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"PRIMARY PRODUCTIVITY IN WINTER IN THE RIA OF PONTEVEDRA (NW OF SPAIN) AND THE CHANGES CAUSED BY THE CONTAMINATION"

J.J. GONZALEZ*, J.M. CABANAS**, A. GLEZ-QUIJANO*

* Instituto Español de Oceanografía
Centro Costero de Vigo
Avda. Orillamar, 47
VIGO (ESPAÑA)

**Instituto Español de Oceanografía
Centro Costero de La Coruña
Apartado, 130
LA CORUÑA (ESPAÑA)

ABSTRACT

Spatial distribution in winter of the primary productivity in the Ria of Pontevedra (NW of Spain), is shown. It is proved that industrial and urban efluents have a negative effect on photosynthesis, especially on the surface of the water, and on the Northern Coast, which is in accordance with the dynamics of the Ria.

RESUME

On indique la distribution spatial d'hiver de la production primaire dans la Ria de Pontevedra (NO d'Espagne). Les debuts industrielles et urbains affectent negativement la photosynthése. Cette influence est plus noté dans la surface et spécialement dans la zone Nord de la Ria.

INTRODUCTION

The Ria of Pontevedra (or Marin), is one of the four "Rias Bajas" of Galicia, situated in the NW of Spain (Fig. 1).

It has the following characteristics in common with the other four Rias: a) NW/SW orientation of the central axis. b) Positive estuarial circulation (Parthy due to the fact that the largest rivers that run into the Rias, do so in the innermost section). c) Upwelling phenomena (produced by NW winds in the next platform, and perhaps the influence of deep water from the Mediterranean). d) They have an owerage depth of 20-30 m., with surface areas of between 130-240 K^2, varying in length from 18-33 Km. e) Semidiurnal tide cycle with tidal variation between 1,5 and 4 m.

As a consequence of the above, and of its geographical position the Rias have a high primary productivity (with values of up to 2,0 grC/m^2day) which gives rise to intensive semiculture of mussels, and the existence of large natural banks of clams, oysters, cockles, scallops, razorshell, and other crustaceans and mollucs.

The Ria of Pontevedra is 23 Km. long, and has an area of 152 Km^2 in the shaded area (Fig. 1), with depths of up to 47 m. in the wider central part, and approximately 1 m. to the East of Tambo island.

The average flow of the Lerez River is 1,67 Hm^3, with wide seasonal variations, and the total contribution to the Ria by natural streams and run-off (including the Lerez) can be estimated at 2,75 Hm^3/day.

The location of the principal waste outlets, of both urban and industrial origin, is shown in Fig 1, and its qualitative and quantitative characteristics, in Table 1.

The nature of some of these outlets (highly-coloured, strong-smelling, and foam-producing), the fact that it is a tourist zone, and the hypothetical reduction in the quantity and quality of shellfish stock, brought about the programming of an interdisciplinary study of this Ria. Some of the data obtained in Phase I of this study, are shown in this paper.

OBJECTIVE.

1.- Make a diagnosis of the present state of the Ria, and its foreseeable evolution.

2.- Find out how the effluents affect the biotope and biocoenosis.

3.- Compare the biological/oceanographical characteristics with the two closest Rias (Arosa and Vigo), of which more is known.

4.- Propose immediately-feasible solutions, to avoid the deterioration of this area.

METHODOLOGY.

The study of the pollution of the Ria of Pontevedra, was divided into two phases. The first, which began in winter 1980, involved making a preliminary assessment of the problem, and defining the programme of work to be done in Phase II.

After compiling, analizing and synthesizing all existing data, a 20 day long field-trip was planned, in which the principal waste outlets were located and analysed, qualitatively and quantitatively; the marine dynamics, meteorology, microbiology, benthos, phytoplanckton and zooplanckton, hydrography, primary productivity, heavy metals, DDT's and PCB's, hydrocarbons, detergents, etc., were studied.

SAMPLING.

From 15th February to 4th March 1980 samples were taken twice (series A and B), from the 20 stations whose location is shown in Fig. 2. An attempt was made to take them in differing tidal levels, but this was not always possible.

The taking of water was carried out with Niskin bottles, equipped with inversion thermometers. The depths were decided upon after checking the whole water column with a RS5 (Beckman) salinometer, and an underwater photometer. Normally less than 10 m. of water wasleft unsampled. The number of bottles used, varied between 2-7.

Samples were taken to determine salinity, dissolved oxigen, nutrients, particulate C and N, chlorophyls, and phytoplanckton. The primary productivity "in situ" with C-14, was determined at the stations marked with a black dot in Fig. 2.

M A T E R I A L A N D M E T H O D S.

a) Solar radiation. At each station, measurements were taken every metre, with an underwater light meter (Kalsico, model 268). When the incubations were collected, the readings were repeated.

With the data the best-adjusted curve was plotted for the equation $I = I_o \times e^{-kz}$, obtaining from it the values of I_o and K. From the equation were also calculated the theoretical depths reached by 25%, 50% and 100% of the incident radiation.

b) Nutrients. The samples were preserved by quick-freezing at -20 ºC in 40% glicol solution. The nutritive salts (NO_2^-, NO_3^-, NH_4^+, $PO_4H_2^-$, $Si(OH)_4$) were determined with a Technicon AAII Autoanalyzer, using the Strickland and Parsons method.

c) Chlorophyles and other pigments. 2-3 litres of water were passed by vacuum through Whatman GF/C filters. These were frozen at -20 ºC in centrifuge tubes, with screw caps, in which the extraction was carried out in the laboratory.

The readings were taken using a spectrophotometer with a double beam, using cells of 5 cm. light path.

The pheopigments were determined by adding ClH and taking readings at 750 and 665 nm.

The formulas used were those of Jeffrey and Humphrey and Barnes, with concentrations of Chlor."a", Chlor. "b", Chlor. "c", Carotenes, Xanthophylls, Index 430/665 and Pheopigments.

d) Primary productivity with C-14. The usual technique of "in situ" incubations was used, with a duration 2-2½ hours. The depths were those at which there was a light energy of 100%, 50%, 25% and 10% of the incident radiation at the beginning of incubation, the latter being performed between 10 am and 13,30 pm (local time).

