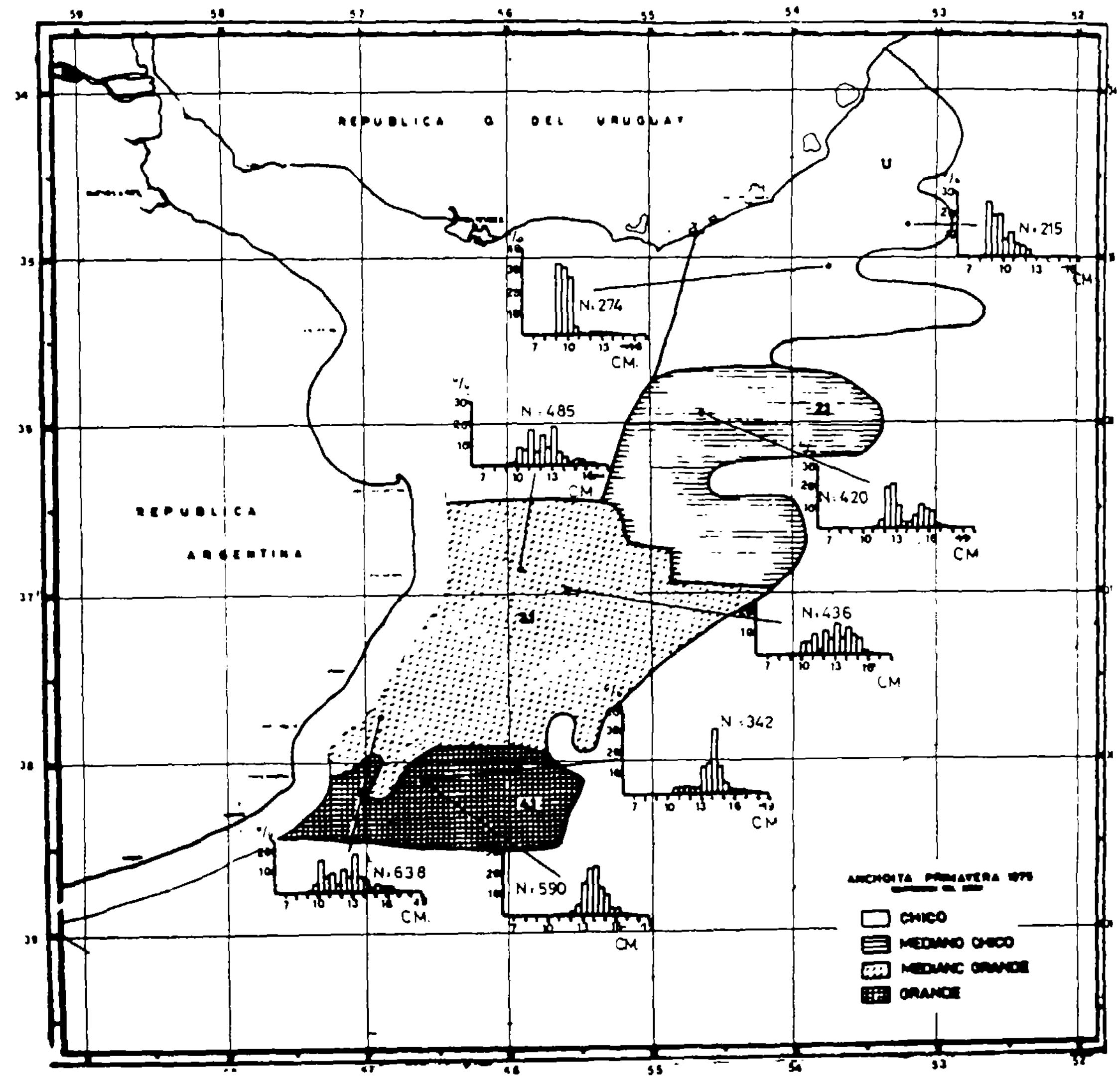


Figure 1: Length frequency distribution of anchovy stock in spring 1975.

FIGURE 2

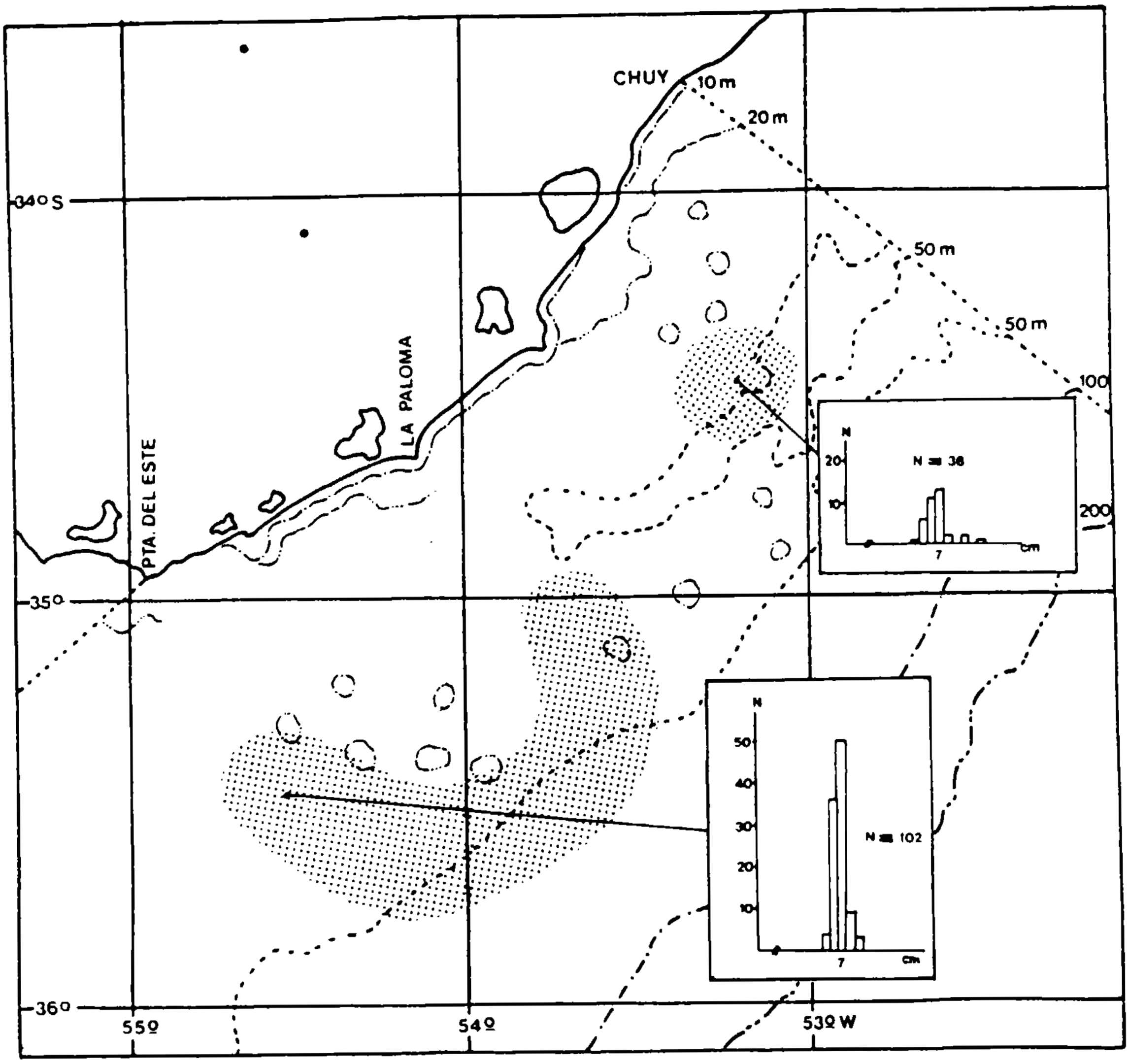


Figure 2: Distribution of anchovy juveniles (from Pin, 1989).

FIGURE 3

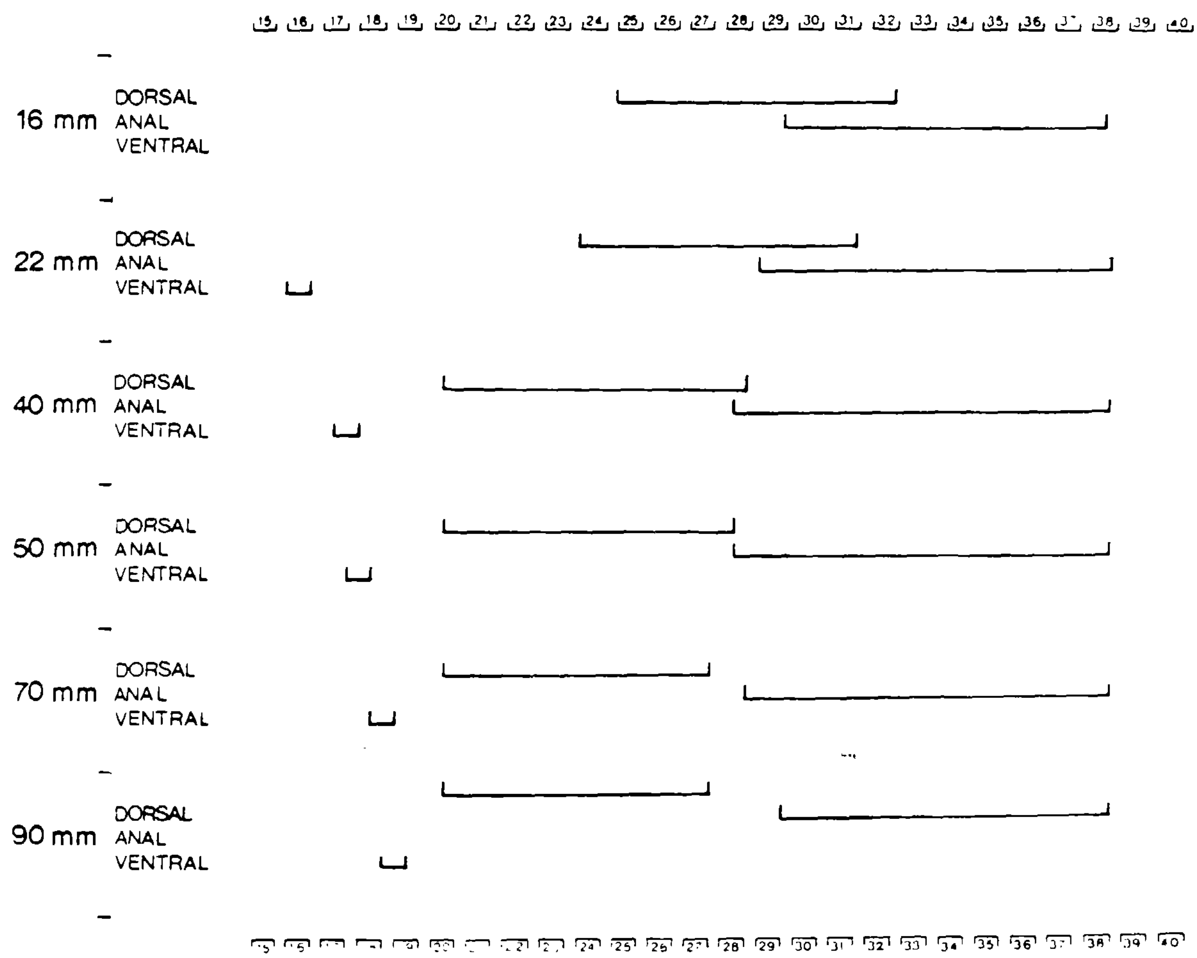


Figure 3: Progress of fin migration in the course of anchovy development (from Mantero, 1986).

