ENVIRONMENTAL STATUS OF A MULTIPLE USE ESTUARY, THROUGH THE ANALYSIS OF BENTHIC COMMUNITIES: THE SADO ESTUARY, PORTUGAL

Thesis submitted for the Degree of Doctor of Philosophy

**In the
University of Stirling**

by

Ana M. J. Rodrigues

**Department of Biological and Molecular Sciences
University of Stirling**

January 1992

To my Mother and Father

To Victor and Sara

DECLARATION

The work reported in this thesis is the result of my own investigations carried out at Laboratório Nacional de Engenharia e Tecnologia Industrial - LNETI, Lisbon, Portugal. It has not been nor will be submitted concurrently in candidature for any degree, in this or any other university.

Ana Maria Jesus Rodrigues

Ana Maria de Jesus Rodrigues

Acknowledgements

I wish to thank Professor V. Simão, President of LNETI, for giving me the opportunity of undertaking this work. I am grateful to Dr. M. C. Peneda, Head of Department, for her agreement to this work and her stimulus throughout the study.

To Dr. T. H. Pearson and Dr. D. McLusky, my most sincere thanks for their invaluable guidance, stimulating discussions, manuscript comments, and their friendship which was fundamental in some stages of this work.

Several specialists identified or confirmed some doubtful specimens from the Sado macrofauna. I wish to express my gratitude to Drs. J.-C. Dauvin, Susan Chambers, J. van Aartsen, P. Garwood, F. Pleijel, P. A. Ruzafa, P. Cunha, M. Antunes, D. Heppell, D. George, Alex Muir, C. Watson Russel, P. Knight-Jones, M. Pettibone and K. Fauchauld. My thanks to Dr. D. Newberry, with whom I discussed some data treatment methods, particularly Twinspan, and to J. McArthur for his invaluable help with the 3D colour figures presented in this thesis.

I am most grateful to Prof. R. Neves for his prompt interest and invaluable help on the calculation of original hydrodynamic data, and comments on the manuscript sections related to this subject.

I am also indebted to my colleagues of the physico-chemical group, in particular to Dr. F. Duarte, for allowing me to use unpublished data. The several collegues who participated on the sampling survey and laboratory work are gratefully acknowledged, especially J. C. Santos and M. Machado.

I wish to express my gratitude to INVOTAN, for the financial support given to this thesis.

Thanks to Jo Pearson and Margaret Barnes for their friendship during my stays in Scotland and to Maria Manuel and Carlos, who "adopted" Sara whenever Victor and I couldn't be present.

Victor, my colleague and life companion, shared the best and the worst moments of this thesis. His enthusiasm, encouragement and stimulating discussions were always present and he is a part of much of this work.

Abstract

This work on the Sado outer estuary (western coast of Portugal) considers its bio-sedimentary characterization, and evaluates the prevailing hydrophysical and sedimentary environmental conditions. The quality status of the estuary is discussed. The thesis is based on the analysis of superficial sediments and benthic macrofauna collected from 133 sites, and on hydrodynamical data obtained from a mathematical model.

The environmental variables considered were the superficial sediment temperature, granulometry and organic matter content, together with the water current velocities, flow and shear stress. The macrofaunal characterization and the analysis of the state of disturbance was based on a study of the composition, structure and spatial distribution of faunal assemblages and their relationship to the prevailing environmental conditions.

The Sado was shown to be inhabited by an abundant and diversified fauna with high biomass. Two major faunal assemblages have been identified, a marine and an estuarine community, separated by a transition region. The estuarine community comprises the majority of the area and contains important subdivisions. The regions identified have been shown either to be controlled by anthropogenic inputs or to reflect mainly the effects of natural forces.

The main structuring factors influencing the benthos are the hydrodynamic conditions, coupled with sediment type, and organic matter of natural and anthropogenic origin. Sedimentary organic enrichment effects have been noted in all the areas studied and in general the Sado outer estuary reveals signs of eutrophic conditions. In the more disturbed regions the macrofauna data also suggest chronic toxicity effects.

Although disturbance effects due to anthropogenic inputs are suggested through the biosedimentary approach, the estuary as a whole can not be considered badly polluted. However, defaunated, impoverished and over-enriched areas, appear as a result of localised severe pollution indicating the need to improve effluent treatment systems.

The methodological approach followed in this study has been shown to be effective in assessing the quality status of the Sado outer estuary. Multivariate and direct gradient analysis proved to be very useful methods and a detailed analysis of the macrofaunal species has been shown to be effective in the detection of organic enrichment effects in some of the areas.The extreme aspects of the gradients were identified by all the analytical techniques, but the univariate methods were shown to be poor at discriminating the more subtle effects.

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

CHAPTER 2

SADO ESTUARY

CHAPTER 3

METHODOLOGY

CHAPTER 4

ENVIRONMENTAL VARIABLES: HYDRODYNAMICS AND SEDIMENTOLOGY

CHAPTER 5

MACROFAUNA CHARACTERIZATION

CHAPTER 6

MACROBENTHOS-ENVIRONMENT RELATIONSHIPS

CHAPTER 7

DISCUSSION

CHAPTER 1

INTRODUCTION

1.1 - GENERAL BACKGROUND TO THE PRESENT STUDY

Estuaries are included amongst the most productive ecosystems of the biosphere (Odum, 1971, Amanieu & Lasserre, 1981) and have long been a focus of human settlement and development for transportation facilities, waste disposal and recreational purposes. This has transformed estuaries into multiple use systems which have increasing difficulties to reconcile all the demands made on them. Conflicts of usage occur between those activities which need a more or less natural functioning of the estuarine ecosystem like fishing, mariculture, amenity and conservation, and those for which ecosystem quality is of little interest, like shipping, industrial purposes and waste disposal (Wilson, 1988, McLusky, 1989). In an attempt to identify, ameliorate and solve the problems posed by the multiple use of estuaries, the acquisition of greater knowledge on estuarine systems, especially in relation to pollution effects, has become a necessity in recent decades.

Estuaries present natural gradients which are mainly related to the constant mixing of fresh and salt water. Compared with the open sea, they are naturally heterogeneous environments varying remarkably in physical, chemical and biological characteristics (Kennish, 1986, Wilson, 1988, McLusky, 1989). In addition to these natural gradients others, resulting from anthropogenic activities, may be established thus increasing the natural environmental stress to which species have to adapt (e. g. Pearson & Rosenberg, 1978, Reish, 1984).

The responses of organisms and communities to increasing environmental stress evolved from the detection and adaptative response of individual behavioural and metabolic changes, to genetic adjustments of individual species populations, culminating in species replacement and community succession (Pearson & Rosenberg, 1978, Pearson & Blackstock, 1983, Blackstock, 1984). Assessment of effects of any particular environmental disturbance could be evaluated by analysing the biotic changes at these various levels. However while the monitoring of the behavioural and metabolic changes and population genotypic variability are mainly suitable to assess immediate or short term responses, analysis of changes in the community structure allows the assessment and monitoring of long-term and wide scale effects (Pearson & Rosenberg, 1978, Pearson, 1980).

Several types of materials enter estuaries as a result of human activities, of which organic wastes comprise the greatest volume (Clark, 1986). Pollution resulting from organic enrichment is nowadays the most common cause of pollution in coastal ecosystems (Pearson & Rosenberg, 1978, Rosenberg, 1985). For this reason much of the research on the biological effects of pollutants has been focused on the assessment and monitoring of the effects of organic enrichment. Most of the studies are directed to assess long-term effects and thus focused on changes at the community level. Sediment and its benthic macrofauna are the components of the ecosystem usually analysed. Their importance and usefulness, because of their stability and longevity, in contrast to that of pelagic organisms, has been clearly demonstrated by many workers (e. g. Soulsby *et al.*, 1985, Bilyard, 1987, Warwick, 1988a, Larsen & Jensen, 1989, Rees *et al.*, 1990).

The benthic macrofauna is most generally chosen for study because sediments represent, in most of the cases, the final repository for contaminants, because benthic macrofauna is long-lived (generally > 1 year) and sedentary (thus acting as an integrator over time of the effects of particular contaminants and/or disturbances). More is known of the general biology of macrofaunal species, in comparison with other benthic organisms (meio and microbenthos), and taxonomic keys are also available for most of the groups (Rees *et al.*, 1990).

Benthic community change in response to pollution is a very complex process which makes the establishment of predictive response models difficult. This difficulty is increased by the fact that the separation of effects due to anthropogenic and natural inputs is not always straightforward. However, successional sequences resulting from organic enrichment and/or disturbance have been defined for a range of habitats and communities and used as general descriptive predictive models of environmental disturbance effects (Pearson & Rosenberg, *op. cit.*, Rhoads *et al.*, 1978, Hily, 1984).

The sequences resulting from increasing organic enrichment, particularly the fluctuations of Species richness, Abundance and Biomass referred to in the SAB model proposed by Pearson & Rosenberg (*op. cit.*) have been reported from many locations in Northern Europe (e. g. McLusky, 1982, Pearson *et al.*, 1986, Elliott & Kingston, 1987, Gray *et al.*, 1990), Southern Europe and the Mediterranean (e. g. Bellan *et al.*, 1980, Hily, 1984, Hily *et al.*, 1986), the Northern American Atlantic coast (e. g. Wildish *et al.*, 1979, Wildish, 1983, Wildish *et al.*, 1986), and Pacific coast (e. g. Reish, 1980, Bascom, 1982, Chapman *et al.*, 1987) and in Asia (e. g. Thompson & Shin, 1983, Tsutsumi *et al.*, 1991), clearly suggesting universal response of benthic communities, and thus supporting the basic conceptions underlying the SAB model.

The complexity of the response of benthic communities to environmental disturbance precludes any simple or rapid method of assessing pollution effects and the utility of using a range of techniques to analyse biotic response to environmental changes has been proposed (Gray *et al.*, 1988, Underwood & Peterson, 1988, Rees *et al.*, 1990).

The sampling methods widely used to obtain macrofaunal data are still largely based on the use of grab samples since the most recent techniques (underwater video or television, REMOTS) (Holme & McIntyre, 1984, Rhoads & Germano, 1982, 1986) still do not allow the collection of quantitative data for the macrofaunal communities.

For data treatment the several techniques proposed to assess the response of macrofaunal communities to an organic gradient range from the simple analysis of species richness, abundance and biomass fluctuations (Pearson & Rosenberg, *op. cit.*), to the identification of indicator species or higher taxa (Pearson & Rosenberg, *op. cit.*, Gray & Pearson, 1982, Pearson *et al.*, 1983) to the study of community structure patterns, based on abundance and/or biomass distributions among species and trophic groups (e. g. Sanders, 1968, Hulbert, 1971, Pearson, 1971a, Frontier, 1976, 1977, 1985, Gray, 1979, Gray & Mirza, 1979, Shaw *et al.*, 1983, Warwick, 1986, Warwick *et al.*, 1987) or to various multivariate statistical analyses, using abundances of either species or higher taxa (e. g. Schwinghamer, 1988, Warwick, 1988c, Warwick & Clarke, 1991). There is however some controversy about the most useful treatment methods and the kind and amount of data which must or is enough to be used to assess pollution effects (e. g. Gray, 1979, 1983, Gray & Mirza, 1979, Shaw *et al.*, 1983, Lambshead & Platt, 1985, Warwick, 1986, 1988c, Warwick *et al.*, 1987, Kingston, 1987, Beukema, 1988, Schwinghamer, 1988, Kingston & Ridle, 1989, Ferraro & Cole, 1990, Meire & Dereu, 1990), indicating the need of more interdisciplinary research effort, namely on the basic biology of species, on the basic knowledge of ecological processes, on the fate and effects of pollutants, and on modelling (Gray, 1985, Fenchel, 1987).