Photosynthesis was stopped with Lugol. The cellulose acetate filters, had a pore size of 0,8 u.

The readings were taken using a liquid scintillation counter (Packard tricarb. Model 2002).

8 hours of light per day were considered with the graphic integration carried out throughout the photic zone.

R E S U L T S A N D D I S C U S S I O N.

a) Light Radiation. The quantity of light energy at sea level during the sampling period was low, (usual in winter), of the order of 65-100 W/m^2 with wide variations: extreme values of 8 and 550 W/m^2.

The absolute values of the extinction coefficients, calculated as previously indicated, show some quite marked characteristics:

1.- They are very high in the interior part of the Ria, and decrease towards the mouth.

2.- The tides and the wind play an important role. The highest values were obtained at the end of the incoming tide, with Westerly winds. (the effluents are trapped in the interior of the Ria). Fig. 3 and 4.

In comparison with the Ria of Arosa where a river with a larger volume of water than the Lerez, flows out into the most internal part of the Ria, the values of the extinction coefficients of the Ria of Pontevedra, are 30-50% higher. This increase is mainly due to industrial effluents.

3.- The penetration of light throughout the water column is less in the Northern part, than in the South. This occurs from station 4 towards the West, and confirms the studies of the hydrology and dynamics, which indicate that the principal outlet of fresh water (and therefore of industrial and urban effluents) is to the South of Tambo Island, and it then flows close to the North Coast.

In Fig. 5, are shown some values of the theoretical depth to which 50% of the light reaching the surface of the sea penetrates.

b) Nutrients. Normally in the Rias, the limiting nutrient is inorganic nitrogen. Phosphates are almost always present in sufficient quantity to support higher productivity levels (the muddy bottoms of the Rias act as regulators: they absorb the phosphates when they are present in high concentrations, and release them when they become scarce).

The distribution of nitrates during the survey was typical for winter in the Galician Rias: at the more interior stations, there were higher levels at the surface than at the bottom, and in the rest of the Ria, there were very homogeneous concentrations, of the order of 4-6 µatg. $N\text{-}NO_3^-/l$. The main origin seems to be from the land.

c) Chlorophyls. The values of chlor. "a" at the surface varied from 0,2 to 4 $mg./m^3$, with lower concentrations in the more interior part, and increasing along the central axis of the Ria, as can be seen in Fig. 6 and 7.

In general terms, the largest phytoplancktonic biomass is in the external part of the Ria (Fig. 8). This distribution cannot be totally attributed to the contamination, given that in the other Rias, the same occurs in winter.

d) Primary Productivity. The values found are typical of the winter season (160 mgC/m^2day) although sporadically there were high values (460 and 350 mgC/m^2day) (Table 2).

These high values are due to the fact that when the incubations were done, there was sufficient light which easily penetrated the water column (station 11 and 13). On the contrary, at station 3 and 7, where there were similar levels of light and nutriens, the productivity was one-third lower, fundamentally due to the poor light penetration (high K values).

Station 3 is nearest to the outlet from the pulp and paper factory, whose effluent, in addition to the characteristics noted in Table 1, has a deep chocolate-brown colour (aprox. 2000 colour-units Pt-Co). Most of the industrial and urban waste passes Station 7, mostly on the surface.

Photosynthesis is carried out more rapidly in the Southern part than in the North, as can be seen by the data of both chlorophyl "a" and C-14. This is due to the circulation in the Ria, and location of the effluent outlets.

This North/South difference is more marked at the surface than over the water-column as a whole. (The effluents are released at the surface, and are less dense than the seawater). If the values of chlorophyl "a" at station 4 in Fig. 6 and 7 are observed, they can be seen to clearly confirm this.

In Fig. 11, in which only surface photosynthesis in shown, the North/South differences are confirmed. (The exception of station 4 is due to the fact that, as previously mentioned, this is the place where most of the pollutants of the Ria penetrate.

In Fig. 12 and 13, the anomalies or deviations of the chlor. "a" values at the surface, are shown in relation to the water column as a whole. The role played by the tides is confirmed.

Levels of dissolved oxigen and particulate C and N reaffirm the above.

It is thought that the industrial effluents, in addition to inhibiting light penetration, contain chemical compounds, which reduce photosynthesis.