FIGURE 4

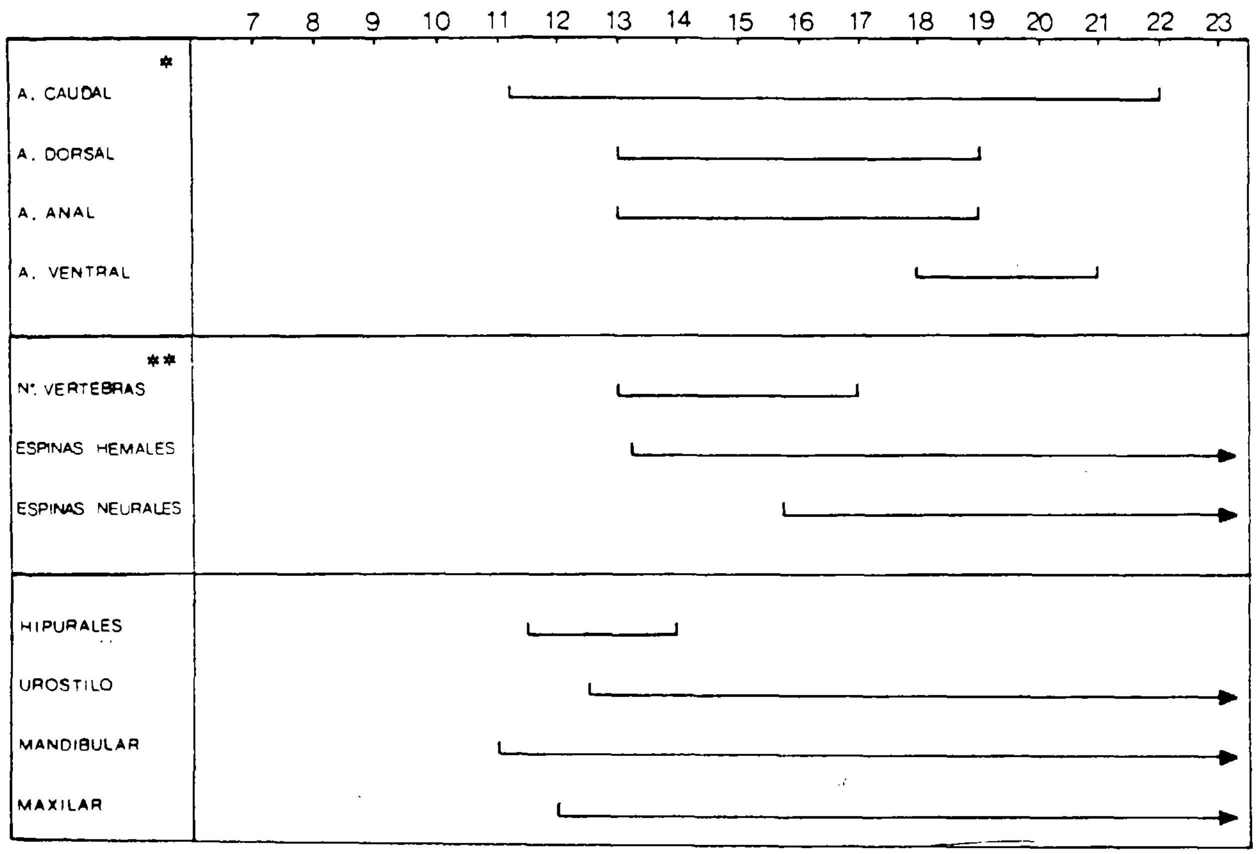


Figure 4: Ossification process in larval anchovy (from Mantero, 1986);

FIGURE 5

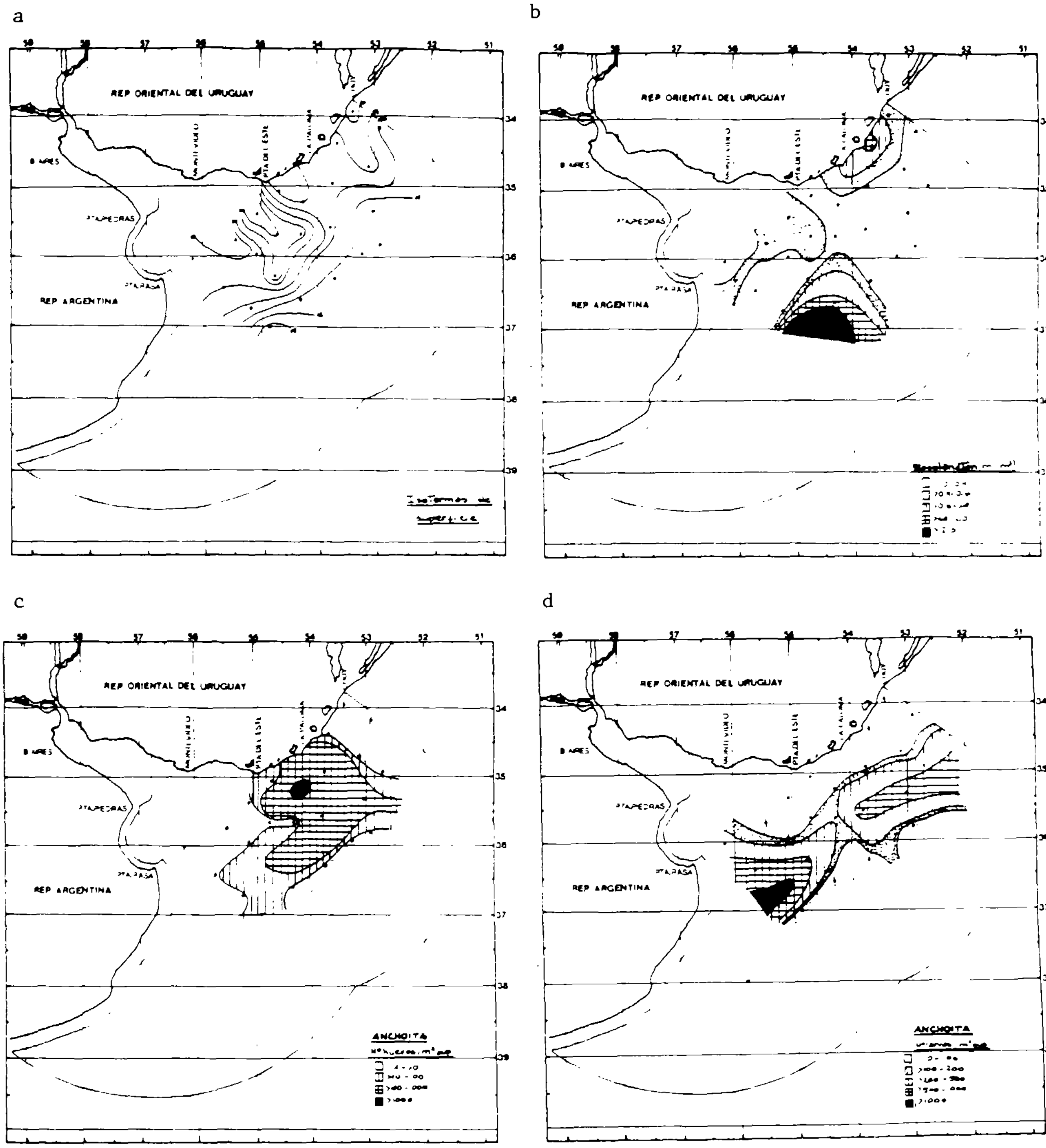


Figure 5: Distribution of anchovy eggs and larvae, in spring (6-21 December, 1979), in relation to environmental parameters. a) sea-surface temperature b)zooplankton volumes c) anchovy eggs d) anchovy larvae;

FIGURE 6

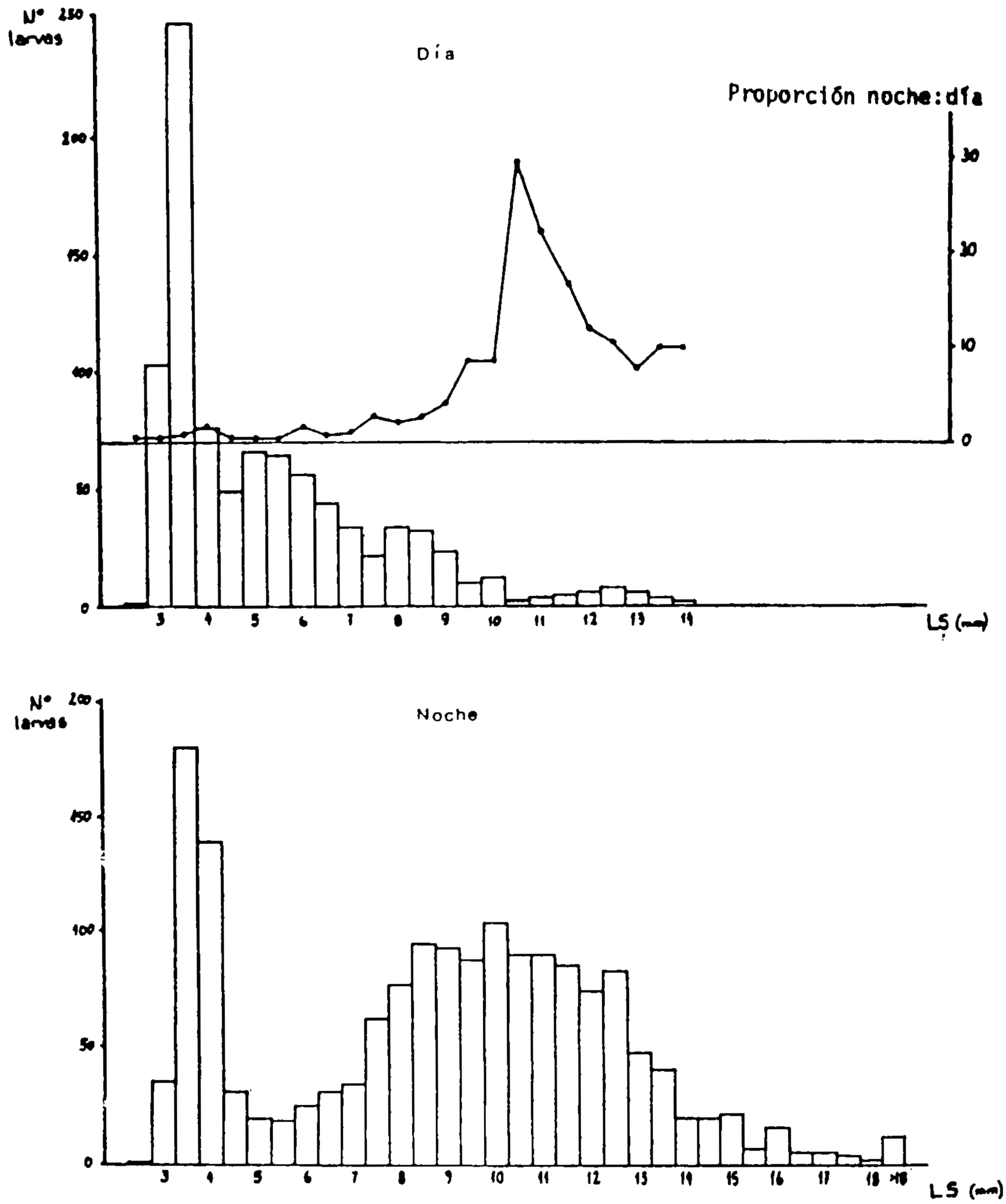


Figure 6: Length frequency distributions of anchovy larvae from day (upper figure) and night (lower figure) collections (from Matsuura, 1981).