The present work has been developed in the Sado estuary, western coast of Portugal, a multiple use system, which supports a variety of activities with different ecosystem requirements, some of them incompatible. Its most important use is for industrial and urban waste disposal purposes and harbour associated activities, but it also has two natural reserves, and supports recreational activities, mariculture and fishing. In the future, several new industries will be developed which will increase the stresses already imposed to the estuary. However some industrial units are presently installing more efficient effluent treatment systems in an attempt to limit the effect of discharges on the Sado system. It is hoped that this study will provide the baseline information against which the effectiveness of such remedial measures will be judged.

The most comprehensive studies on the Sado estuary developed before this work, were related to the physico-chemical characteristics of the water column and hydrodynamics (Wollast, 1978a, 1978b, 1979, Ribeiro & Neves, 1982, Neves, 1985a, Ferreira & Neves, 1987), the geochemistry and geomorphology (Quevauviller, 1987), metals and organochlorines (Vale and co-workers, 1988-

1991) and also several ecological studies conducted by Peneda and co-workers to assess the impact of a thermal power plant (Peneda, 1980, 1981, Peneda *et al.*, 1982a, 1982b). Previous investigations of the sedimentary ecology of the estuary have been concerned with small scale temporal and spatial variability (Rodrigues, 1982), with intertidal communities (Costa, 1988, Rodrigues *et al.*, *in press*) or were less comprehensively designed for the assessment of its spatial heterogeneity (Pinto, 1982, Monteiro Marques, 1982, Cancela da Fonseca *et al.*, 1987). There was thus very little information available on the general ecology and of the quality status of the estuary, prior to the present study.

During 1986/87, Peneda and co-workers, in the Portuguese National Laboratory of Technological and Industrial Engineering, LNETI, launched a study to analyse the effects of the industrial effluents in the outer Sado estuary, involving the characterisation of industrial effluents (Catarino *et al.*, 1989a to 1989g), ecotoxicological bioassays (Picado, 1991), the physico-chemical characteristics of the water column (Duarte & Henriques, 1991), the faecal contamination (Baeta-Hall, *in prep.*), the fish populations (Antunes *et al.*, 1991), the plankton populations (Santos, 1990, Duarte, *in prep.*) and the benthic component of the system (Rodrigues & Quintino, 1991a, present work). This study is derived from the latter part of this programme.

1. 2 - AIMS OF THE PRESENT WORK

The principal objective of this work is concerned with the identification of the spatial variability, or gradients, in the composition and structure of the estuarine benthic communities, while considering and integrating the effects of both natural and man-induced disturbance on those gradients.

Although variability in the sedimentary ecology of estuaries has been extensively studied in a variety of areas (e. g. Gray, 1985), the current concepts underlying the definition of "normal", the deviation from this situation and the evaluation of the respective significance of damage and cause, are far from being final. Moreover, the distinction between induced effects on faunal communities by natural or anthropogenic stress is difficult to quantify (Wilson,1988, McLusky, 1989, Elliott, 1983), as is the separation of the effects, for example, of inputs of organic and inorganic material, which are usually introduced together through the same input (Pearson & Rosenberg, 1978).

The objective of this thesis is to achieve in a detailed manner and as objectively as possible, a diagnosis of the present quality status of the estuary, knowing both the human pressures to which it is submitted, particularly along its northern margin, and the ability of benthic communities to serve such a diagnostic purpose (see among others, Bilyard, 1987, Warwick, 1988a, 1988b, Rees *et al.*, 1990).

It was designed to acquire a sound baseline of biological knowledge of the area for future use as reference material either in the assessment of the effects of possible multiple uses projected for this important estuarine system of the Portuguese western coast, or for the establishment of more specific research programmes directed to the analysis of pollution effects.

Also, it was intended to provide information for the establishment of realistic quality standards and the definition of future monitoring programmes, based not only on direct effects of human health, but on the balance of ecosystem functioning (estuarine quality) and ecosystem use (McIntyre, 1984, 1986, Segar & Stamman, 1986, Underwood & Peterson, 1988, Elliott & O'Reilly, 1991).

This broad purpose obviously needs more effort than that devoted to a study of the sedimentary macrofaunal communities, but the Sado estuary was, and is being studied by several workers, covering a variety of fields from hydrodynamic and physical research to chemical and biological subjects. During the course of this survey, other colleagues were analysing physico-chemical and microbiological parameters of the water-column and industrial effluents, studying the plankton communities, the demersal fish populations and conducting ecotoxicological bioassays. When appropriate the additional knowledge obtained by such colleagues has been used to complement the present study.

CHAPTER 2

SADO ESTUARY

2.1 - GENERAL CHARACTERISTICS

The Sado estuary, the second largest estuary in Portugal, is located on the Setúbal Peninsula and discharges to the Atlantic Ocean bordering Setúbal city (northern side), located some 40-50 Km south of Lisbon, and the Troia Peninsula (southern side).

The estuary comprises two main geographic regions (figure 2.1):

- Region I, the outer estuary, with a surface area of approximately 140 Km^2, a mean depth of 10 meters and a complex geometry, and
- Region II, inner estuary, which comprises a narrow channel of approximately 20 Km length and mean depth of 1 meter (Alcácer channel).

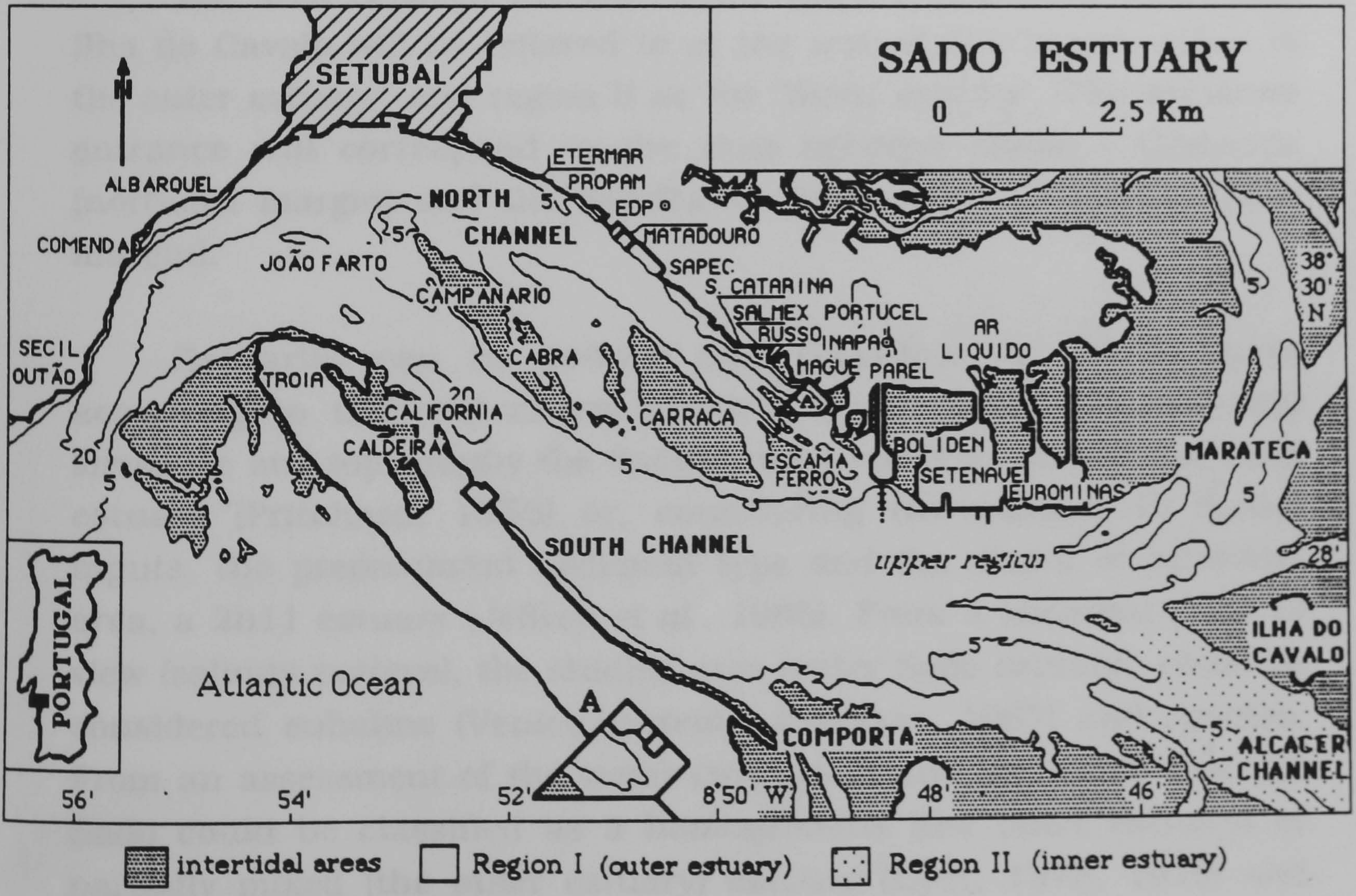


Figure 2.1 - Sado Estuary. General bathymetry (depth in meters) and geometry.

The inner part of region I, Comporta (in the southern channel) and Marateca (in the northern channel) (*cf.* figure 2.1), is shallow, and tidal flats comprise almost 50% of the total area. The outer area of region I, extends from the Outão, near the entrance of the estuary, to Ilha do Cavalo, landward, and is partially divided along its longitudinal axis by intertidal sandbanks, which divide a northern channel, in general no deep than 10 meters from a southern channel where depths reach 25 meters.

The estuary communicates with the ocean by a narrow and deep channel, 2 Km wide with a maximum depth of 50 meters which is very important to the general pattern of the estuarine circulation.

The area covered by the present work corresponds to region I, excluding Marateca and Comporta and comprises approximately 65 Km^2. It is located between the coordinates 38°32' - 38°26'N and 8°44' - 8°56' W and has a main SE/NW orientation. It will be identified in the text as the "outer estuary".

The area between the end of the sandbank Escama Ferro and Ilha do Cavalo will be referred to in the text as the "upper region of the outer estuary" and region II as the "inner estuary". The estuarine entrance will correspond to the area between Outão - Comenda (northern margin) and the sandbank Cambalhão - Troia (southern margin).

Estuaries can be defined and classified in various ways according to different characteristics. By reason of its physical structure and topography the Sado estuary could be considered a bar estuary (Pritchard, 1955) or, considering the number of fluvial inputs, the predominant sediment type and the extent of intertidal area, a 2b11 estuary (Jeffrey *et al.*, 1985). From a chemical point of view (salinity pattern), the studied area (outer Sado estuary), could be considered euhaline (Venice system - Carriker, 1967) and positive. From an assessment of the water circulation and the sediments, the Sado could be classified as a homogeneous (the outer estuary) or partially mixed (the inner estuary) estuary (Dyer, 1973, 1979) and finally, from the point of view of ecosystem energetics it could be considered an emerging system (Odum & Copeland, 1974).

2.2 - SADO ESTUARY USAGE

In the present century the Sado estuary has evolved from an ecosystem used almost exclusively for fishing and bivalve exploitation, towards a multiple usage system, with a strong industrial component.

The exploitation of the Portuguese Oyster, *Crassostrea angulata*, almost extinct since 1978, was previously a very important activity in the Sado estuary. Its maximum production was almost 10000 tons and in 1971 it was still of 6016 tons, but has thereafter decreased precipitously (Carrapiço & Costa, 1978 *in*: Costa, 1988).