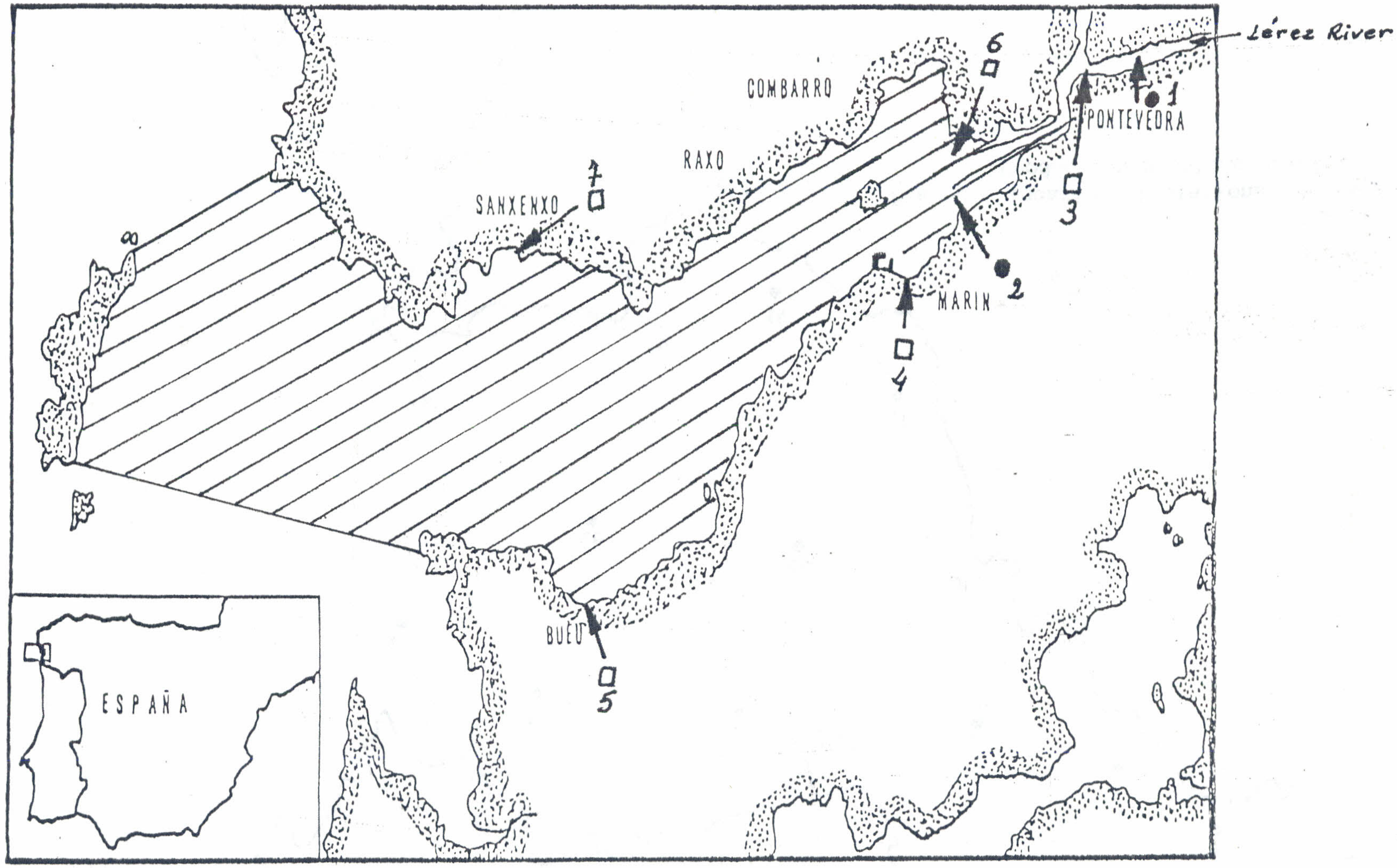

Fig. 1.- Ria of Pontevedra. Location of industrial and urban waste outlets.

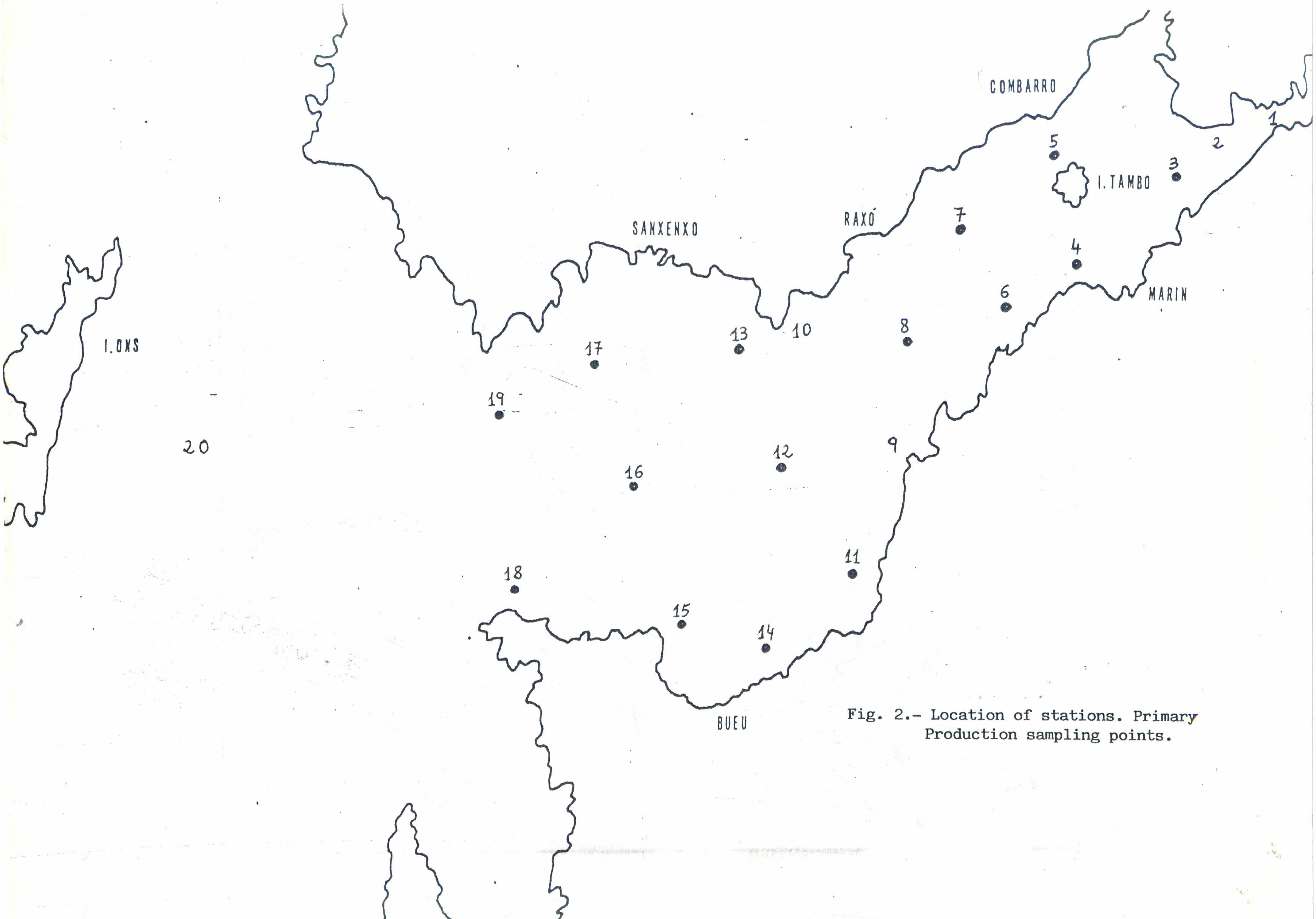

Fig. 2.- Location of stations. Primary Production sampling points.