FIGURE 7

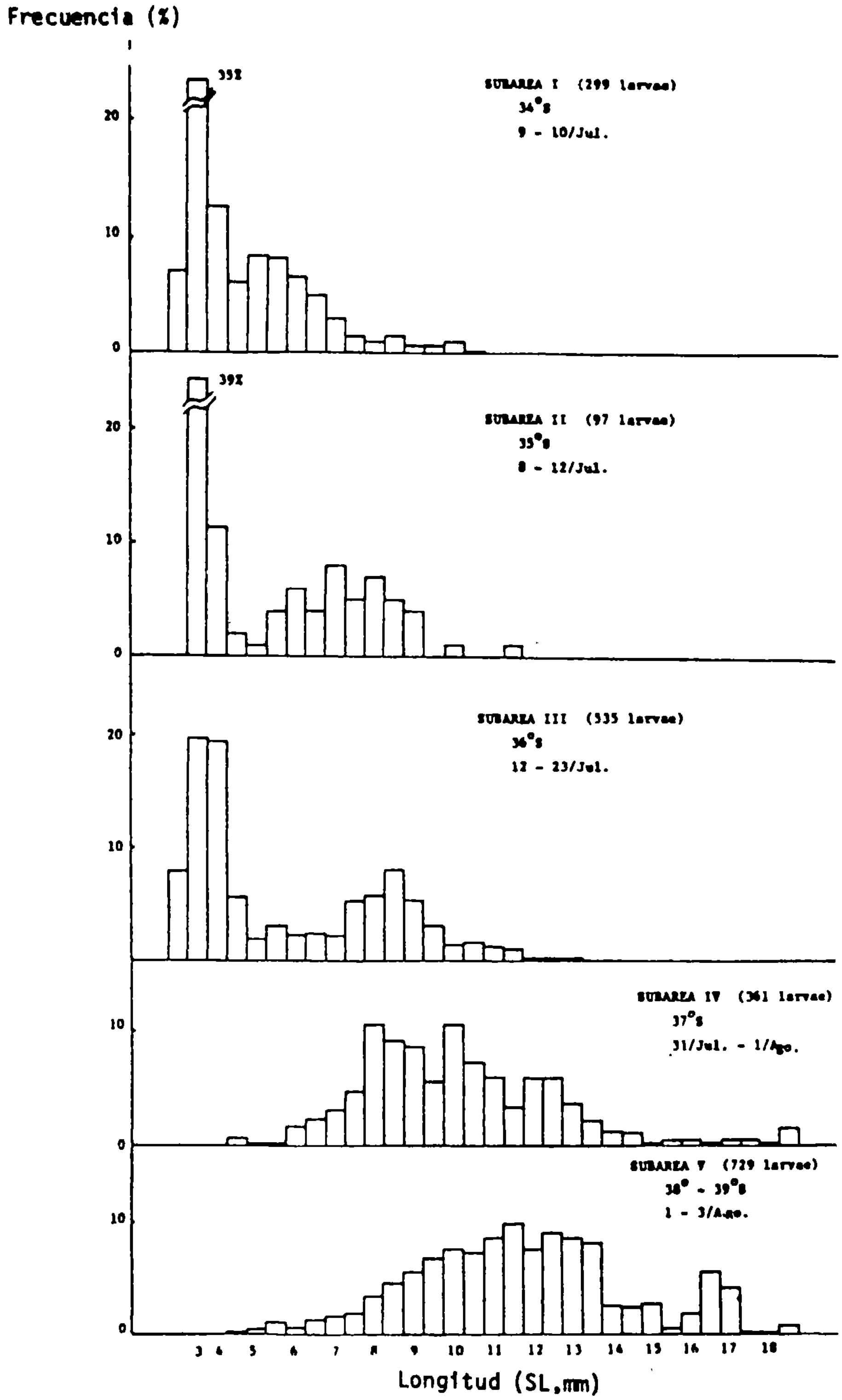


Figure 7: Length frequency distributions of anchovy larvae, arranged by latitude during a winter cruise (from Matsuura, 1981);

FIGURE 8

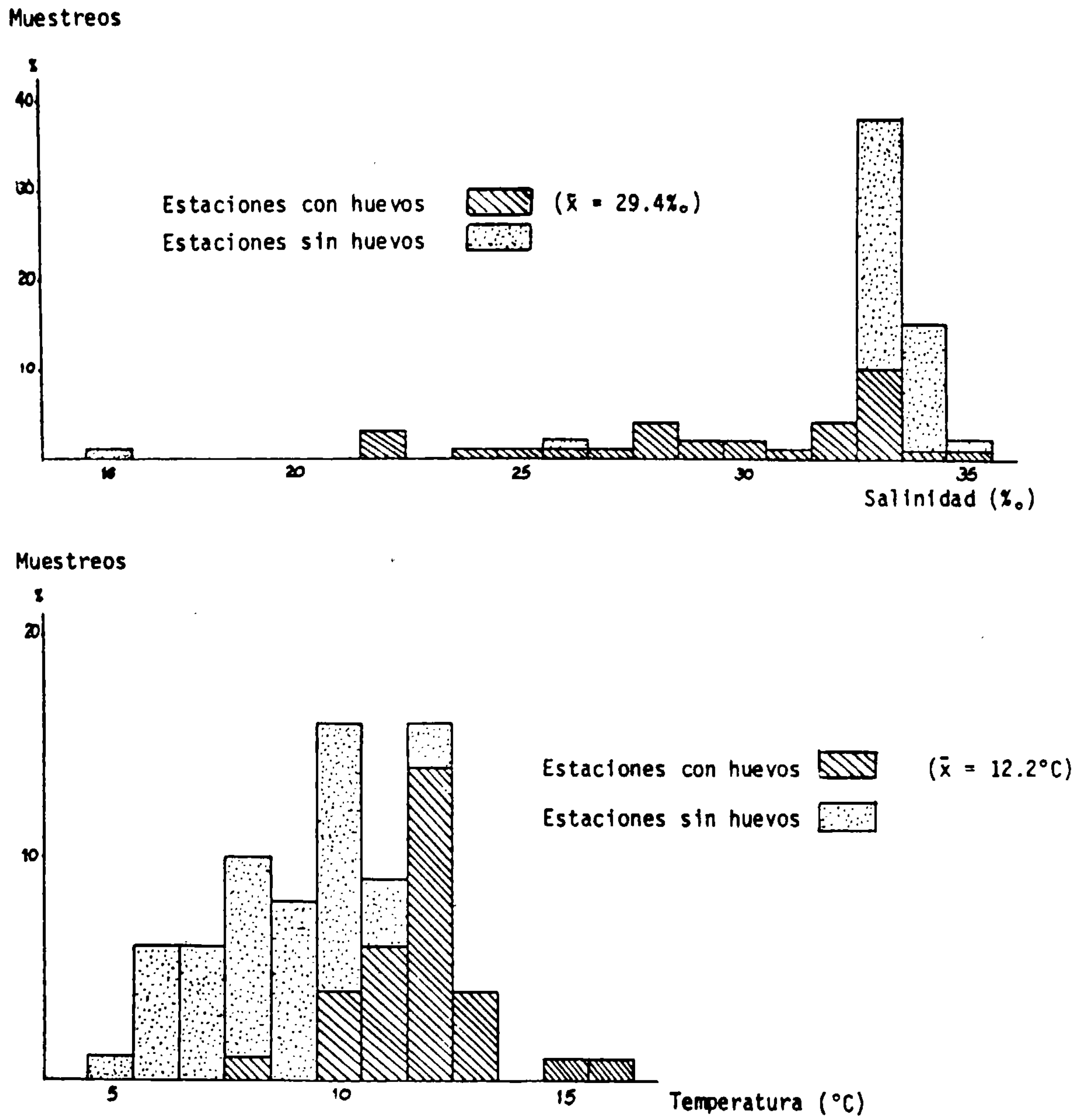
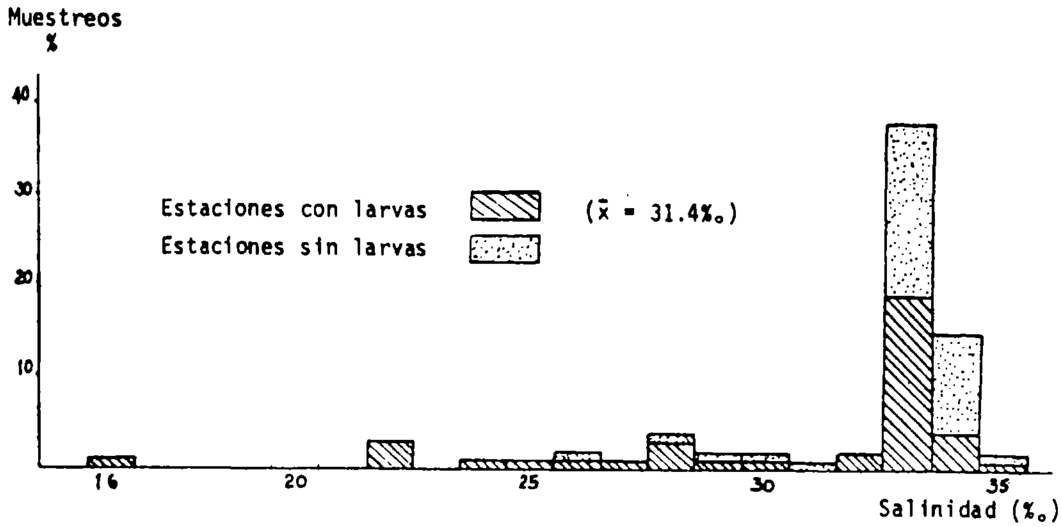


Figure 8: Anchovy eggs percent distribution in winter in relation to Temperature and Salinity ranges.

FIGURE 9



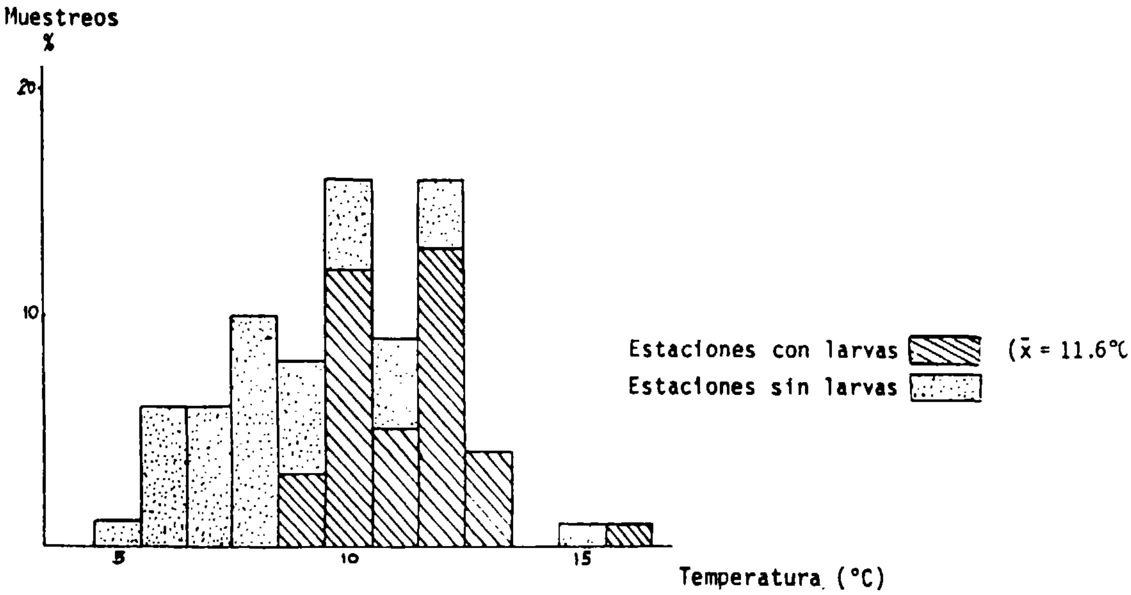


Figure 9: Anchovy larvae percent distribution in winter in relation to Temperature and Salinity ranges.