Nowadays different areas can be delimited according to their different estuarine uses (figure 2.2). The Sado estuary includes two natural reserve areas, one near the mouth, in the northern margin, the Natural Park of Arrábida, and in its inner reaches the Natural Reserve of the Sado estuary, includes parts of the Tróia Peninsula, Comporta, Alcácer channel and Marateca. Inside the Sado estuary reserve mariculture activities and fishing bait exploitation (*Marphysa sanguinea* and *Diopatra neapolinata*) are allowed, being the latter also developed in the sandbank Carraca.

In the intertidal regions of the inner estuary some agricultural activities are developed, mainly of rice cultures which make use of pesticides and herbicides. The Troia Peninsula offers areas of coastal recreational facilities and is used for a range of leisure interests. Fishing activity occurs throughout the estuary, but it is, however, of decreasing importance as industrial activities are being developed.

The most important utilization of the estuary is for industrial and urban waste disposal purposes and for harbour associated activities (ship movement, ship repairing, painting and breaking). The harbour and all the industries are located along the northern margin of the outer estuary.

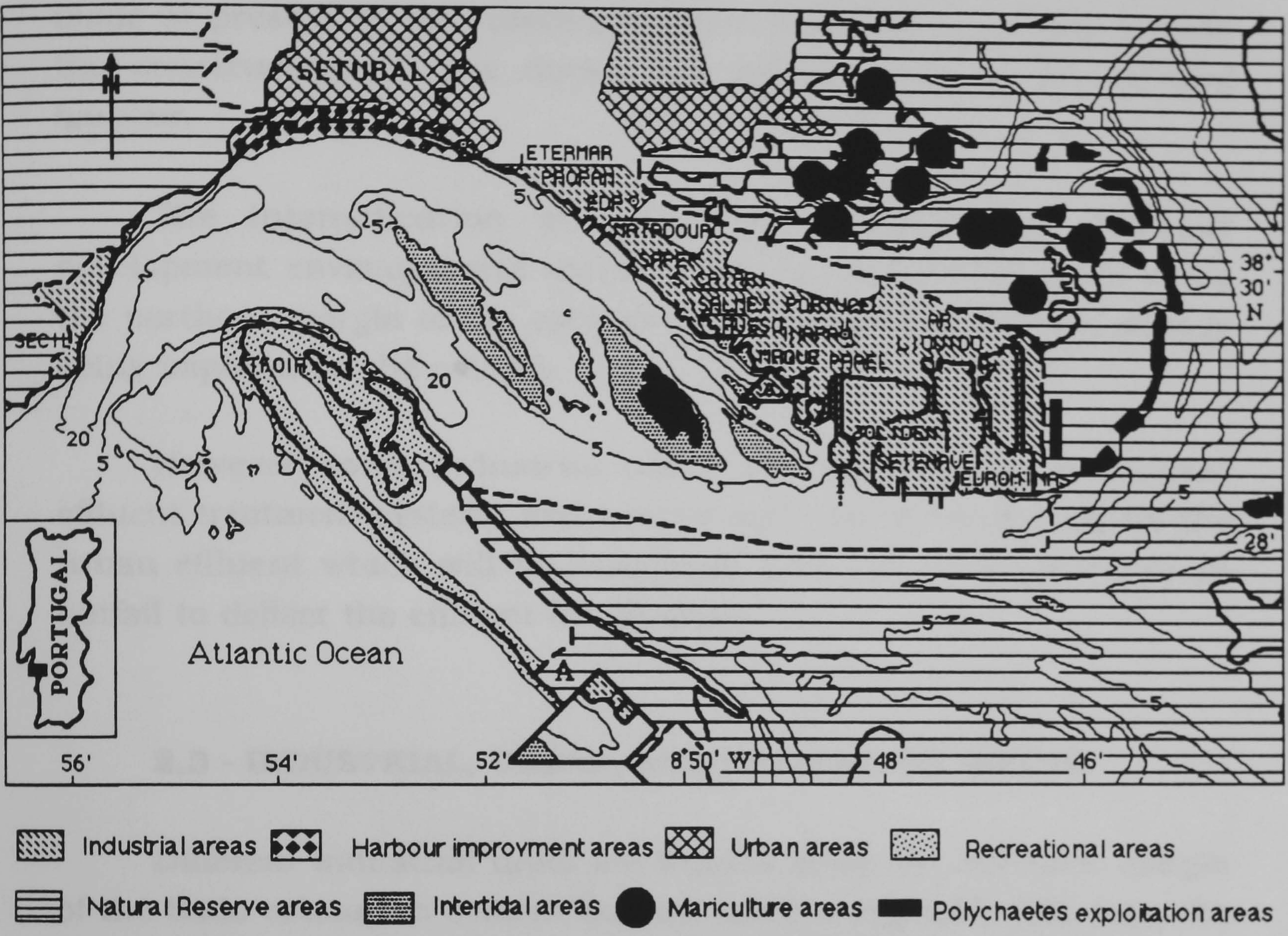


Figure 2.2 - Sado Estuary use.

Thus, the Sado estuary is clearly a multiple use system, which supports a variety of activities with different ecosystem requirements, some of them incompatible. The greatest incompatibilities arise between fishing, mariculture, amenity and conservation, which depend to a greater or lesser degree on the maintenance of natural estuarine conditions, and industrial waste disposal which is system independent and usually has a negative effect on water, sediments and biotic communities (Wilson, 1988).

In the past some areas of the estuary have been reclaimed for industrial settlement. In the future, and as a result of a predicted increase in the development of the Setúbal Peninsula, several new industries will be developed. Amongst others a new natural gas terminal will be located near Setenave and a new harbour for a motor industry will be built. This will necessarily promote, besides the construction of the harbours, the need for dredging activities to allow the movement of ships. Also, important improvements are being made at present to the existing harbour installations which include the construction of new docks and enlargement of the existing harbour.

The intensification of industrial activities and harbour development envisaged will increase the reclamation of areas along the northern margin of the estuary and increase the stresses already being imposed on the estuary

However some industrial units are installing more efficient effluent treatment systems and a treatment unit is being built for the urban effluent which will be associated with the construction of an outfall to deflect the effluent far off-shore.

2.3 - INDUSTRIAL, URBAN, AND SADO RIVER INPUTS

Different industrial units are located along the northern margin of the Sado estuary: a cement factory, Secil; a vegetable oils unit, Sta Catarina; the Municipal abattoir (Matadouro); pulp and paper mill industries, Portucel, Inapa and Parel; a yeast factory, Propam; chemical products processing units, Arliquido (producing oxygen, nitrogen, argon and acetylene) and Sapec (producing fertilizers, pesticides, animal food, sulphuric acid); a thermal power plant, EDP (Electricidade de Portugal); and finally industrial units related with machinery and mechanical construction, including ship breaking, repairing and painting: Russo, Mague, Setenave, Boliden, Etermar. Another metallurgical industry on the estuary, Eurominas, had metallic wastes stored in the open air.

The effluent of Setúbal city is discharged into a small river, Ribeira do Livramento, and is a mixture of domestic and industrial wastes the latter resulting from small industries mainly related with cars repairing.

A characterization of effluents discharged to the estuary was made during 1988 by researchers of the LNETI/DEII, for seven of these industrial units (Propam, abattoir, Sapec, Sta. Catarina, Inapa+Parel and Portucel) and for the urban sewage outfall (Catarino *et al.*, 1989a to 1989g, Mendonça & Picado, 1989). The annual load to the estuary from these effluent discharges is presented in table II.1, and was calculated from the results presented in the various reports (Catarino *et al.*, *op. cit.*, Mendonça & Picado, *op. cit.*).

		Propam	**Abattoir**	**Sapec**	**S.Catarina**	**Inapa+Parel**	**Portucel**	**Urban**
BOD5	(t/y)	8020.60	11.10	126.40	65.00	488.00	6045.50	3073.00
S S	(t/y)	235.00	9.80	962.10	8.00	1156.00	4206.30	1811.00
Phosphates	(t/y)	-	-	119.90	-	-	-	96.10
Nitrites	(t/y)	-	-	0.04	-	-	-	1.20
Nitrates	(t/y)	-	-	3.30	-	-	-	0.13
Amonia	(t/y)	7.30	0.41	491.80	3.40	0.77	9.50	372.00
Toxicity (EC50-24h)	(%)	63.10	71.00	13.50	n.t.	100.00	n.t.	46.40
Metals	(Kg/y)							
Cr		2.80	0.24	88.80	1.20	59.40	3600.00	11.30
Fe		47.00	52.20	7400.00	25.20	3800.00	7600.00	9400.00
Ni		136.60	0.31	590.70	8.60	446.60	492.30	353.50
Cu		450.00	1.70	2500.00	-	77.80	394.40	724.40
Zn		726.00	2.60	5400.00	-	1500.00	172.20	1700.00
As		n.d.	0.07	3700.00	12.90	n.d.	27.10	97.00
Pb		33.02	0.11	391.40	3.20	104.90	120.10	136.10
Hg		1.80	n.d.	n.d.	n.d.	n.d.	n.d.	4.50

Table II.1 - Annual loads to the Sado estuary and associated toxicity of the industrial and urban effluents. n.d. - not detected. n.t. - not toxic.

Sado River Inputs

The Sado river is characterized by contrasting dry/wet season flows, which are particularly high during very wet winters, when the water discharge could reach 248 m^3/s, in contrast to the rest of the year when flows of 1-3 m^3/s are recorded. This results in riverine sediments being deposited in the estuary almost exclusively during winter (Castro *et al.*, 1990).

This situation was observed namely during surveys undertaken in 1987/1988 and reported by Castro *et al.* (1990) and Ferreira *et al.* (1989). These authors pointed out that during most of the year the concentration of fluvial suspended matter varied from 5 to 22 mg/l increasing in winter to 84 mg/l during runoff.

Castro *et al.* (1990) also analysed the PCB and DDT concentration in the river estimating that the annual river inputs to the estuary was approximately $16x10^3$ tons of sediments, 0.3 Kg of PCB and 0.3 kg of DDT, with 94% of sediments, 84% of PCB and 98% of DDT discharged between December and February.

These authors noting an enrichment of DDT in runoff derived material, considered as its source the erosion of agricultural soils of the Sado drainage basin, where this compound was used. The source of PCB was considered to be mainly atmospheric deposition, since no major industry or city is located in the riverine system.

Castro *et al* (*op. cit.*) suggested that the retention period of DDT and PCB, before entering the outer estuary, is very short, estimated in in the case of DDT to be 2 months.

A study of the distribution of these two compounds in the sediments of the outer and inner estuary (Castro & Vale, 1991) showed clearly the highest concentrations of PCB in the outer estuary to be mainly in the industrial zone and the highest concentrations of the DDT to be in the upper part of the inner estuary. This clearly accords with the main sources of PCB and DDT, being, the industrial effluents in the outer estuary and the agriculture activities in the riverine system, respectively.

The annual loads into the estuary through the river estimated for the hydrological year of 1987/1988 are shown in table II.2.

SADO RIVER (1987/1988) (Annual loads)		
SS	(t/y)	16000.00
DDT	(Kg/y)	0.30
PCB	(Kg/y)	0.30
Metals	(t/y)	
Fe		963.00
Cu		9.00
Zn		239.00
Mg		111.00
Cd		0.46

Table II.2 - Annual loads to the outer estuary through the river. Sources: metals - Vale & Cortesão *comm. pers.*; SS, DDT, PCB - Castro *et al.* (1990).