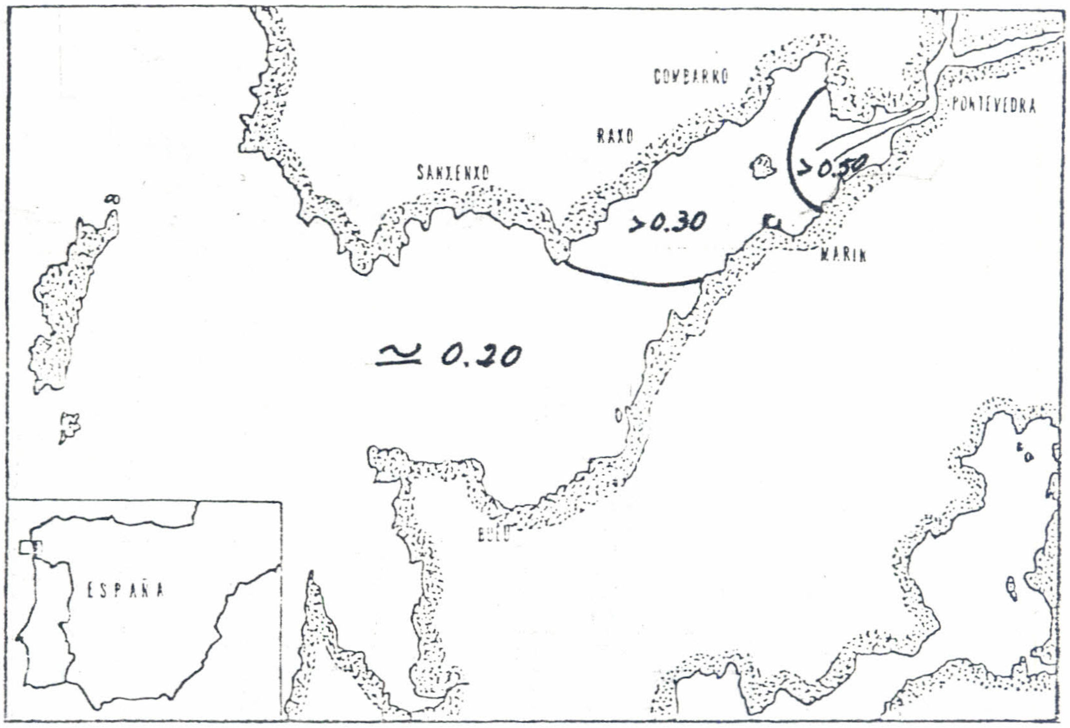

Fig. 3.- Extinction coefficients (-K) (rising tide)

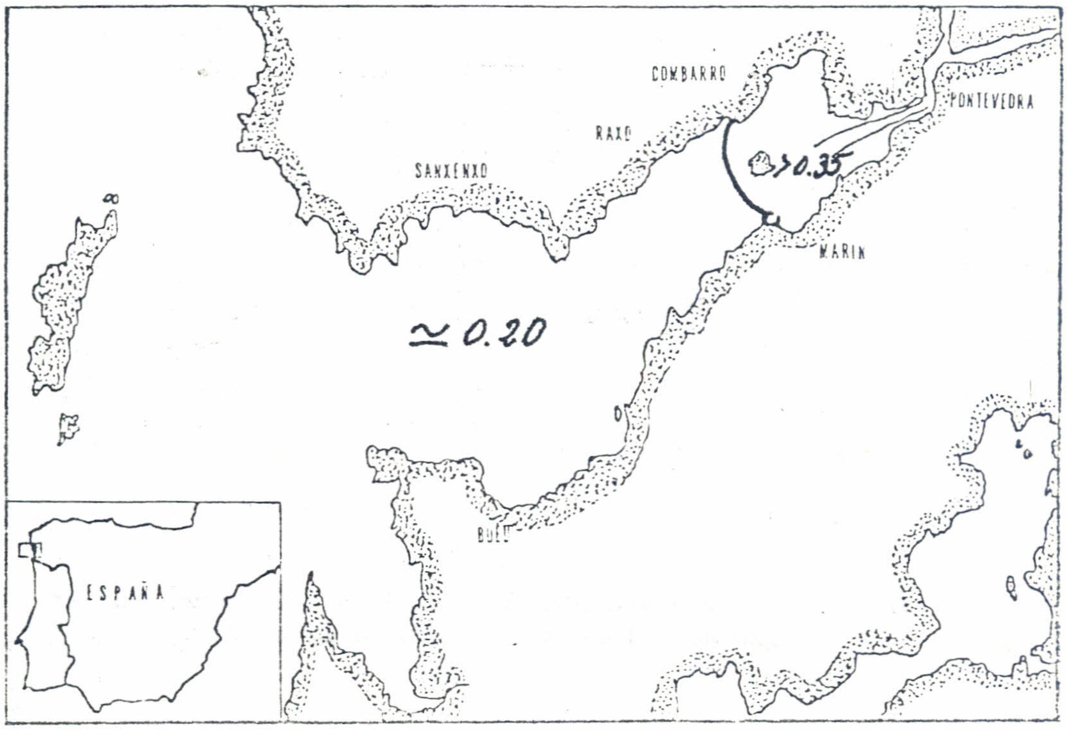

Fig. 4.- Extinction coefficients (-K) (falling tide)