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ANNEX VII

SYNOPSIS ON THE REPRODUCTIVE BIOLOGY AND EARLY LIFE HISTORY OF *Engraulis anchoita*, AND RELATED ENVIRONMENTAL CONDITIONS IN BRAZILIAN WATERS

by

JORGE P. CASTELLO

INTRODUCTION

The South-western Atlantic anchovy (*Engraulis anchoita*) occurs on the continental shelf between latitudes 22°S off the Brazilian coast and 47°S off the Patagonian coast in Argentina. This synopsis refers to what is known about the early life history of this species in Brazilian waters between 22°S and 34°S.

1. ANALYSIS OF ENVIRONMENTAL CONDITIONS

1.1 THE PHYSICAL ENVIRONMENT

The physical habitat of the anchovy in Brazilian waters embraces the continental shelf of the South-eastern and Southern regions. The South-eastern region has been described by Matsuura (this report). Therefore the following description refers only to the Southern region.

1.1.1 The oceanographic setting

The southern region is under the influence of the Sub-Tropical Convergence (25°S-45°S and 45°W-65°W) of a locally limited up-welling region off Santa Marta Cape (28° 45'S) and of the freshwater discharge of the La Plata River (Uruguay/Argentina) and the estuary of the Patos Lagoon (Emilson, 1961; Miranda, 1969; Miranda et al., 1973; Castello & Moller, 1977; Hubold, 1980 a,b; Moller et al., 1989).

In the typical Winter situation, cold waters from the Malvinas (Falkland) Current formed by Sub-Antarctic Water (SAW), proceed in a North-eastern direction, from Argentina and Uruguay, approximately following the 150-200m isobath. Between 32°S and 33° 40'S, surface water on the continental shelf has a temperature range between 12°-15°C. About 65 nm off the coast, a pronounced surface thermal front is found. Temperature rises to 17°-18°C over a distance of ten nm. The thermal gradient, particularly its position and extension, depends on the presence of rather unstable meanders and vortices. This thermal transition zone is related to the Sub-Tropical Convergence.

The Tropical Water (TW) of the Brazil Current flow in a South-westerly direction, along the continental slope.

South Atlantic Central Water (SACW), also called Sub-Tropical Water (STW) by some authors, results from the mixture of Tropical and Sub-Antarctic Water flowing northward under the TW layer.

Fresh water discharged by the La Plata River mixes with the SAW over the shelf area forming the Coastal Water (CW) which is characterized by its low salinity and steep salinity gradients. Depending on the amount of rainfall, the Patos Lagoon may also contribute to the dilution of the CW. During Summer, the Malvinas Current recedes to the South and the thermal front is no longer present in the area under consideration. Most of the continental shelf is then covered by TW. Surface temperatures range from 22° to 27°C.

Off Santa Marta Cape, mainly during Spring and Summer time, when North-eastern winds blow along the coast a locally limited up-welling can be observed. This is characterized by low surface temperatures and the occurrence of SAW.

1.1.2 Topography

The Southern region is characterized by a continental shelf of variable width. Off Santa Marta Cape (28° 40'S) it extends over 51 nm and then enlarges to 95 nm between Torres and Capao da Canoa (30° 10'S), but off Mostardas (31° 27'S) it extends only over 42 nm. The widest shelf area (100nm) is found off Rio Grande (33° 00' S). Between the latitudes 32°S and 34°S, several hard and soft bottom banks are present in coastal waters with less than 40 m depth.

1.1.3 Fresh Water Discharge

A significant and seasonal fresh-water discharge in the Southern area comes from the estuary of the Patos Lagoon. Also, the influence of the La Plata River water on the CW may be observed, sometimes extending North up to 32°S.

1.2 PHYTOPLANKTON

1.2.1 Nutrients

Nutrient input stems mainly from the SAW penetration during Winter and Spring time. Typical Winter/Spring mean values are 0.14/0.11, 3.01/2.70 and 0.67/0.46 μmol/l for nitrite, nitrate and phosphate, respectively, while maxima found in the core of the Malvinas Current were 0.5, 12.0 and 0.9 μmol/l, respectively. Continental input may be also expected from the Patos Lagoon (Niencheski et al., 1989).

1.2.2 Species composition

Information on species composition of the area is rather scarce. Some publications deal with species identification , e.g., Hentschel (1932), on material from the Meteor expedition, Seguin (1965), Aguiar & Corte Real (1973), Corte Real & Callegaro (1973), Rosa & Buselato (1981), Kremer & Rosa (1983) and Dohns (1983).

The Southern region is considered to be one of the most productive marine habitats in Brazil. The following data were collected during the Spring of 1987 and Winter of 1988.

Phytoplankton communities in coastal and oceanic areas differ from each other. *Coscinodiscus* and *Thalassiosira* species dominate in the coastal waters. *Chaetoceros spp.* and *Nitzchia spp.*, are very frequent in the southern oceanic area, due to the influence of the SAW. The coastal area which is exposed to the fresh-water discharge of the Patos Lagoon has a high abundance of *Skeletonema costatum, Nitzchia sp.* and *Scrippsiella trochoidea* (Kitzman et al., 1988).

Other algae, such as the diatom *Rhizosolenia* and the dinoflagellate *Ceratium*, are widely distributed, but do not show high densities.

Protozooplankton, such as *Strombidium* and *Protoperidinium*, occur with moderate densities in association with coastal concentrations of phytoplankton and under the influence of the runoff of the Patos Lagoon.

1.2.3 Size structure

During Spring time, microphytoplankton (>20μ) is the dominant fraction. Occasionally nannoplankton (1-20μ) is also important with concentrations up to 40% to 80% of the total phytoplankton, Picoplankton (<1μ) contributes with about 40%-60% of the phytoplankton on the continental slope area, in association with the protozooplankton, such as small ciliates and the heterotrophic dinoflagellate *Gyrodinium* (Odebrecht et al., MS).

1.2.4 Distribution and abundance of phytoplankton in relation to hydrographic structures

Hubold (1980a) found coastal concentrations of chlorophyll-a between 2.4 and 3.4 μg/l during Winter and Spring time. In Autumn, coastal concentrations off Santa Marta Cape, off Tramandai and between Rio Grande and Albardao fluctuated between 2.1 and 3.0 μg/l (Hubold, 1980b). Values, mostly below 0.5 μg/l, were found by Dohns (1983) in the Summer.

Recent available information (Ciotti et al., 1988) for Spring 1987 showed regions of high chlorophyll-a concentrations. Cholorophyll concentration is found about 60 nm from the coast at 34°S. It depends on the SAW which forms a "tongue" advancing to the north and keeps a more or less constant distance from the coast. In the euphotic layer (30m) the 11°C isotherm seems to be associated with the high concentrations of chlorophyll-a. The second center of chlorophyll concentration is a coastal area under the influence of the fresh water discharge from land (<30°/oo). Here, chlorophyll-a concentrations are high from the surface to 40m depth. The highest concentrations are found, off Patos Lagoon, with maxima values below the surface. Microphytoplankton is the dominant size fraction (80%).

1.2.5 Levels of primary production

Data on primary production for the area under investigation are scarce. Teixeira, et al. (1973) published some data on C fixation based upon rates of C14 uptake for April and October of 1972. Mean value for Autumn was 45.72 $mgC/m^2/h$ and 120.33 $mgC/m^2/h$ for Spring with some isolated maxima in coastal waters. Odebrecht, et al. (MS) presented a mean fixation rate of 84.4 $mgC/m^2/h$ for Winter of 1988. Thus, an annual production rate around 300 mgC/m2/year, based upon means of 3 seasons of the year, might be suggested.

1.3 ZOOPLANKTON

1.3.1 Qualitative and quantitative composition of zooplankton

Navas-Pereira (1973) examined zooplankton samples collected seasonally on the shelf area off the state of Rio Grande do. Sul. During Winter time, Cladocera, Copepoda, Appendicularia and Chaetognatha showed the highest relative abundances. Other groups, such as Hydromedusae, Siphonophora, Polychaeta, Mollusca, Ostracoda, Amphipoda, Euphausiacea and several kinds of crustacean larvae, showed high frequencies of occurrence. The first 4 groups were also abundant and dominant during Spring time. Duarte (MS) analysed samples collected in the Spring of 1987 and found that Copepoda, Hydromedusae, Chaetognatha, Euphausiacea and Cladocera were the most abundant groups. Within the Copepoda (average density was 250 ind/m^3 with a range of 4 to 2005 ind/m^3), the calanoids *Calanus simillimus* and *Ctenocalanus sp.* were the most abundant species. They are typical of antarctic and sub-antarctic waters. The occurrence of *Paracalanus quasimodo* is characteristic for warm waters from the North. The hydromedusa *Liriope tetraphylla*, was found with highest densities occurring in samples where copepoda densities were low. This is probably due to predation by *L. tetraphylla* on copepods.

In Summer, Cladocera, Copepoda, Thaliacea, Appendicularia and Chaetognatha showed the highest relative abundances. Thaliacea are typical for tropical waters. In Autumn, Mollusca, mainly Lamellibranchia larvae, occurred together with the species encountered. (Navas-Pereira, 1973).

2. AVAILABLE INFORMATION ON SPAWNING GROUPS

2.1 KNOWN NUMBER OF SPAWNING GROUPS IN THE AREA

Data from several eggs and larvae cruises show that there are at least 4 spawning groups. The first one is in the North of the Southeastern region, off Cape Frio, Rio de Janeiro, and Juatinga Point in water depths between 15 and 50 m and 50 to 100 m. The second one is in the vicinity of Santa Catarina Island and off Santa Marta Cape, in water depths between 100 and 200 m (Nakatani, 1982). Southward of Santa Marta Cape, eggs have been observed over most of the southern continental shelf during Autumn, Winter and Spring time (Weiss and Souza, 1977).

2.2 BIOMASS ESTIMATES OF SPAWNING GROUPS

Biomass has been estimated by using egg abundances in the plankton, the swept area method (mid-water trawl) and eco-integration. Table 1 summarized these data.

Table 1: Estimations of anchovy biomass.

AREA	SEASON	METHOD	BIOMASS (tons)	AUTHORS
33°20'S-34°20'S	WIN/76	swept area	282,706	Melo, 1978
" "	WIN/77	" "	510,545	" "
31°40'S-33°20'S	WIN/76	" "	104,166	" "
" "	WIN/77	" "	41,221	" "
22°00'S-25°25'S	SUM/79	eco-integr.	177,517	#Matsuura et al., 1985.
23°00'S-29°00'S	SPR/75	egg-abund.	4,465,000	*Nakatani, 1982
28°30'S-34°20'S	WIN/80	eco-integr.	1,658,015	Castello & Habiaga, 1982.
28°30'S-34°20'S	SPR/80	" "	379,850	" "
32°00'S-34°20'S	SPR/81	" "	66,252	" "
28°30'S-34°20'S	SPR/82	" "	52,785	" "
31°45'S-34°20'S	SPR/87	" "	858,850	Castello et al., (MS)
31°45'S-34°20'S	WIN/88	" "	230,729	" "
22°15'S-29°00'S	SPR/88	" "	399,146	Castello et al.,(in press)

\# *Engraulis anchoita* plus 3 other engraulid species.
* The estimates of total fecundity ignored that anchovies are batch spawners.

2.3 SPAWNING SEASONS AND GROUNDS

Nakatani (1982) described a spawning of anchovy off Cape Frio in late Spring and early Summer, which is clearly related to the up-welling in the area. Spawning occurs also in late Winter and early Spring over most of the continental shelf. Weiss & Souza (1977) and Weiss & Souto (1988) observed anchovy spawning in Autumn, Winter and Spring over most of the southern continental shelf.

2.4 KNOWN NURSERY GROUNDS

In the southern region, nursery grounds are mainly coastal areas, sometimes extending to the East.

2.5 REPRODUCTION

2.5.1 Sex ratio

Acuña & Castello (1986) reported that mid-water trawl catches showed a significant higher proportion of females.