2.4 - HYDRODYNAMICS

Several authors have contributed to the present knowledge of the hydrodynamics of the Sado estuary (Sobral, 1977, Wollast 1978a, 1978b, 1979, Ambar *et al.*, 1982, Ribeiro & Neves, 1982, Neves, 1985a, 1985b, 1986, Ferreira & Neves, 1987). These authors clarified several features of the water movement in the Sado estuary, in particular Neves (1985a, 1986), who developed the first hydrodynamic model for the tidal flow and residual circulation in this estuary.

Some of the characteristics of the Sado river and estuary should be emphasized:

Tides in the Sado estuary are semi-diurnal with a mean amplitude range of about 2 meters.

The entrance region is particularly important, being narrow and deep and with a very irregular bottom profile, causing not only the high current velocities in this region (1.5 to 2m/s) but also a considerable vertical homogeneity of the water column in the outer estuary (Sobral, *op. cit.*, Ambar *et al.*, *op. cit.*, Ribeiro & Neves, *op. cit.*). The river water flow is in general low being characterized by a torrential regime, with inputs during a "normal" winter which can attain more than 100 m^3/s and during the remaining of the year less than 10 m^3/s (Ambar *et al.*, *op. cit.*). The tide thus seems to be the driving force for water movement in the estuary and data obtained by the "Direcção Geral de Portos" in 1961, showed mean values for the water flow in the section "Tróia - Comenda", near the entrance of the estuary, of 2×10^4 m^3/s and 1×10^4 m^3/s, respectively during spring and neap tide (DGP, 1961 *in:* Neves 1985a).

A study by Sobral (1977) showed another characteristic of water movement in the Sado, namely the difference between the current velocity in the southern and northern channels, being stronger in the former. Moreover when the tide changes, the velocity vector at a station located in the middle of the section "Tróia -

Comenda", always turns to the North, and null velocity values are always first noted in the north channel.

A study by Ambar *et al.*, (*op. cit.*) of current velocities and vertical salinity profiles, agreed with Sobral's (*op. cit.*) results and also emphasized the slight stratification of Sado estuary.

Wollast (1978a, 1978b, 1979) focused on the general estuarine characterization (outer and inner estuary) in relation to salinity, temperature, dissolved oxygen, nutrients and some current velocities values. He showed that a lateral stratification occured in the outer estuary resulting from the differences between and within the two channels. According to the author, the lowest salinities in both channels at low tide were found near the margins. In the upper part of the outer estuary, a slight vertical stratification of the water column occured, becoming more evident on rainy days.

Wollast (1978a, 1978b, 1979) also found stronger currents and lower salinities at low tide, in the southern channel than in the northern channel. During the flood, water masses of lower salinity are found in the north channel. He explained this by suggesting that the water coming out through the southern channel during ebb tide will turn inwards through the northern channel during the flood.

From an analysis of the salinity values he concluded that during ebb tide the water from the river moves essentially in the direction of Setenave, on the northern margin, before turning in the direction of the peninsula of Troia, on the southern margin.

Between 1978 and 1981, Ribeiro & Neves (1982), undertook a sampling programme designed to characterize the hydrodynamics of the outer part of the estuary. This programme consisted of two phases: in the first phase a series of measurements of temperature, conductivity and dissolved oxygen were made in order to obtain horizontal profiles along the estuary and in the second phase a series of measurements of current velocities were taken at fixed stations during tidal cycles, at the surface and near the bottom.

They concluded that the outer estuary may be considered vertically homogeneous and showed that the values for the surface current velocity never exceed by more than 25% the values measured at 3m from the bottom. This vertical homogeneity could be attributable to the low input of river water, to the vertical mixing enhanced by strong tidal currents, to the bottom irregularity, mainly in the entrance, and finally to the low mean depth of this region of the Sado estuary (Neves, 1985a; Ribeiro & Neves, 1982). They also concluded that the water circulation inside the estuary is mainly due to tides, and the maximum current velocity (higher than 1m/s) occurs in the California region of the southern channel. The circulation is stronger in the southern channel and the direction of the residual circulation tends to be landward in the northern channel and seaward in the southern channel.

This data was further used for the calibration of a numerical hydrodynamic model (tide and residual currents), developed by Neves (1985a) and Ferreira & Neves (1987), which, in general, agrees with the experimental data.

The model shows that in the northern channel the flood tide lasts longer and begins earlier than in the southern channel. The flow over the sandbanks is very important for the northern channel hydrodynamics, being responsible for the differences between the temporal evolution of velocity in the two channels. In fact when the sandbanks are exposed, water circulation in the northern channel becomes more difficult and the transition between flood - ebb and ebb - flood is different in the two channels (Neves, *op. cit.*). This is the main reason for longer flood tides and weaker transient velocities in the northern channel.

Figures 2.3 and 2.4, obtained through this hydrodynamic model represent the transient flow in the estuary (= transient velocity x depth = m^2/s) and show this circulation pattern quite clearly. 3.02hours after high water (figure 2.3) the water moves seawards both in the southern and in the northern channel, showing higher transient flows (and velocities) along the southern channel. In the shallow areas of the upper part of the estuary, the transient flows are still low.

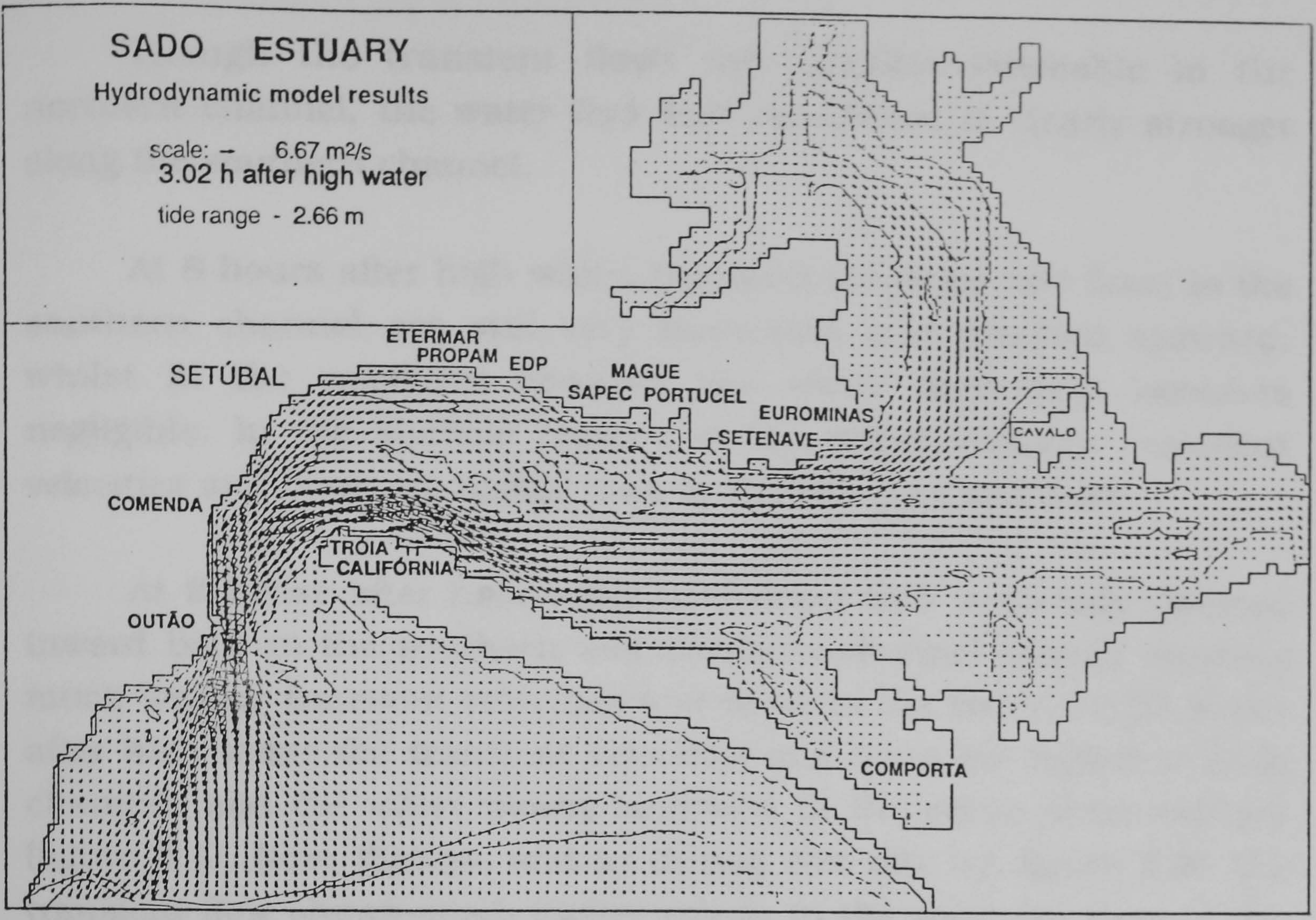


Figure 2.3 - Sado Estuary. Transient flow 3.02 hours after high water (after Neves, original).

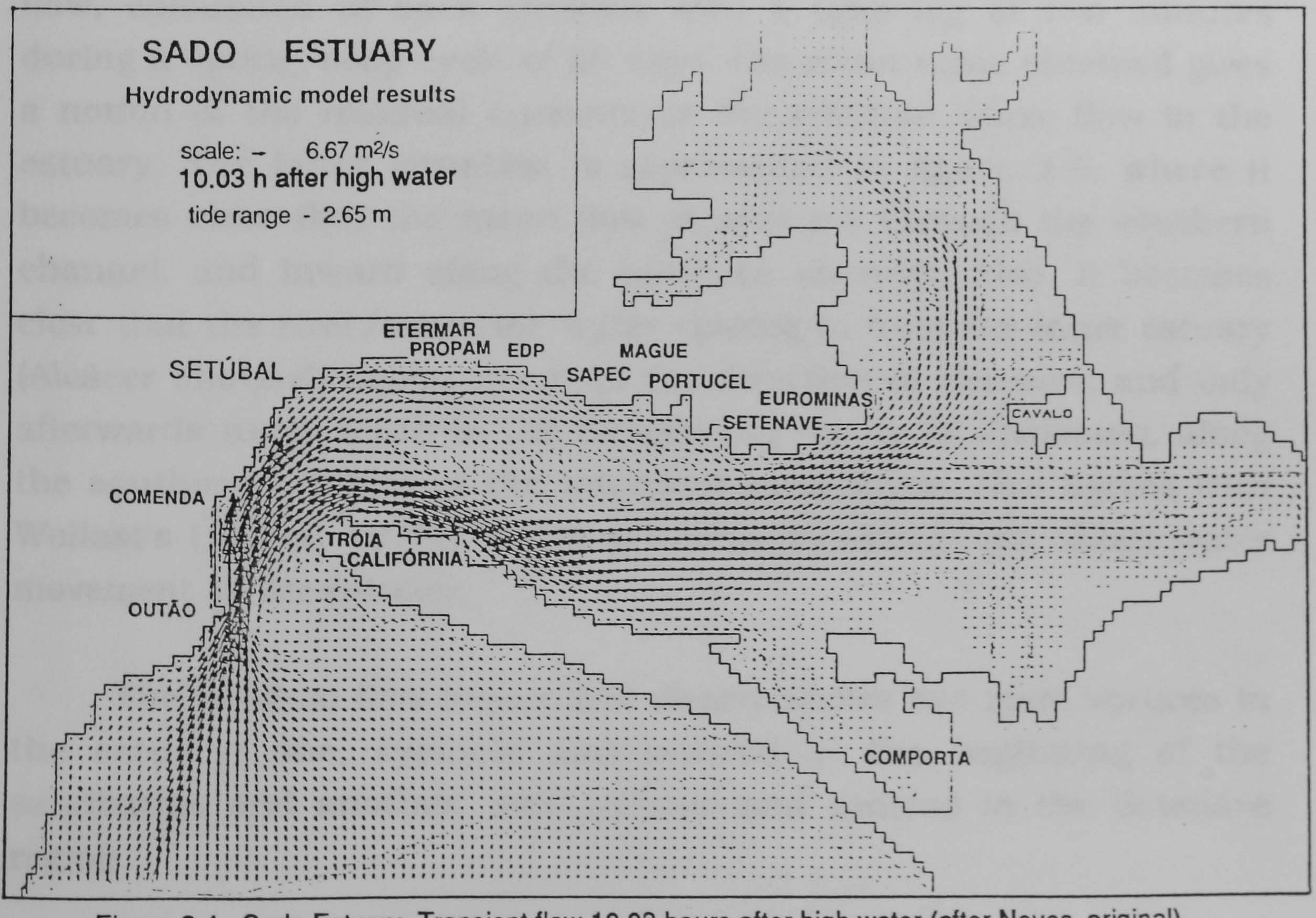


Figure 2.4 - Sado Estuary. Transient flow 10.03 hours after high water (after Neves, original).