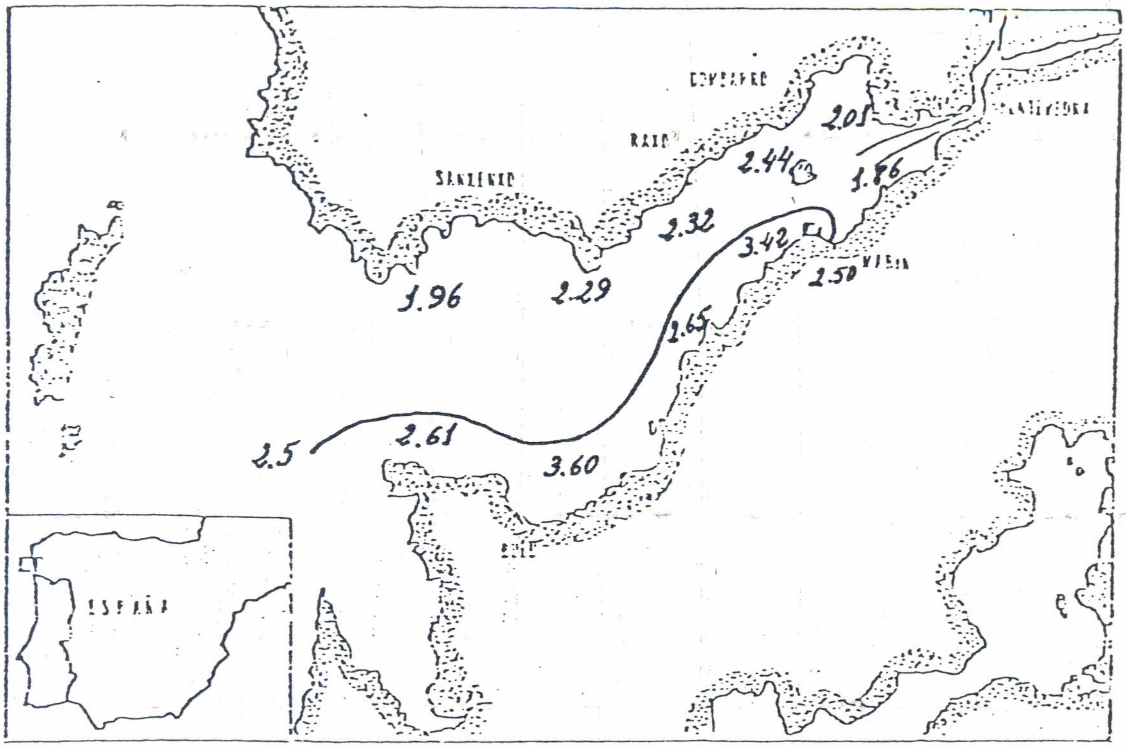

Fig. 5.- Depths in metres to which 50% incident radiation penetrates.

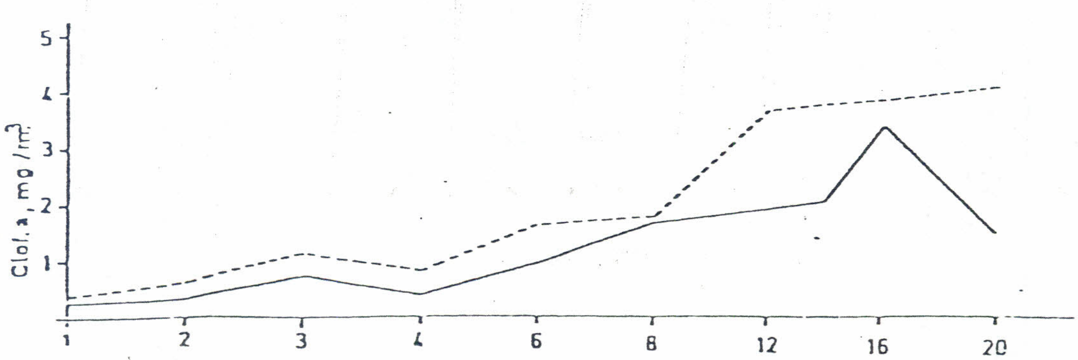

Fig. 6.- Maximun and minimun values of chorophyl "a" at surface along the central axis of Ria.

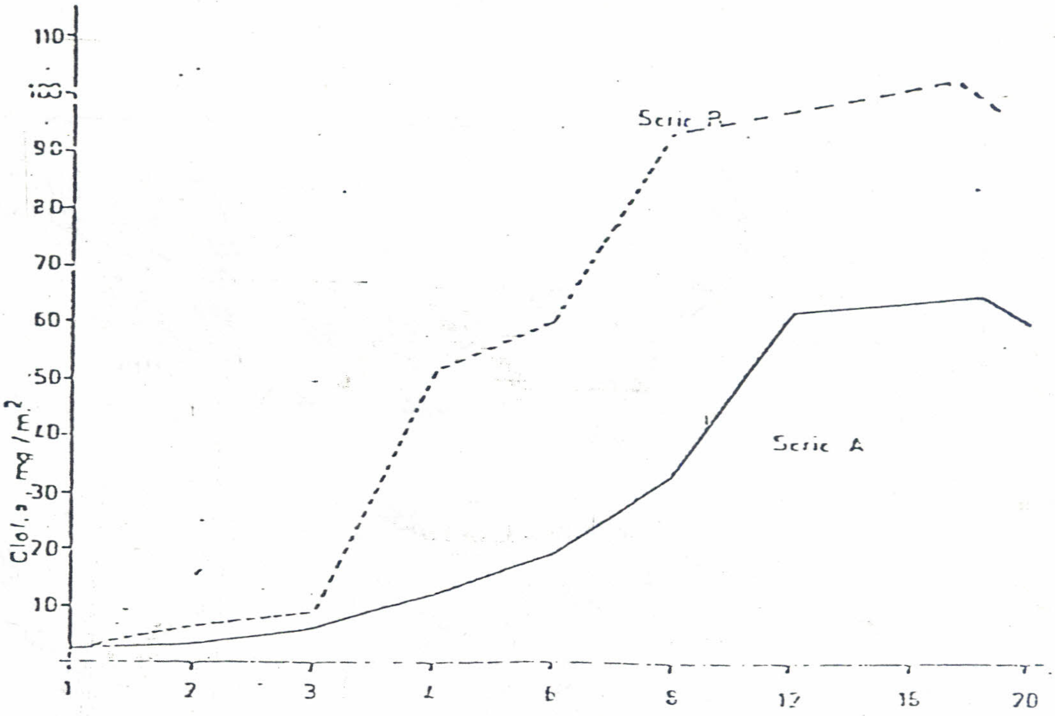

Fig. 7.- Values of Chor. "a" integrated along the water column, following the central axis of the Ria