2.5.2 Length at first maturity

According to Phonlor (1984) anchovy females of 68-71 mm TL are mature. Acuña & Castello (1986) reported that females reach first maturity at 70-74 mm TL and males at 80-84 mm TL.

2.5.3 Frequency of reproduction

No information available.

2.5.4 Fecundity

No information available.

2.5.5 Time of spawning

Spawning takes place at night, between 2200 and 0400 hours.

3. EARLY LIFE HISTORY

3.1 DEVELOPMENTAL STAGES

The 3 embryonic stages described by Alhstrom & Ball (1954) were adopted by Phonlor (1984a) for the Brazilian anchovy. After eclosion, 4 larval stages were identified: yolk-sac larva; larva; methamorphic or transitional larva and young stage (Phonlor, 1984b).

<u>Note</u>: Information on egg stage duration, larval growth, embryonic mortality and distributional patterns of eggs and larvae are not available for anchovies in Brazilian waters.

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ANNEX VIII

SYNOPSIS ON THE REPRODUCTIVE BIOLOGY AND EARLY LIFE HISTORY OF THE BRAZILIAN SARDINE, *Sardinella brasiliensis* AND RELATED ENVIRONMENTAL CONDITIONS

by

YASUNOBU MATSUURA

1. ANALYSIS OF ENVIRONMENTAL CONDITIONS

1.1 THE PHYSICAL ENVIRONMENT

1.1.1. Oceanographic setting

The main reproductive area of the Brazilian sardine, *Sardinella brasiliensis*, is limited to the Southeastern Brazilian Bight between Cabo Sao Tome (22°S) and Cabo Santa Marta Grande (29°S). The Northern part of the Bight shows a rigorous coastal upwelling, particularly during Spring and Summer (Ikeda, 1976; Miranda, 1982). The Brazil Current flowing to the Southwest along the continental slope comes near the neuritic zone over the continental shelf between Cabo Frio and Ilha Grande. The South Atlantic Central Water (SACW) which flows northward beneath the Brazil Current penetrates bottom layer over the continental shelf during late Spring and Summer and gives rise to a strong thermocline (Matsuura, 1986b; Castro et al., 1988). In Autumn, the SACW starts to recede to the margin of the continental shelf and temperature and salinity in the coastal region become homogeneous over the whole water column during Winter. The coastal water which is under the influence of fresh water discharge from land, occupies a narrow band of the coastal region. Its influence on the water masses over the continental shelf is limited (Figure 1).

1.1.2 Topography

The Southeastern Brazilian Bight has a large extension of the continental shelf and its bottom topography is normally smooth. Off Cabo Frio the width of the shelf is 70 km. It then extends further offshore, up to 200 km in the Santos area. Off Cabo Santa Marta Grande, the shelf again becomes narrower and extends to only 120 km.

1.2 PHYTOPLANKTON

1.2.1 Nutrients

The strong inflow of the SACW into the lower part of the water column in the coastal region during Summer leads to the formation of a stable thermocline. The presence of cold SACW which is rich in nutrients, in the euphotic zone during Summer switches on many biological processes. In the nertitic region, (> 50 m depth) a medium sized frontal eddy is frequently observed (Castro et al. 1988). The compensation depth in this region is usually above the thermocline. However, whenever the frontal eddy has been formed, it pumps the cold SACW from bottom layer into the euphotic zone and gives rise to high primary production. The presence of frontal eddies is frequently recorded in the Ubatuba (Matsuura, ms) and in Paranaguà regions (Brandini, 1988a), however, their frequency and duration is not yet known.

1.2.2 Species composition

The Southeastern Brazilian Bight is considered as an oligotrophic environment. Phytoflagellates are the most abundant planktonic organisms in the coastal and oceanic region. Coccolitophorids and cyanophyceans dominate in the Northern part where the influence of tropical water (= Brazil Current) is stronger. Diatoms, dinoflagellates and silicoflagellates are more abundant in the Southern part where the sub-antarctic coastal water is prevailing (Brandini, 1988 a & b).

1.2.3 Size structure

Due to the oligotrophic nature of the environment, the phytoplankton community is dominated by nano- and picoplankton. Within these categories the phytoflagellates (< 10 um) are the most abundant phytoplankton in the region (average of 90% of the total phytoplankton).

1.2.4 Levels of primary production

The photosynthetic rate varies from 0.2 to 10.4 mgC/mgChl- a/h over the continental shelf and a high primary production was observed in the costal region during summer (Aidar-Aragao, et al., 1980; Brandini, 1988a).

1.3 SECONDARY PRODUCTION

1.3.1 Qualitative and quantitative composition of zooplankton

The zooplankton community is dominated by small herbivorous copepods (Calanoidea) which feed on nano- and picoplankton. The zooplankton biomass varies from 0.17 to 8.82 g/m^3, with higher concentration occurring in the upper mixed layer (0-25 m).

2. AVAILABLE INFORMATION ON SPAWNING GROUPS

2.1 KNOWN NUMBER OF SPAWNING GROUPS IN THE AREA

It is not known if the Brazilian sardine in the area under investigation can be separated into different sub-populations. The spawning season in the Northern area (Rio de Janeiro) is longer than in the Southern area (Santa Catarina). However, spawning is intensive in both areas during December and January. Morphological and morphomeristic studies of adult sardine indicate 2 different groups, but their distribution patterns are strongly influenced by the oceanographic conditions and by migrating sardines inside the Bight. This results in a mosaic pattern of distribution of morphological and morphomeristic characteristics (Rossi-Wongtschowski, 1977).

2.2 BIOMASS ESTIMATES OF SPAWNING GROUPS

The biomass of the sardine population was estimated applying acoustics. The results of 8 acoustic surveys ranged from 141,000 to 414,000 metric tons (Johannesson, 1975; Rijavec & Amaral, 1977; Matsuura, et al. 1985). These results are considered as sub-estimations, because of limitation of equipment used and because of the avoidance of sardines. A recent survey carried out in October 1988 yielded a very low biomass value (58,000 metric tons) in the Bight (Castello, et al. ms).

Traditional ichthyoplankton surveys in this area indicated a spawning stock biomass between 0.5 to 3.26 millions metric tons (Matsuura, 1971; 1975a; 1979; 1983). Since fecundity and spawning frequency were estimated incorrectly, these biomass values are considered to be over estimations.

Using Virtual Population Analysis of the sardine stock after recruitment, an estimate of 531,000 metric tons was obtained for the period 1978-79 (Matsuura, 1986a). For 1978-84, the results of biomass estimates by VPA varied from 370,000 to 550,000 metric tons (PIEBS, ms).

2.3 SPAWNING SEASON AND GROUNDS

The austral Summer is the spawning season of the Brazilian sardine. In the areas off Rio de Janeiro and Cabo Frio, spawning starts in November and ends in March. In the Southern areas, peak spawning is during December and January. The sardines spawn in the surface layer, between the coast and the 100 m isobath. In most years, the highest concentrations of spawning were observed in the 50-100 m isobath zone. The locations of the spawning areas change from year to year (Matsuura, 1971; 1975a; 1979; 1983), however, 2 main spawning grounds could be identified: the regions off Ilha Grande-Ubatuba and Santos-Paranaguà (Figure 2).

2.4 KNOWN NURSERY GROUNDS

Most of sardine larvae and juveniles stay near the spawning areas, however, their distributional range is larger than the spawning area. The entire continental shelf can be considered as a nursery ground (Matsuura, 1977b; 1979; 1983).

2.5 REPRODUCTION

2.5.1 Sex Ratio

Sardines can be sexed macroscopically once they reached 90 mm TL. The sex ratio for 90-180 mm length groups was 1:1. In larger sizes, the proportion of the females increases (Rossi-Wongtschowski, 1977).

2.5.2 Length at first maturity

On average, the length at first maturity of the Brazilian sardine is 160-170 mm TL and all adults are mature when they reach 210-220 mm TL (Rossi-Wongtschowski, 1977).

2.5.3 Frequency of reproduction

Spawning frequency has been estimated twice using the percentage of post-ovulatory follicles in ovaries: Isaac-Nahum, et al. (1988) reported that the Brazilian sardines spawn every 2 days, whereas Dias (pers. comm.) estimated 11 days. However, as the aging of post-ovulatory follicles of the Brazilian sardine has not been validated and as the number of females analysed in both studies was rather small, further studies of the spawning frequency are required.

2.5.4 Fecundity

Several fecundity estimates applying the stereometric method showed that the number of oocytes in the most advanced mode varied from 21,000 to 54,000 (Isaac-Nahum, et al. 1985). Batch fecundity estimates applying the hydrated oocytes method gave an average of 31,000 eggs per batch (n=19) (Dias, pers. comm.).

2.5.5 Time of spawning

As most other clupeoid species the Brazilian sardine spawn during night at the surface. The daily peak spawning time is around midnight and most of spawning occurs from 21:00 to 03:00 hours (Matsuura, 1983).

3. EARLY LIFE HISTORY

3.1 DEVELOPMENTAL STAGES

The embryonic stages of the Brazilian sardine were determined according to Nakai (1961): A-stage starts with fertilization and ends with closure of the blastopore, B- stage begins after closure of the blastopore and ends at the beginning of departure of tail bud from yolk surface, and C-stage starts when the posterior part of body becomes free from yolk surface and ends with hatching. Each stage was subdivided into 2 or 3 sub-stages. The larval development, early life history and life cycle of the Brazilian sardine have been studied by Matsuura (1975b, 1976, 1977a, respectively).

3.2 EGG STAGE DURATION

The average temperature of the spawning grounds of the Brazilian sardine is about 24°C and the larvae hatch after 20 hours at this temperature (Matsuura, 1976).

3.3 LARVAL GROWTH

Using the growth data obtained in laboratory experiments, Yoneda (1987) described the growth of sardine larvae by the following linear regression for a period of 40 days: $SL = 0.619*d + 2.022$ (SL = standard length in mm and d = days after hatching).

3.4 EMBRYONIC MORTALITY

No information.

3.5 LARVAL MORTALITY

Using a daily growth rate of 0.7 mm/day, the age of each size class of larvae was estimated. This allows the determination of the natural mortality rate of larvae. The instantaneous co-efficient of natural mortality ranged from 0.131 to 0.369 and the rate of natural mortality from 12.3% to 30.9% per day (Matsuura, 1983).

3.6 DISTRIBUTIONAL PATTERNS OF EGGS AND LARVAE

The combined effects of spawning aggregations of the adults, short incubation period and fast growth of the eggs and larvae of the Brazilian sardine lead to a strongly patchy distribution.

3.7 LARVAL FEEDING BEHAVIOUR

Feeding behaviour of the Brazilian sardine larvae is very similar to that observed in other clupeoid larvae. First feeding begins on the second day after hatching and larvae start to show pre-striking movements curving their bodies in S-shape. From the third day on they swim constantly showing frequently S-shape movements to feed on rotifers (Yoneda, 1987). Stomach contents of larvae and juveniles in the field collected samples consisted mainly of small copepods. Diatoms and dinoflagellates were also found.

3.8 PREDATION

No Information.