Though the transient flows are already noticeable in the northern channel, the water flow and circulation is clearly stronger along the southern channel.

At 6 hours after high water, transient velocities and flows in the southern channel are still very important and directed seaward, whilst in the northern channel the water movement becomes negligible. In the shallow regions of the upper estuary, transient velocities and flows are higher than in the previous situation.

At 8 hours after high water, the water flow is already directed inward both in the southern and northern channel though showing much weaker transient velocities and flows in the latter. 10.03 hours after high water the transient velocities and flows are higher in both channels and the water moves landward in the entire outer estuary (figure 2.4). Nevertheless, and as during ebb tide (*cf.* figure 2.3), the transient flow shows much higher values in the southern than in the northern channel (*cf.* figure 2.4).

Integrating the values of the transient velocity or the transient flow, calculated in each location with a time lag of two minutes during a spring/neap cycle of 28 days, the mean value obtained gives a notion of the residual currents or the residual water flow in the estuary. The latter situation is represented in figure 2.5, where it becomes clear that the mean flow is seaward through the southern channel, and inward along the northern channel. Also, it becomes clear that the river/estuarine water coming in from the inner estuary (Alcácer channel) moves north in the direction of Setenave and only afterwards turns south in the direction of the Troia Peninsula, along the southern margins of the intertidal sandbanks. This agrees with Wollast's (1978a, 1978b, 1979) previous considerations about water movement in the estuary.

The residual flow (figure 2.5) clearly shows two main vortices in the estuary: one, cyclonic and centred at the beginning of the sandbanks and another, anti-cyclonic and centred in the Setenave region.

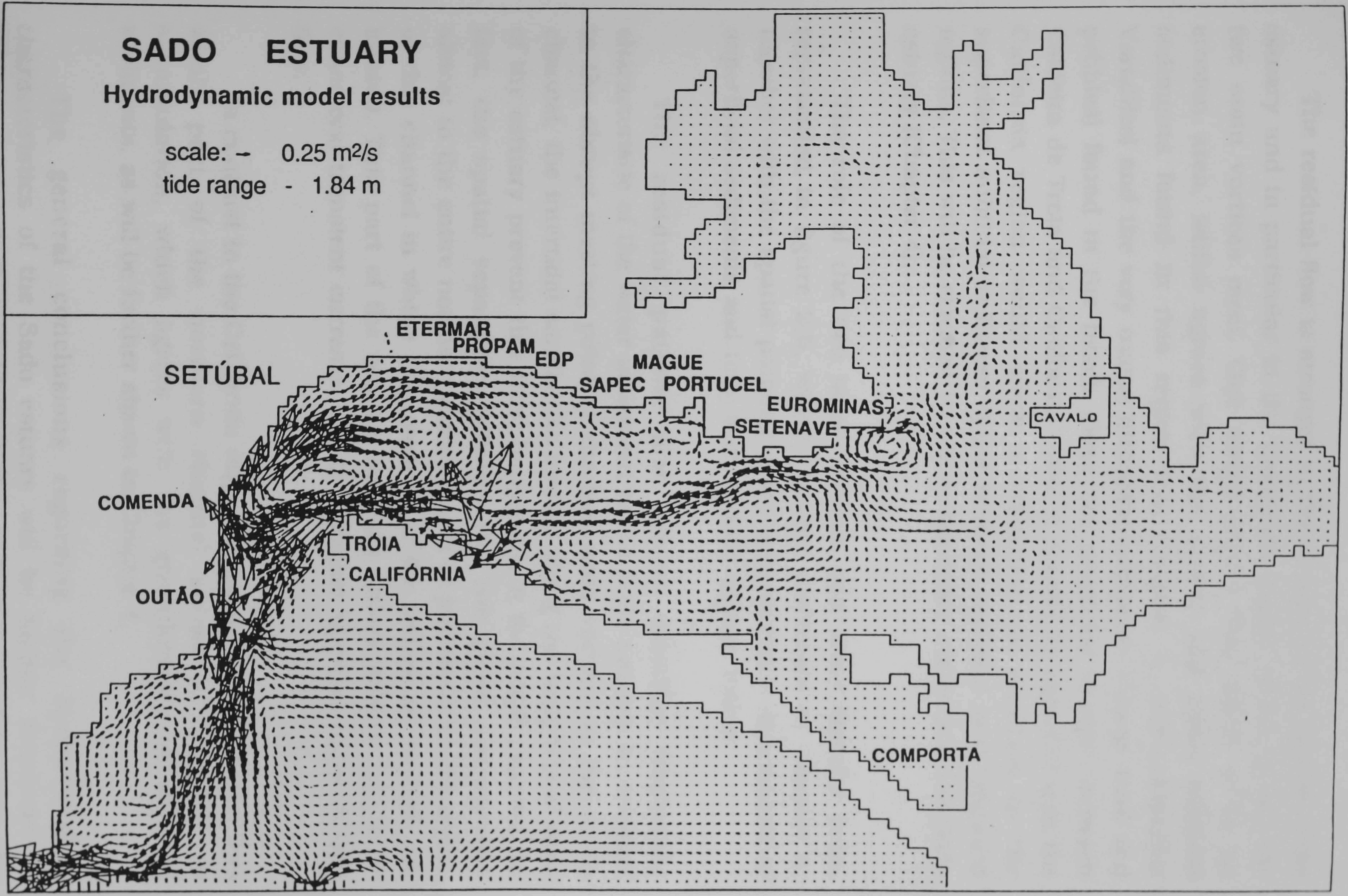


Figure 2.5 - Sado Estuary. Residual flow, calculated with a time lag of two minutes through a 28 days period (after Neves, original).

The residual flow is stronger in the vicinity of the mouth of the estuary and in particular in the California region, where in fact the two main vortices meet. One would expect this region to be an erosion area, which agrees with the coarse and clean subtidal sediments found in this region (see Chapter 4, Environmental Variables) and the very coarse intertidal sediments (coarse sand and pebbles) found in the beach along the southern margin, between Caldeira de Troia and California. Also, it should be expected that the California region would show a transition or partition in the superficial subtidal sediment types between seaward and landward regions. This will be clarified by the sedimentary analysis of the Sado estuary (Chapter 4).

The role of the two main vortices and other smaller ones, represented in figure 2.5, will be further discussed in Chapter 4, together with the spatial patterns of the granulometric distribution of superficial sediments and total sedimentary organic matter.

The residual pattern also shows another important characteristic of the water movement in the Sado estuary. In contrast to the abrupt meeting point of the two main vortices in the south channel, the intertidal sandbanks located along the longitudinal axes of the estuary prevent this from happening in the north channel. In fact, the spatial separation between the two gyres, corresponds almost to the entire northern channel, and in particular to the region of this channel in which the majority of the industrial outfalls are located. This part of the estuary not only shows weaker and more ephemeral transient currents, but also weaker residual currents and flow.

In contrast to the California region in the southern channel this whole part of the northern channel shows a tendency to accumulation, which agrees with the granulometry of subtidal sediments, as will be further shown in Chapter 4.

The general conclusions regarding the hydrodynamic characteristics of the Sado estuary will be further discussed in Chapters 4 and 6, considering the sedimentary data and the structure of benthic communities.

2.5 - PHYSICO-CHEMICAL CHARACTERIZATION OF THE WATER COLUMN

The physico-chemical data on which this section is based were obtained by Duarte and co-workers (*unpub. data*). This data consists of physico-chemical descriptors analysed in water samples collected monthly throughout 1987 at 23 sampling stations in the outer estuary. The water samples were taken with a vertical 5 l Niskin bottle, at the surface and near the bottom whenever possible. Data have been chosen from a total of 7 stations, located along the longitudinal axis of the whole outer estuary. They are named A to G in this section and their position is presented in figure 2.6.

The choice of the stations, the type of data obtained there, the graphical treatments, the interpretation of the data and the conclusions presented in this section have been undertaken for this thesis by the present author.

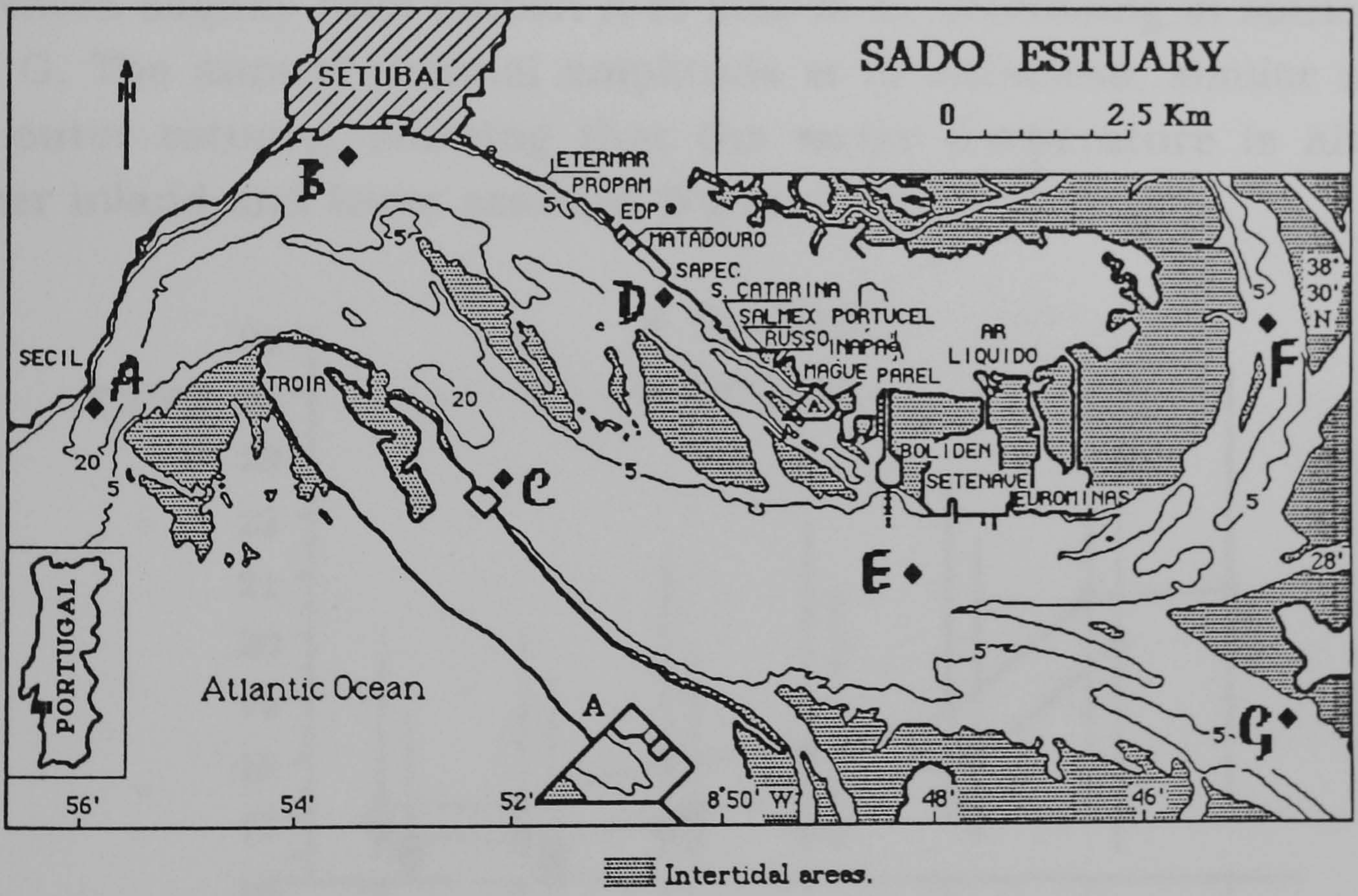


Figure 2.6 - Sado Estuary. Localization of the sampling stations used for the physico-chemical characterization of the water column.