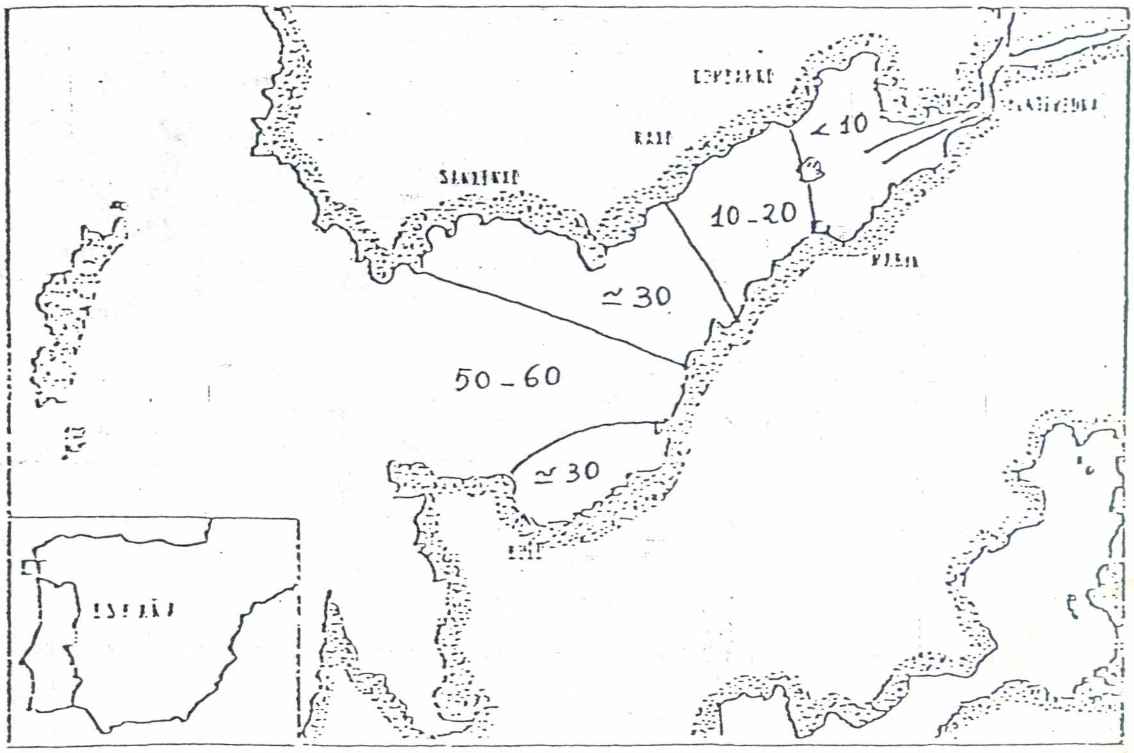

Fig. 8.- Values of Chlor. "a". (integrated) mgr./m^2.

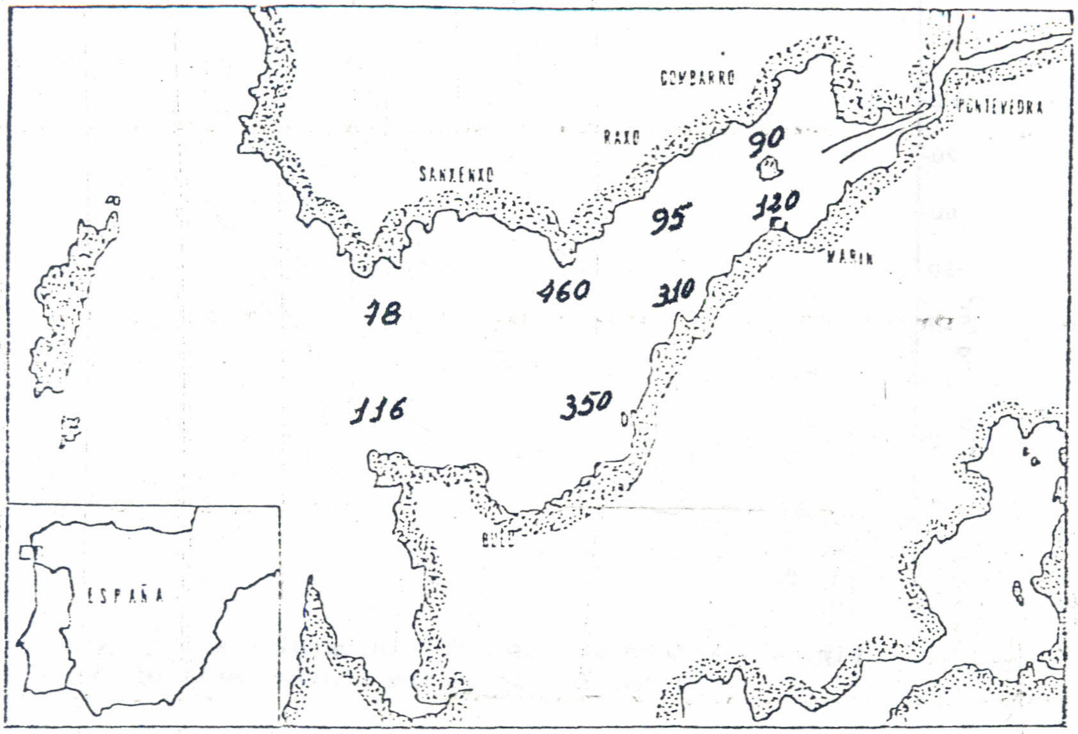

Fig. 9.- Photosynthesis mgC/m^2. day.