FIGURE 1

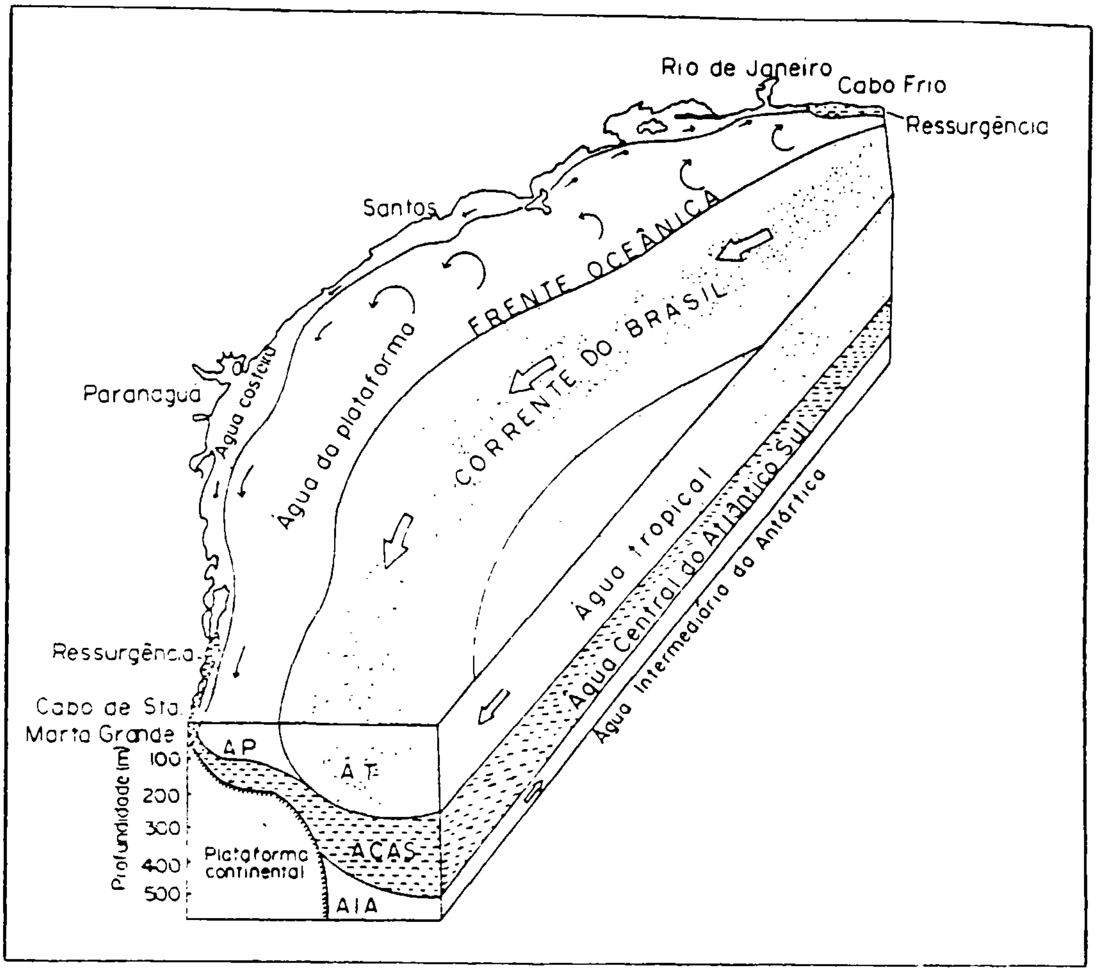

Figure 1: Water masses in the Brazilian Bight.

FIGURE 2

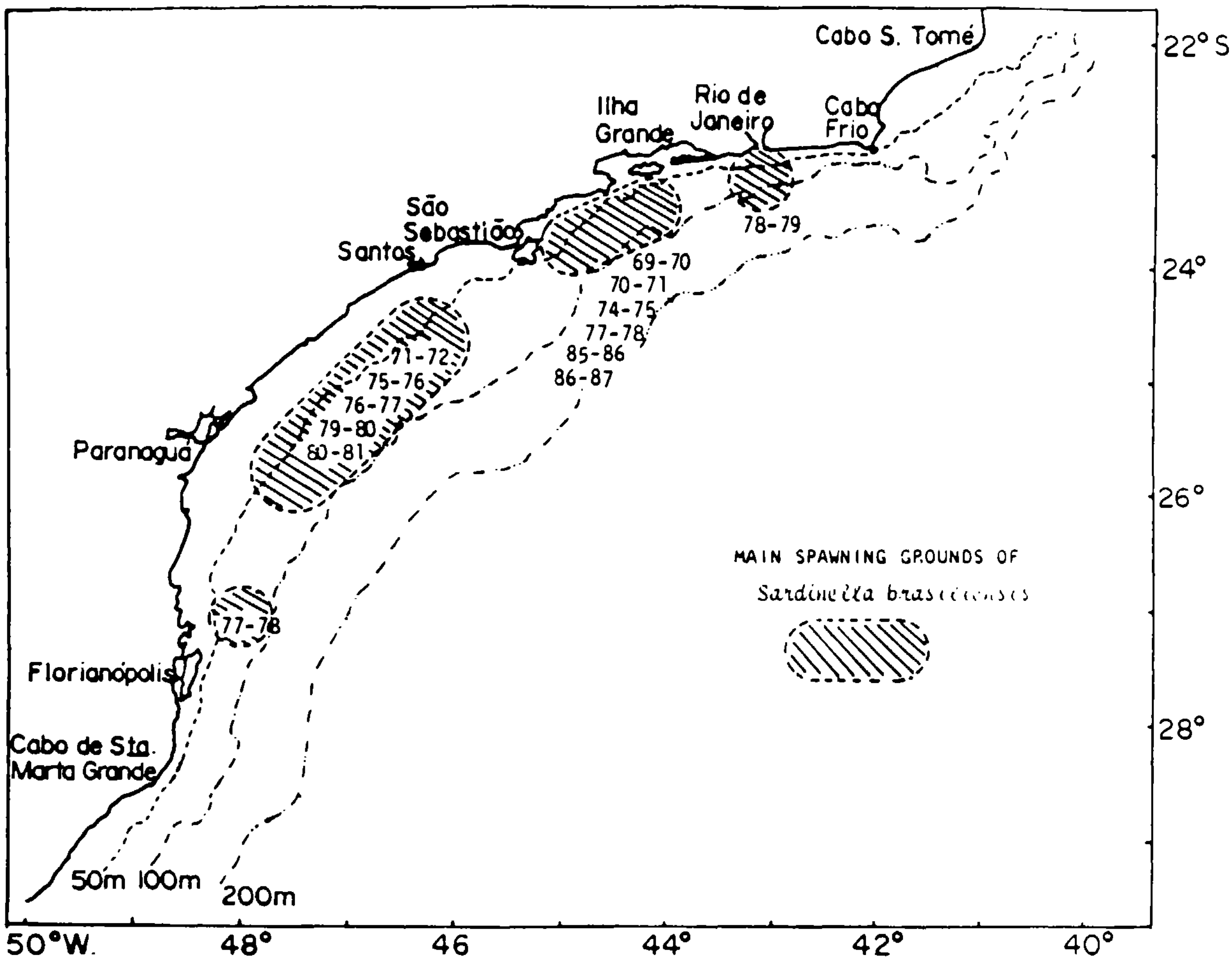

Figure 2: Main spawning grounds of Sardinella brasiliensis.

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ANNEX IX

PROPOSAL FOR COMPARATIVE STUDIES ON RECRUITMENT AND REPRODUCTIVE BIOLOGY OF THE SOUTHWEST-ATLANTIC ANCHOVY *Engraulis anchoita*, WITH THE RESEARCH VESSEL 'METEOR'

by

JURGEN ALHEIT

ABSTRACT

The proposed studies will provide a better understanding of the biological-oceanographic processes which govern the recruitment fluctuations of marine fish stocks and which are at present the central theme of an international research programme (Sardine/Anchovy Recruitment Project - SARP) under the guidance of IOC/Unesco and FAO. The investigations will be carried out in a marine area which is particularly suitable because of its high oceanographic diversity, the Southwest-Atlantic shelf between 28°S and 43°S, on a clupeiform species, *E. anchoita*, which is particularly suitable due to its protracted spawning season and its expanded spawning area. The influence of starvation and predation on the survival of fish eggs and larvae and the relevant physical-oceanographic factors will be studied in 3 hydrographically very different sub-areas by applying a complex of new methodologies which have not yet been applied in the proposed combination.

STATE OF RESEARCH

Recruitment is the entry of a new year class into the adult or fished stock. For most marine fish species, the extent of annual recruitment and future stock sizes can at present not be predicted.

The larger part of the fish stocks spawn vast numbers of eggs each year a fraction of which survives to the recruit stage. Eggs and larvae of fish are particularly susceptible to unfavourable environmental conditions. The annual number of recruits is therefore, even when the adult stock size remains the same, exposed to considerable fluctuations, in extreme cases hundredfold.

Despite the numerous studies of the recruitment problem over the last decades, we are at present still very far from an understanding of the processes which cause recruitment variability. The reasons why past studies failed are not hard to see. The success or failure of annual recruitment can have a number of different causes. Feeding conditions and predation are important parameters the effects of which are mediated by the physical environment. Although often ignored, currents, wind stress, turbulence and/or stratification can be also important factors governing recruitment. This complex of biological and physical-oceanographic processes cannot be substantially elucidated by many independent studies. There was also a serious lack of adequate methods to investigate certain processes and of reliable equipment which permitted the required high spatial resolution of the distribution of zoo- and ichthyoplankton. The increased interest in tackling the recruitment problem in an interdisciplinary and international manner during the last years (IOC/Unesco 1983, ICES 1986) and the simultaneous development of a number of new methodologies and sampling equipment now let us expect a breakthrough in the understanding of recruitment variability in the years to come.

It is commonly assumed that annual recruitment is determined during the early life history stages, particularly the larval stage. All attempts at trying to explain recruitment variability can be divided into 3 hypotheses: Starvation-, Predation- and Advection-Hypothesis (LASKER 1985, BAKUN in Press). These hypotheses postulate that starvation of larvae or predation on eggs and larvae or drift of eggs and larvae into unfavourable areas determines the extent of recruitment.

According to the Starvation Hypothesis, recruitment success depends on the availability of enough food for the first-feeding larvae (LASKER 1978, 1981a, 1981b, 1985). The required, patchily distributed, dense aggregations of food organisms can be formed only in stratified water in calm conditions. Storms or upwelling events destroy these aggregations and the larvae die of starvation. LASKER was unable to prove this mechanism. The findings that mortality rates of first-feeding larvae are no higher than those of older larvae and that starving larvae are rarely encountered in the field do not support this hypothesis (HUNTER 1982). However, recently the Starvation Hypothesis gained new momentum as PETERMAN and BRADFORD (1987) showed a significant linear relationship between the mortality rates of first-feeding larvae of the northern anchovy and the frequency of occurrence of calm periods with low wind speed in the upwelling system of California which permit aggregations of food organisms. In addition, we now have new opportunities to determine differential starvation of fish larvae by application of a new method by means of which short- or long-term starvation in individual larvae can be studied via histological (THEILACKER 1986) or biochemical (CLEMMESEN 1987, ÜBERSCHÄR 1987, BUCKLEY and LOUGH 1987) analysis.

The Predation Hypothesis which postulates that recruitment is determined by predation on the early life history stages has gained much support over the last years (HUNTER 1982, SISSENWINE 1984, NELLEN 1986, BAILEY and HOUDE 1987). Although there are many reasonable arguments for this hypothesis its weakness is due to the fact that quantitatively considerable predation has been shown only for eggs (HUNTER and KIMBRELL 1981, ALHEIT 1987). The difficulty in proving quantitatively predation of larvae is due to the rapid digestion of larvae. It is rarely possible to find remains of larvae in stomach contents of potential predators. However, promising new results were recently reported by THEILACKER et al. (1986). They were able to show larval predation by euphausiids applying immunological techniques which prove the presence of larval yolk protein in unidentifiable stomach contents. According to the Advection Hypothesis, recruitment variability is governed by changing currents which transport eggs and larvae into favourable or unfavourable areas.

These 3 hypotheses to explain the causes of recruitment variability are closely connected. For example, a nursery area for larvae is favourable when enough food of the right kind is available and when they are largely protected from predators. In addition, starving larvae are more likely to be predated upon than well fed larvae. This might explain why starving larvae are rarely encountered in the sea.