2.5.1 - Spatial variation

Figures 2.7 to 2.15 present the spatial variation of the physico-chemical descriptors considered. The positioning of stations A to G along the horizontal axes in each graph is on an arbitrary scale, according to their relative distance from the entrance to the estuary. The value of each descriptor represents the annual arithmetic mean ± the standard deviation (S.D.). In some cases the absolute value of S.D. is greater than the mean values and its full graphic representation is not practicable. In these cases, the upper or lower part of the S.D. is represented by an arrow.

The mean values ± the S. D. used in the graphs, together with the absolute maximum and minimum value obtained for the year and the range of each parameter in each station, are given in annex I.

Figure 2.7 clearly shows an increasing gradient in the surface and bottom temperature (T) from the mouth of the estuary to the inner regions, with the highest values at the stations located in the beginning of Alcácer channel and Marateca. Surface values were always higher than the bottom ones, and the annual variability increased slightly from station A to station E, decreasing in stations F and G. The annual thermal amplitude is nevertheless, similar in all the outer estuary, showing that the water temperature is always higher inland and lower seaward (Figure 2.7).

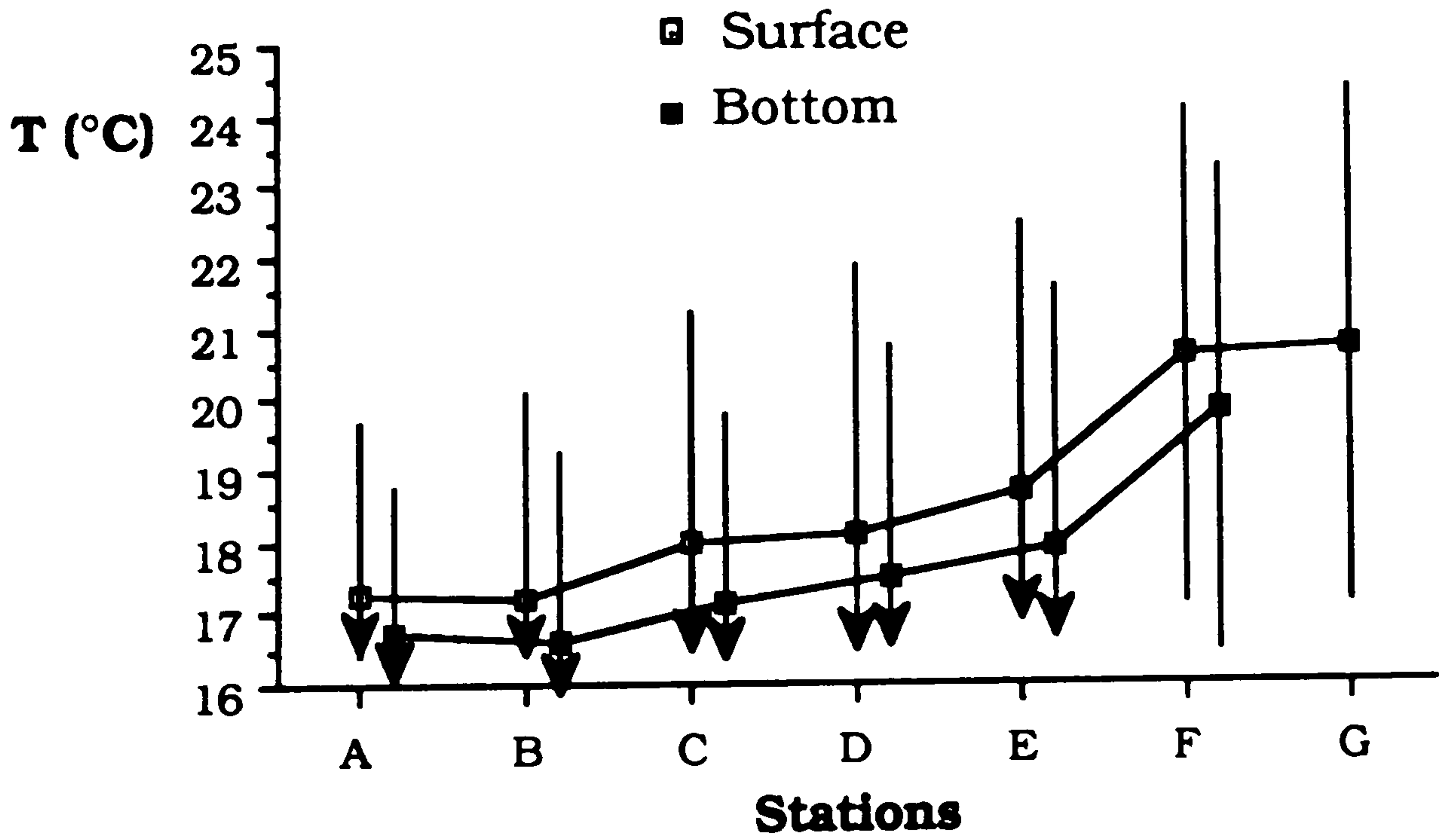


Figure 2.7- Sado estuary. Spatial variation of the water temperature (T) at the surface and near the bottom. The arrows indicate the value of the standard deviation below the mean of stations A to E The stations are plotted on an arbitrary scale, according to their relative position from the estuarine entrance.

The salinity pattern (S) (figure 2.8) shows the opposite tendency to temperature with a decreasing gradient from the entrance of the estuary toward the inner regions. Surface values are always lower than those at the bottom, and in both cases, the annual mean salinity tends to drop clearly in the two most landward stations, F and G. Surface and bottom mean values tend to be similar in station A, the closest to the estuarine entrance, whereas at station F, one of the most landward in this spatial representation, the difference between surface and bottom salinity tends to be highest. Temporal variability, assessed through the relative importance of the standard deviation, tends to be lower in the bottom water close to the estuarine entrance (*cf.* figure 2.8).

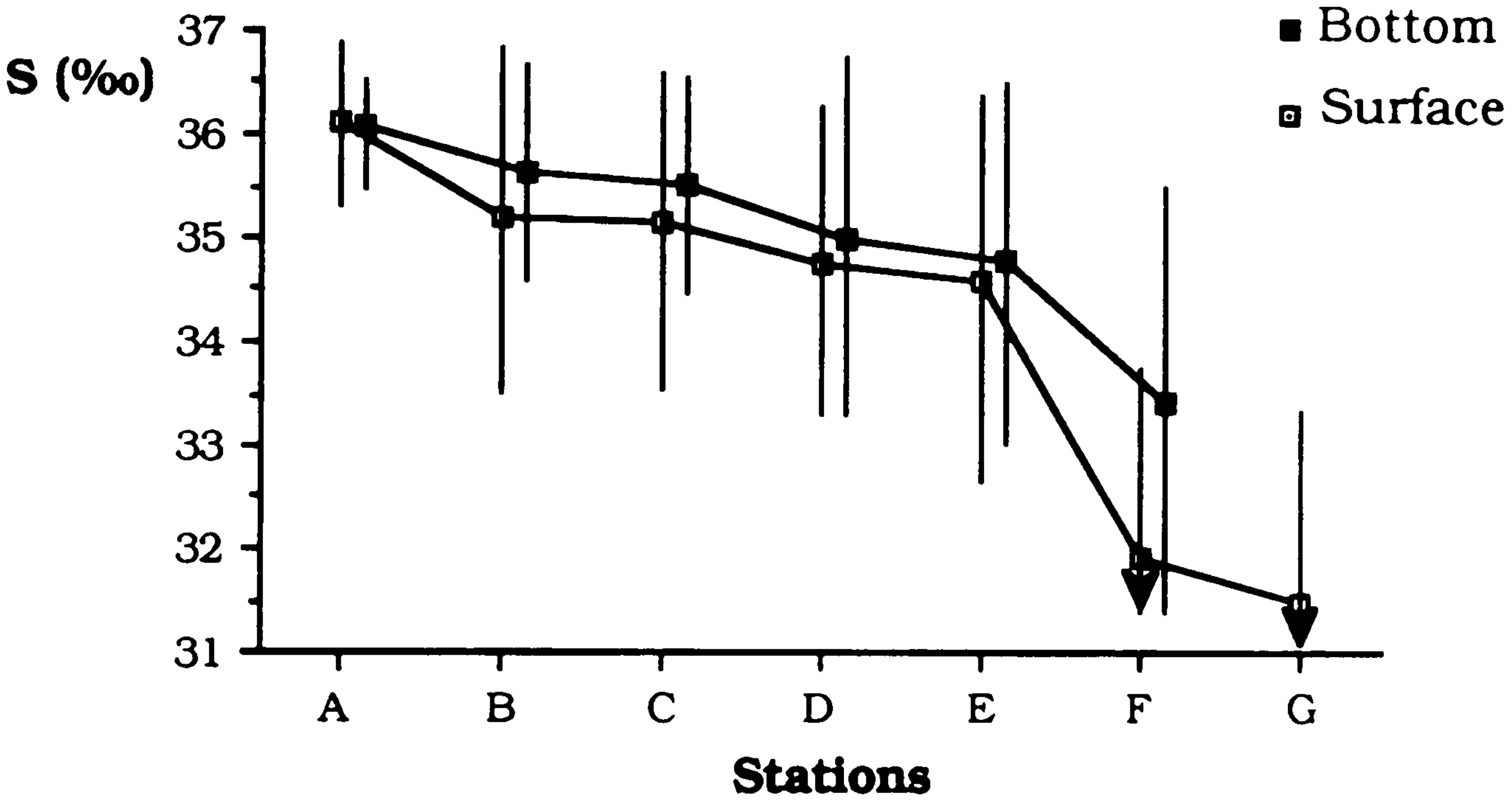


Figure 2.8 - Sado estuary. Spatial variation of the salinity (S) at the surface and near the bottom. The arrows indicate the surface value of the standard deviation below the mean of stations F and G. The stations are plotted on an arbitrary scale, according to their relative position from the estuarine entrance.

The water temperature and salinity show clear natural gradients. They reflect the influence of the sea water near the entrance to the estuary - lower temperature, higher salinity, lower temporal variation and similar values for surface and bottom water. In landward regions of the estuary the effect of runoff water dominates - higher values of temperature, lower values of salinity, higher annual thermal variability and higher difference between surface and bottom values for salinity.