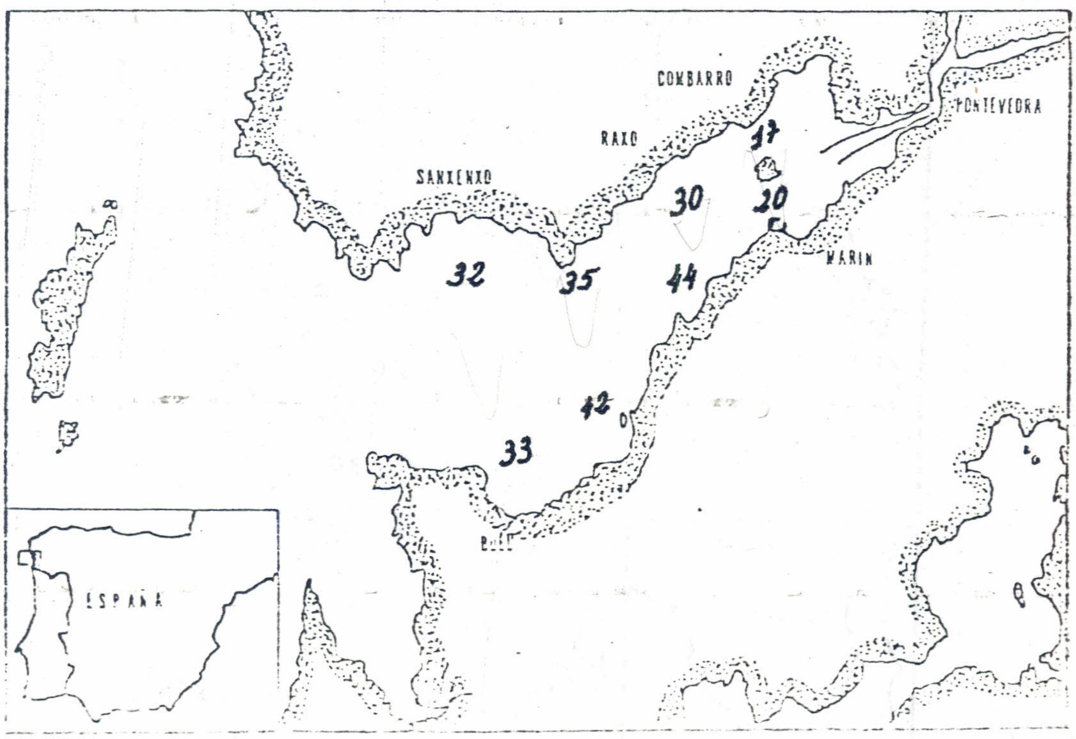

Fig. 10.- Chlor. "a" integrated. (mg.Chlor."a"/m^2)

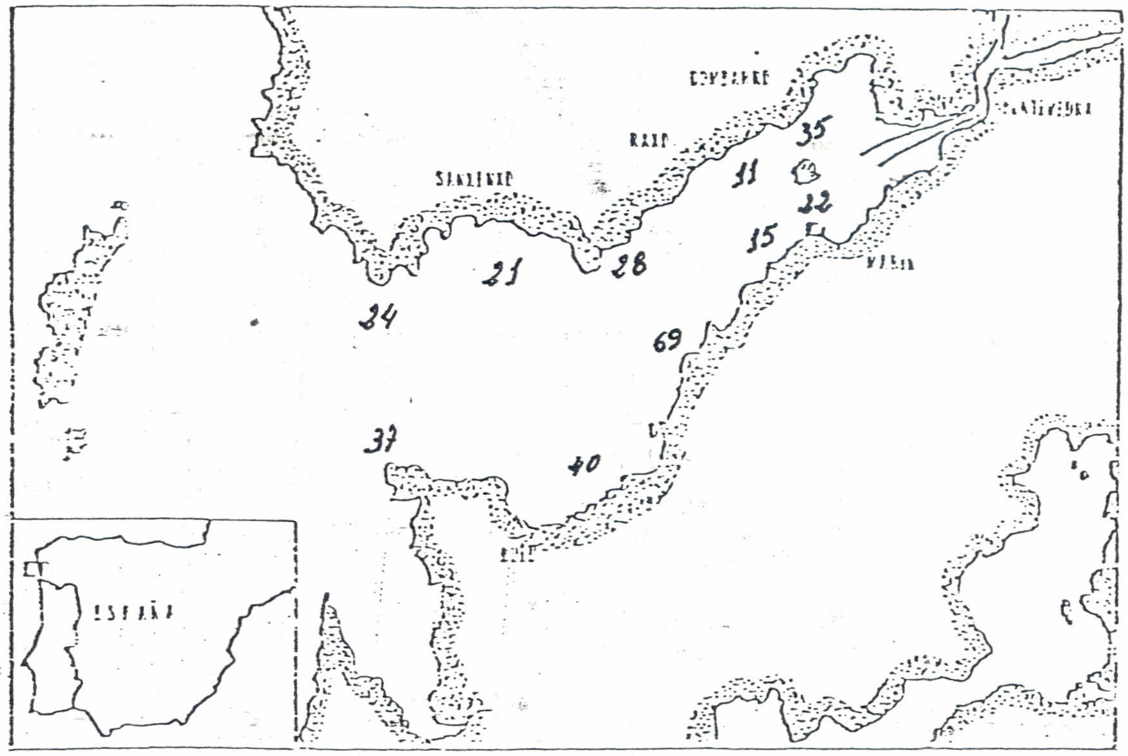

Fig. 11.- Photosynthesis at surface (mgC/m^3 hour)