HOUDEs (1987) theoretical calculations recently showed that small changes in daily mortality and growth rates can considerably influence the success of recruitment. Larval mortality rates can be determined only by extensive field work and their accuracy is rather low which prevents detection of small changes. However, larval growth rates can now be determined with high accuracy by means of daily growth rings on otoliths. The daily nature of these growth rings has been shown for a large number of marine fish species (JONES 1985).

The extended spawning area of the Southwest-Atlantic anchovy includes several different water masses with different physical and chemical properties offering different spawning conditions for the adult fish and different nursery conditions for the eggs and larvae. Its spawning area is characterized by the convergence of the cold Falkland/Malvinas current and the tropical Brazil current, by the considerable outflow of fresh-water from the Rio de la Plata and the Laguna dos Patos, by upwelling, by the mixing of different water masses and by frequent occurrence of frontal systems. Eggs and larvae of the anchovy occur in all these different hydrographic units with exception of the Brazil current. The Southwest-Atlantic anchovy is a serial (batch) spawner which spawns all year round, but with different intensity. Peak spawning is, depending on latitude, between October and January. The highest larval abundances were recorded in December and January. This anchovy species is therefore ideally suitable for comparative studies on recruitment and reproductive biology, as comparative investigations can be carried out systematically in a period of a few weeks under very different hydrographic and biological conditions.

The necessary requirement for such studies is the new development of adequate sampling equipment which was particularly intensified over the last 10 years. The new equipment permits small-scale biological sampling in highly structured water bodies; e.g., the MOCNESS-net for the consecutive sampling of ichthyoplankton in different depth strata (WIEBE et al. 1985), the Longhurst-Hardy Plankton Recorder for determining small-scale distribution of planktonic organisms (COOMBS et al. 1983) and the GISMO current/CTD/fluorescence profiler from Göteborg, Sweden, for the simultaneous recording of a number of physical and biological parameters relevant for larval studies (SHAFFER pers. comm.).

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PREPARATORY WORK

The participating scientists belong to 9 different institutes. All are working in research teams which have gained wide experience in the field of oceanographic-biological investigations on eggs and larvae of clupeiform fish (anchovy, sardine, sprat). The following review is based on studies of the scientists who were involved in the first discussions on the planned cruise and who are likely to be nominated for the cruise by their home institutions.

One important requirement for the success of the planned studies is a knowledge of basic hydrographic (water masses, currents, mixing processes) and biological (spawning period, spawning area, spawning ecology) data. These were gained mainly over the last 10 years by the South American scientists, particularly by the research teams of CIECHOMSKI, Mar del Plata, and of MATSUURA, Sao Paulo. Publications of both teams have gained international reputation.

A comprehensive description of the **hydrography** off Argentina, south of the Rio de la Plata, was given by BRANDHORST and CASTELLO (1971). MATSUURA (1986a) described the oceanographic structures between Cabo Frio and Santa Marta in Brazil thoroughly. New data on the physical oceanography off the Rio de la Plata were recently published by an Uruguayan team (ELGUE et al. 1986).

Knowledge of distribution and annual variability of **phyto-** and **zooplankton** increased considerably over the last years. AKSELMAN et al. (1986) studied the distribution of plankton in the spawning area of the Southwest-Atlantic anchovy on the Argentinian shelf. CARRETO et al. (1986) carried out investigations of phytoplankton blooms off the Rio de la Plata. A description of the phytoplankton species composition in the same area was given by BAYSSE et al. (1986). CIECHOMSKI and SANCHEZ (1983) revealed the relations between the abundance of ichthyoplankton and the associated zooplankton communities. GOBERNA (1986) described the copepoda fauna off Uruguay.

Distribution, annual variability and other important **ichthyoplankton** parameters, particularly for the anchovy, in the Argentinian-Uruguayan area were extensively described since the mid-sixties in a series of publications by CIECHOMSKI and co-workers. An impressive review of most of the results was recently presented (CIECHOMSKI and SANCHEZ 1986). Similar studies on the ichthyoplankton in the Brazilian area were carried out by MATSUURA (1971). Detailed data on the **reproductive biology** and **spawning ecology** (e.g., CIECHOMSKI and WEISS 1973, CHRISTIANSEN and WEISS 1981, ACUÑA and CASTELLO 1986) and on the **biology and early life history stages** of the Southwest-Atlantic anchovy (e.g., CIECHOMSKI and WEISS 1971, CIECHOMSKI 1973, SANCHEZ 1986, MANTERO 1986) were reported in a large series of publications of Argentinian, Uruguayan and Brazilian scientists.

Some of the prospective cruise participants carried out extensive studies on the reproductive biology and on eggs and larvae of **other clupeiform fish species** in other marine ecosystems: **Sardinella** off Brazil (review in MATSUURA 1986b), anchovies and sardines in the Peruvian upwelling system (ALHEIT 1985, 1987b, ALHEIT et al. 1987), anchovies in the Californian upwelling system (THEILACKER 1980, THEILACKER and LASKER 1984, THEILACKER et al. 1986) and North Sea sprat (ALHEIT 1987a, ALHEIT et al. 1987). SHAFFER recently started investigations on the influence of physical-oceanographic factors on the survival of sardine and anchovy larvae in the upwelling system off Chile (unpubl.).

There will be specialists on board for all aspects of the planned programme and for all new methods to be applied.

For the **rearing of eggs and larvae** the required experience will be available. THEILACKER and McMASTER (1971) demonstrated a breakthrough in the mass culture of food organisms for the northern anchovy. CIECHOMSKI and SANCHEZ (1984) succeeded in rearing eggs and larvae of the Southwest-Atlantic anchovy. YONEDA (1987) carried out similar experiments on eggs and larvae of the Brazilian sardine.

The **food spectrum** of the Southwest-Atlantic anchovy was described in detail by CIECHOMSKI (1967) and CIECHOMSKI and WEISS (1974). Growth rates and condition factor of anchovy larvae were determined by CIECHOMSKI et al. (1986). Interestingly, they were able to catch starving larvae in the field. Important studies to determine **starvation** applying histological methods on jack mackerel larvae in the Californian upwelling system (1978) and to estimate quantitatively the proportion of starving larvae of jack mackerel (1986) were carried out by THEILACKER. In the NELLEN research team, promising, new biochemical analyses are being developed to determine different grades of starvation of individual fish larvae by the RNA/DNA ratio (CLEMMESEN 1987a, 1987b) or by enzymatic activity (ÜBERSCHÄR 1985, 1987).

Embryonic mortality rates were investigated by CIECHOMSKI and SANCHEZ (1984) and SANCHEZ (1986) for eggs and larvae of the Southwest-Atlantic anchovy, by ALHEIT (1987b) for eggs of the Peruvian anchovy and by ALHEIT et al. (1987) for eggs of North Sea sprat. The high mortality of anchovy eggs in the Peruvian upwelling system (65% mortality per day) was particularly impressive and has to be considered as a potentially important factor for recruitment variability.

Predation on anchovy eggs by anchovies and sardines in Peru was determined quantitatively by ALHEIT (1987b) by stomach content analysis. Twenty-two percent of the total egg mortality was caused by egg cannibalism. This is strong evidence for a density-dependent mechanism for the regulation of recruitment variability. THEILACKER et al. (1986) successfully developed an immunological method to determine quantitative predation on larvae. They were able to show that a surprisingly high percentage of euphausiids in the Californian upwelling system feed on yolk-sac larvae of the northern anchovy. Here is for the first time a method available by means of which the assumed high predation on fish larvae might be proven.

YONEDA (1987) of the MATSUURA research team and ALSHUTH (1988) of the ALHEIT team were able to prove the daily nature of **growth rings** on **larval otoliths** of the Brazilian sardine and of North Sea sprat, respectively. The simultaneously determined daily growth rates of the larvae opens up new opportunities in the comparative investigation of the life history of different intra-seasonal cohorts of larvae.

The MOCNESS net for **sampling of ichthyoplankton** was continuously improved over the last years under field conditions by the NELLEN research team and was adapted according to the particular requirements. The recently developed GISMO current/CTD/fluorescence profiler of the SHAFFER team from Göteborg was already mentioned.

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OBJECTIVES OF CRUISE

The cruise has 2 principal objectives:

(i) To demonstrate a number of new methods and equipment which are particularly suitable for recruitment-related research and to apply these in an integrated, multidisciplinary fashion. The main objective is technology transfer; and

(ii) to investigate the importance of several, inter-related biological oceanographic processes for recruitment variability and a better understanding of how these processes interact.

The working hypothesis is: Survival of fish larvae depends crucially on the physical properties of their environment (water body) which - apart from the direct influence of temperature on growth and metabolic rates - affect on the one hand the development of the larval food, i.e., the phyto- and zooplankton and on the other hand the occurrence of predators. The proposed studies will be carried out in a marine area which is particularly suitable because of its high oceanographic diversity, the Southwest-Atlantic shelf between 28°S and 43°S, on a clupeiform species, the Southwest-Atlantic anchovy, which is particularly suitable for these kinds of studies because of its protracted spawning season and its expanded spawning area.

The following goals are to be reached:

(i) To detect different water bodies and to define their physical characteristics

(ii) To define the biological properties of these water bodies by

(a) determining the chlorophyll a concentration, the species composition of their phytoplankton community(ies) and the abundances of the most important phytoplankton species

(b) determining zooplankton volume per unit, species composition and small-scale distribution of their zooplankton community(ies) and the abundances of the most important zooplankton species.

(ii) To gain a detailed understanding of the effect of different, biologically and physically determined water bodies on the survival chances of fish eggs and larvae. To that end the following egg and larval parameters will be studied in each water body:

(a) abundance, vertical and small-scale distribution and age composition of the respective anchovy egg 'population'

(b) abundance, vertical and small-scale distribution and age composition of the respective anchovy larval 'population'

(c) condition of the anchovy larvae determined by stomach, histological and biochemical (RNA/DNA-ratio, enzyme activities) analysis

(d) daily growth rates of larvae determined by distances between the rings on larval otoliths

In addition, the potential egg and larval predators, e.g., juvenile and adult anchovies or euphausiids, will be caught in each water body and the extent of predation will be determined by stomach analysis and immunological techniques.

(iv) Analysis of the spawning strategy of the Southwest-Atlantic anchovy by determination of to date unknown reproductive parameters such as batch fecundity and spawning frequency.

PROGRAMME

Three areas to be studied in detail (boxes) will be selected on the basis of their hydrographic properties.

(i) An area on the Argentinian shelf around the Valdez peninsula which is characterized by tidal mixing fronts and which is under the influence of the cold Malvinas Current (Figure 1, Box A). In this area, mixed and stratified water bodies occur together with transition zones.

(ii) An area under the influence of the freshwater outflow from the Rio de la Plata on the Uruguayan shelf in which freshwater, cold sub-antarctic coastal water and subtropical water affected by the tropical Brazil Current are mixed (Figure 1, Box B). The different water bodies in this area are distinguished particularly by their different salinities.

(iii) An area characterized by upwelling events in the subtropical water on the Brazilian shelf off Santa Marta (Figure 1, Box C).

In each area, the hydrographic structures will be studied first, the different water bodies defined and the dimensions of the box determined. Then, a grid of sampling stations will be laid over the box the distances between which depend on the respective hydrography. The relevant physical parameters will be determined repeatedly on all stations over several days. In addition, on selected stations the biological sampling will be carried out.

The biological samples will be taken by using the following equipment at each biological station: fluorescence profiling with GISMO; rosette sampler for phytoplankton; Tetra-Net, Multi-Net and MOCNESS-Net for zoo- and ichthyoplankton; Hardy-Longhurst-Plankton-Recorder for small-scale distribution of zoo- and ichthyplankton; Rectangular Midwater Trawl and Young-Fish-Trawl for larger larvae, euphausiids and juvenile fish. Between the stations, adult anchovy will be fished by pelagic trawling. On the way between the 3 boxes, additional biological sampling stations will be established to gain supplementary information from other water bodies which cannot be studied intensively due to lack of time.