The higher water temperatures for stations F and G during the whole year reflect the important influence of the mud-flats of Marateca in the thermal balance of the estuary, as earlier suggested by Neves (1985a).

These results support the suggestion by several authors (Ambar *et al.*, 1982, Neves, 1985a, 1986, Ribeiro & Neves, 1982, Sobral, 1977, Wollast 1978a, 1978b, 1979) that little slight vertical stratification of the water column occurs in the outer estuary. However slightly higher salinity differences between surface - bottom waters at some inner stations suggest that stratification is a little more pronounced in the inner parts.

Figure 2.9 shows an increase of suspended solids (SS) inland for both surface and bottom values. There was however an increase at D which seems to reflect the effect of the anthropogenic inputs to the estuary. The highest surface and bottom values were found at station D, near SAPEC. Also, the high bottom value at station B could indicate an effect of the urban effluent of Setúbal.

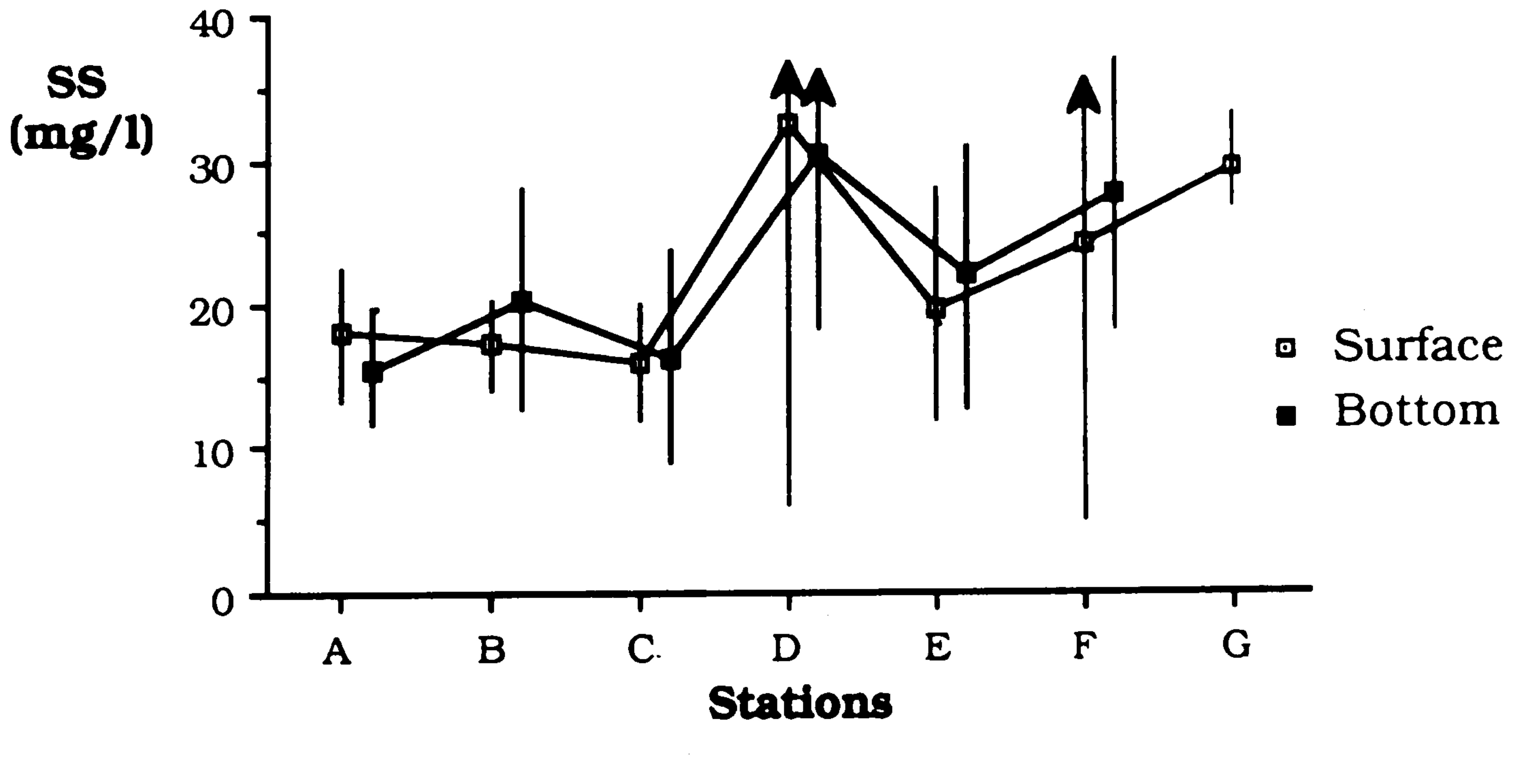


Figure 2.9 - Sado estuary. Spatial variation of the suspended solids (SS) at the surface and near the bottom. The arrows indicate the value of the standard deviation above the mean of stations D (bottom and surface value) and F(surface value). The stations are plotted on an arbitrary scale, according to their relative position from the estuarine entrance.

The values obtained for the dissolved oxygen (DO) are presented in the figure 2.10. The dissolved oxygen tends to decrease from the seaward stations to the inward ones. This general tendency seems to be enhanced locally by the anthropogenic inputs along the northern channel, where the lowest mean annual values were found in stations B and D (figure 2.10).

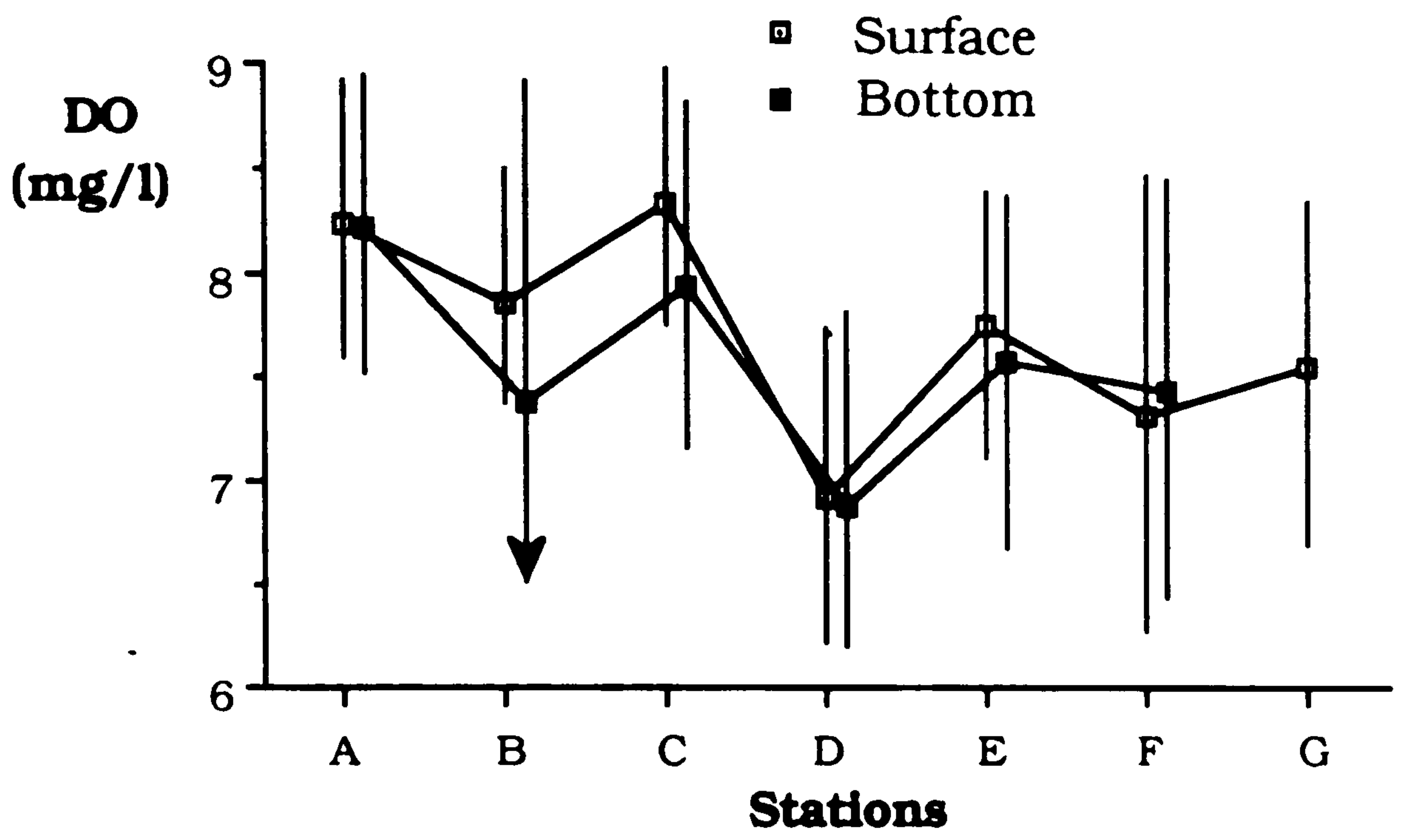


Figure 2.10 - Sado estuary. Spatial variation of the dissolved oxygen (DO) at the surface and near the bottom. The arrows indicate the bottom value of the standard deviation below the mean of station B. The stations are plotted on an arbitrary scale, according to their relative position from the estuarine entrance.

The biological oxygen demand (BOD) (figure 2.11) also separates stations B and D with the highest values, from the others. F and G, located inland also present higher values. BOD thus shows the opposite spatial tendency to dissolved oxygen, with increasing values inland.

The spatial variation of these two parameters clearly show the distinction between stations B and D, located on the north channel near anthropogenic sources. The results suggest that high amounts of organic material occur at these two points, enhancing BOD and decreasing the dissolved oxygen. The mean annual values from the other sampling stations suggest that dissolved oxygen tends to decrease from the entrance of the estuary to the inner regions, whereas BOD follows the opposite tendency.