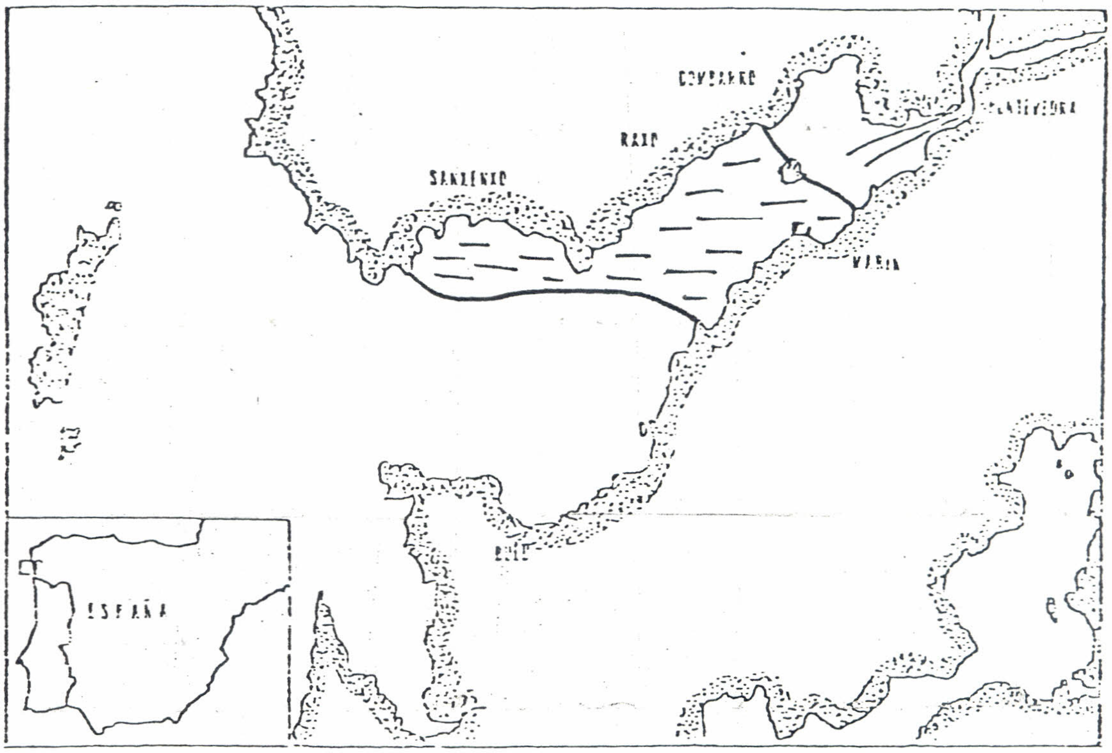

Fig. 12.- Chlorophila "a" anomalies at surface (falling tide)

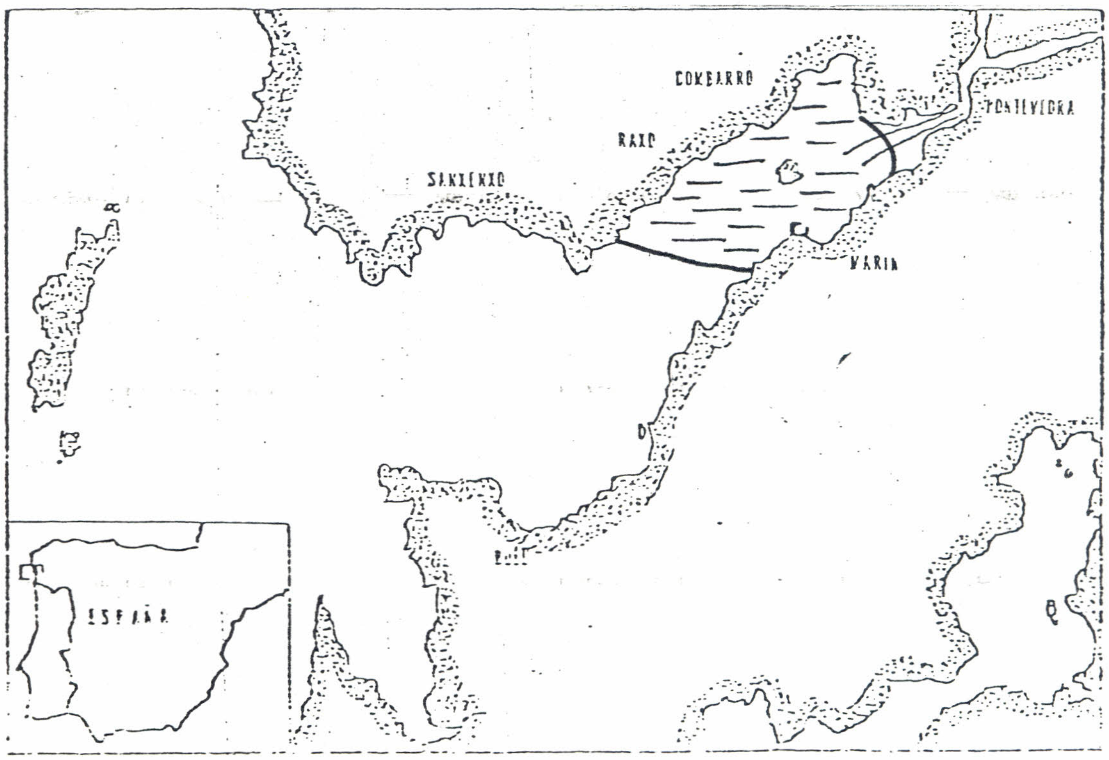

Fig. 13.- Chlorophila "a" anomalies at surface (rising tide)

T A B L E 1

Characteristics and amounts of principal polluting discharges.

Industry or Area	Suspended Solids Kg./day	Dissolved Solids Kg/day	$(BOD)_5$ Kg. O_2/day	(COD) Kg. O_2/day
Factory of Wood Boards ○ 1	69	192	141	288
Pulp of Paper Mill ○ 2	5903	83440	28590	59010
Pontevedra □ 3	3106	4401	1180	2130
Marin □ 4	324	540	131	309
Bueu □ 5	243	405	99	232
Poio □ 6	304	506	131	309
Sanxenxo □ 7	101	169	41	97

T A B L E 2

Some primary productivity data with C-14.

Station	P.P. mgC/m^2 day	NO_3^- in photic zone µat.g/l.	-K	Incident radiation. W/m^2
13	460	6-7	0,21	320
11	350	4-6	0,21	280
16	50	3-4	0,21	20
19	78	3-4	0,22	16
3	105	3-4	0,44	350
7	90	8-9	0,38	230