PROVISIONAL TIME SCHEDULE

Leave Mar del Plata: 23.11.1989

Travel to Box A		1	day(s)
Sampling in Box A		6	"
Travel, incl. sampling, to Box B	4	"	
Sampling in Box B		6	"
Travel, incl. sampling, to Box C	4	"	
Sampling in Box C		6	"
Travel to Rio Grande	1	"	
			28 "

Arrival Rio Grande: 21.12.1989

PARTICIPANTS

Nellen, Hamburg	(cruise leader)
Überschär, Hamburg	
N.N., Hamburg	
N.N., Hamburg	
Alheit, Bremerhaven	(cruise coordinator)
Andrick, Bremerhaven	
N.N., Bremerhaven	
N.N., Bremerhaven	
N.N., Bremerhaven	
N.N., Bremerhaven	
N.N., Argentina	
N.N., Argentina	
N.N., Argentina	
N.N., Argentina	
N.N., Argentina	
N.N., Uruguay	
N.N., Uruguay	
N.N., Uruguay	
N.N., Uruguay	
N.N., Uruguay	
N.N., Brazil	
N.N., Brazil	
N.N., Brazil	
N.N., Brazil	
N.N., Brazil	
Shaffer, Sweden	
N.N., Sweden	
Theilacker, USA	

FIGURE 1

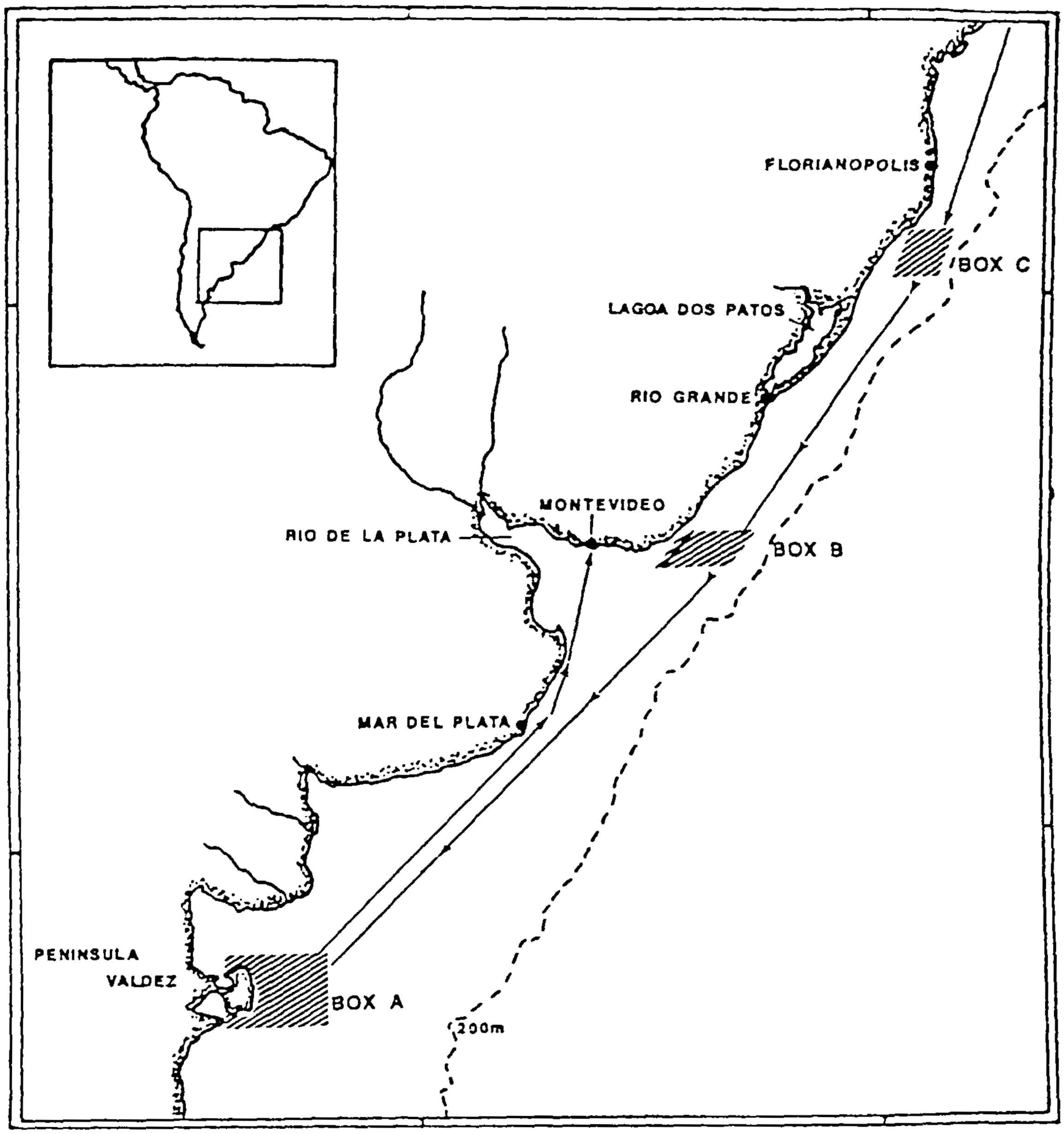

Figure 1: Position of three working areas to be covered during the METEOR cruise.

ANNEX X

LIST OF ACRONYMS

ADCP	Acoustic Doppler Current Profiler
AUCFZ	Argentine-Uruguayan Common Fishing Zone
CTD	Conductivity Temperature Depth
DFG	Deutsche ForschungsGemeinschaft
FAO	Food and Agriculture Organization of United Nations
GISMO	Gothenburg Instrument for Sampling More of the Ocean
IOC	Intergovernmental Oceanographic Commission
LHPR	Longhurst Hardy Plankton Recorder
MOCNESS	Multiple Opening Closing Net and Environmental Sampling System.
NOAA	National Oceanographic and Atmospheric Administration
OSLR	Ocean Science in Relation to Living Resources
RMT	Rectangular Midwater Trawl
ROSTLAC	Regional Office for Science and Technology for Latin America and the Caribbean
SARP	Sardine/Anchovy Recruitment Project
SMN	Servicio Meteorol6gico Nacional
UNESCO	United Nations Educational Scientific and Cultural Organization.

No.	Title	Publishing Body	Languages
32 Suppl	Papers submitted to the UNU/IOC/Unesco Workshop on International Co-operation in the Development of Marine Science and the Transfer of Technology in the Context of the New Ocean Regime Paris, 27 September-1 October 1982	IOC Unesco Place de Fontenoy 75700 Paris, France	English
33	Workshop on the IREP Component of the IOC Programme on Ocean Science in Relation to Living Resources (OSLR) Halifax, 26-30 September 1983	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
34	IOC Workshop on Regional Co-operation in Marine Science in the Central Eastern Atlantic (Western Africa) Tenerife 12-17 December 1983	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish
35	CCOP/SOPAC-IOC-UNU Workshop on Basic Geo-scientific Marine Research Required for Assessment of Minerals and Hydrocarbons in the South Pacific Suva, Fiji, 3-7 October 1983	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
36	IOC/FAO Workshop on the Improved Uses of Research Vessels Lisbon, 28 May - 2 June 1984	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
36 Suppl	Papers submitted to the IOC-FAO Workshop on Improved Uses of Research Vessels Lisbon, 28 May-2 June 1984	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
37	IOC/Unesco Workshop on Regional Co-operation in Marine Science in the Central Indian Ocean and Adjacent Seas and Gulfs Colombo, 8-13 July 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
37 Suppl	Papers submitted to the IOC/Unesco Workshop on Regional Co-operation in Marine Science in the Central Indian Ocean and Adjacent Seas and Gulfs Colombo, 8-13 July 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
38	IOC/ROPME/UNEP Symposium on Fate and Fluxes of Oil Pollutants in the Kuwait Action Plan Region Basrah, Iraq, 8-12 January 1984	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
39	CCOP (SOPAC)-IOC-IFREMER-ORSTOM Workshop on the Uses of Submersibles and Remotely Operated Vehicles in the South Pacific Suva, Fiji, 24-29 September 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
40	IOC Workshop on the Technical Aspects of Tsunami Analyses, Prediction and Communications Sidney, B.C., Canada, 29-31 July 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
40 Suppl	IOC Workshop on the Technical Aspects of Tsunami Analyses, Prediction and Communications *Submitted Papers* Sidney, B.C., Canada, 29-31 July 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
41	First Workshop of Participants in the Joint FAO/IOC/WHO/IAEA/UNEP Project on Monitoring of Pollution in the Marine Environment of the West and Central African Region (WACAF/2) Dakar, Senegal, 28 October - 1 November 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
42	IOC/UNEP Intercalibration Workshop on Dissolved/Dispersed Hydrocarbons in Seawater Bermuda, USA, 3-14 December 1984 (in press)	IOC Unesco Place de Fontenoy 75700 Paris, France	English
43	IOC Workshop on the Results of MEDALPEX and Future Oceanographic Programmes in the Western Mediterranean Venice, Italy, 23-25 October 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
44	IOC/FAO Workshop on Recruitment in Tropical Coastal Demersal Communities Ciudad del Carmen, Campeche, Mexico, 21-25 April 1986	IOC Unesco Place de Fontenoy 75700 Paris, France	English (out of stock) Spanish
44 Suppl.	IOC/FAO Workshop on Recruitment in Tropical Coastal Demersal Communities - *Submitted Papers* Ciudad del Carmen, Campeche, Mexico, 21-25 April 1986	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
45	IOCARIBE Workshop on Physical Oceanography and Climate Cartagena, Colombia, 19-22 August 1986	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
46	Reunión de Trabajo para Desarrollo del Programa «Ciencia Oceanica en Relación a los Recursos No vivos en la Región del Atlantico Sudoccidental Porto Alegre, Brazil 7-11 de Abril de 1986	IOC, Unesco Place de Fontenoy 75700 Paris, France	Spanish
47	IOC Symposium on Marine Science in the Western Pacific: The Indo-Pacific Convergence Townsville, 1-6 December 1986	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
48	IOCARIBE Mini-Symposium for the Regional Development of the IOC-UN (OETB) Programme on "Ocean Science in Relation to Non-Living Resources (OSNLR)"	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
49	AGU-IOC-WMO-CPPS Chapman Conference An International Symposium on "El Niño" Guyaquil, Ecuador, 27-31 October 1986	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
50	CCAMLR-IOC Scientific Seminar on Antarctic Ocean Variability and its Influence on Marine Living Resources, particularly Krill (organized in collaboration with SCAR and SCOR) Paris, France, 2-6 June 1987	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
51	CCOP/SOPAC-IOC Workshop on Coastal Processes in the South Pacific Island Nations, Lae, Papua-New Guinea, 1-8 October 1987	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
52	SCOR-IOC-Unesco Symposium on Vertical Motion in the Equatorial Upper Ocean and its Effects upon Living Resources and the Atmosphere Paris, 6-10 May 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
53	IOC Workshop on the Biological Effects of Pollutants Oslo, 11-29 August 1986	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
54	Workshop on Sea-level Measurements in Hostile Conditions Bidston, UK, 28-31 March 1988	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
55	IBCCA Workshop on Data Sources and Compilation Boulder, Colorado, 18-19 July 1988	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
56	IOC/FAO Workshop on Recruitment of Penaeid Prawns in the Indo-West Pacific Region (PREP) Cleveland, Australia, 24-30 July 1988	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
57	IOC Workshop on International Co-operation in the Study of Red Tides and Ocean Blooms Takamatsu, Japan, 16-17 November 1987	IOC, Unesco Place de Fontenoy 75700 Paris, France	English