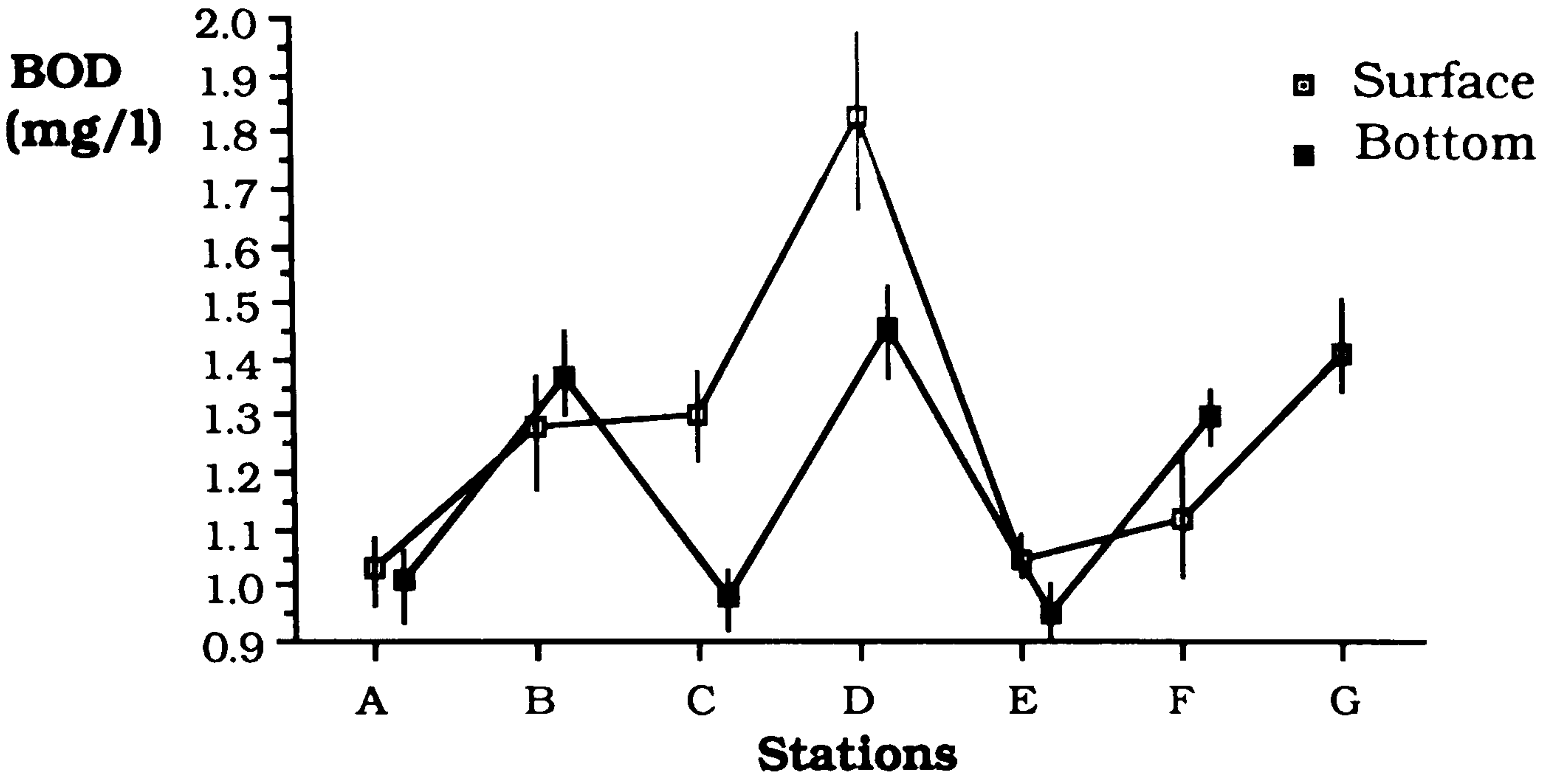


Figure 2.11 - Sado estuary. Spatial variation of the biological oxygen demand (BOD) (with the standard deviation) at the surface and near the bottom.The stations are plotted on an arbitrary scale, according to their relative position from the estuarine entrance.

The figures 2.12 to 2.15 show the spatial trends of nutrients: ammonia (NH_4^+), nitrates (NO_3^{2-}), nitrites (NO_2^-) and phosphates (PO_4^{3-}). With the exception of station D, ammonia concentrations are very similar throughout the outer estuary. Surface and bottom values are identical and the annual variability is low at all localities (figure 2.12). At station B, close to the urban effluent discharge point, the overall values are slightly higher. The most uncommon situation is observed at sampling station D, near a chemical plant, where ammonia shows very high concentrations.

Nitrate concentrations (figure 2.13), are also higher at station D. The most similar surface and bottom values were obtained at station A, which also shows the lowest annual variability. Both the difference between surface and bottom values and the annual variability apparently tend to increase with increasing distance from the estuarine entrance. Relatively similar conclusions may be drawn from nitrite concentrations (figure 2.14) in relation to which, the highest mean values and highest annual variability were again obtained at station D, near the chemical plant.

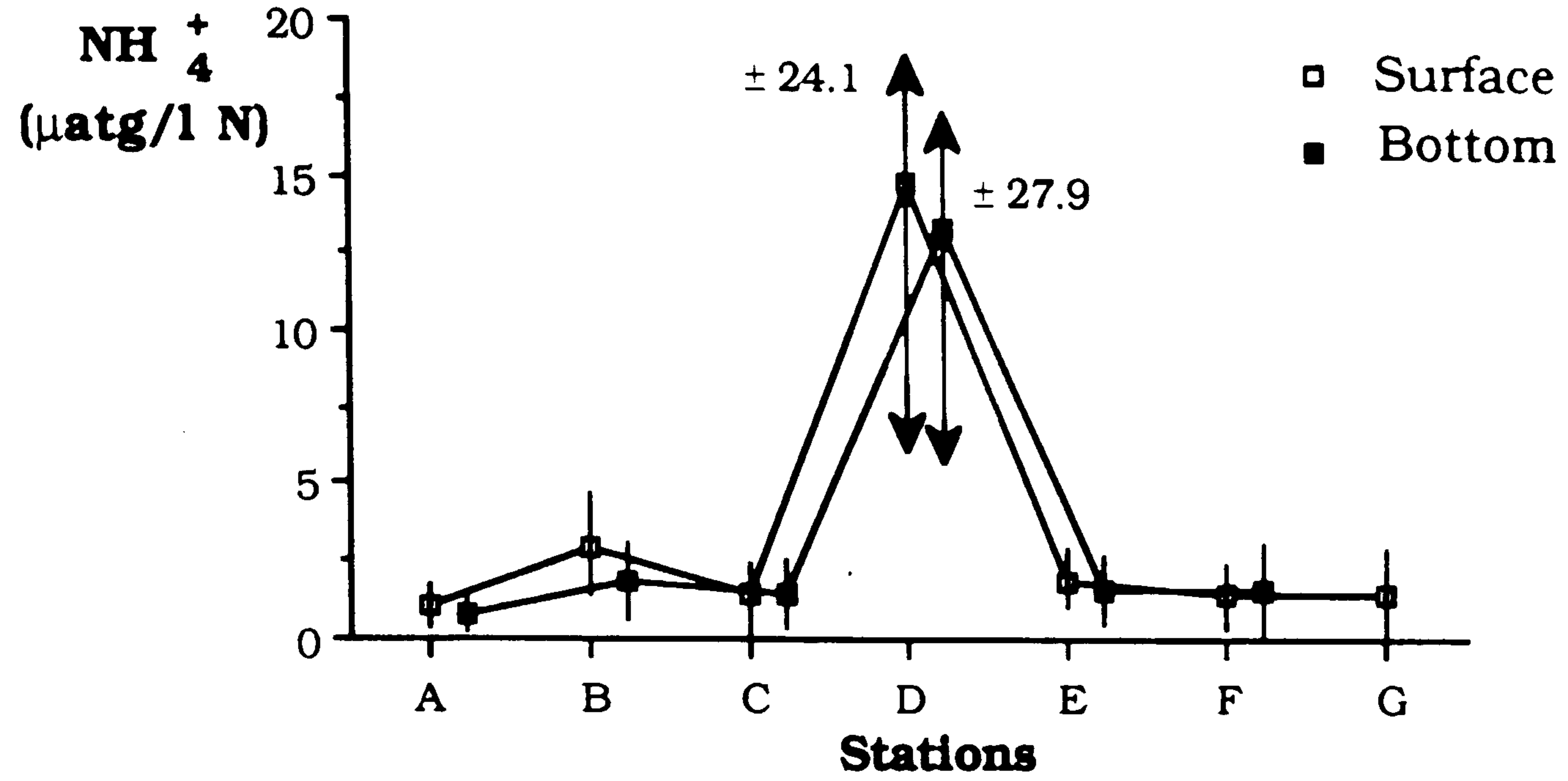


Figure 2.12 - Sado estuary. Spatial variation of the ammonia (NH_4^+) at the surface and near the bottom. The arrows indicate the standard deviation of station D: surface ± 24.1 and bottom ± 27.9. The stations are plotted on an arbitrary scale, according to their relative position from the estuarine entrance.

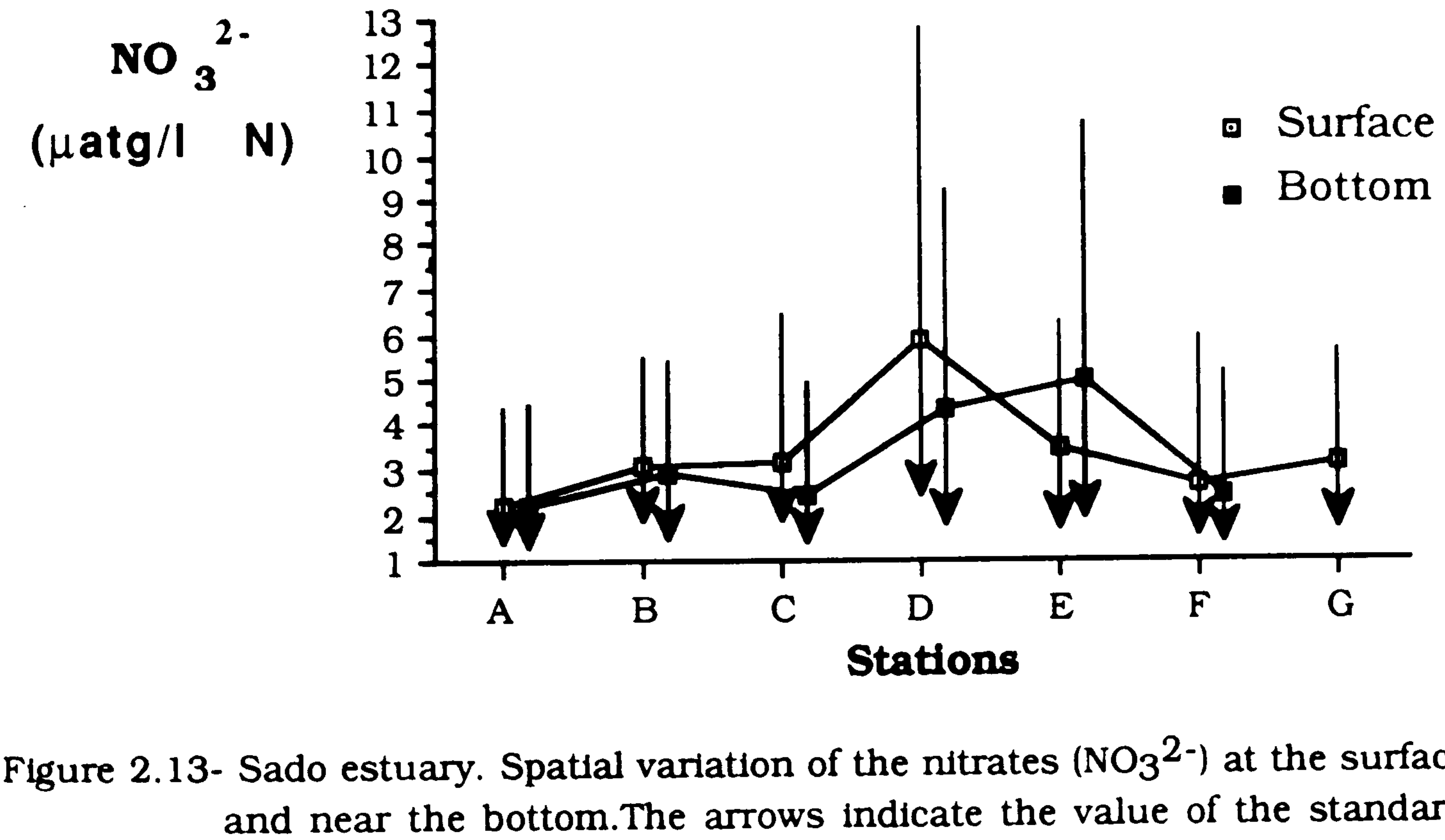


Figure 2.13- Sado estuary. Spatial variation of the nitrates (NO_3^{2-}) at the surface and near the bottom.The arrows indicate the value of the standard deviation below the mean of stations A to G . The stations are plotted on an arbitrary scale, according to their relative position from the estuarine entrance.

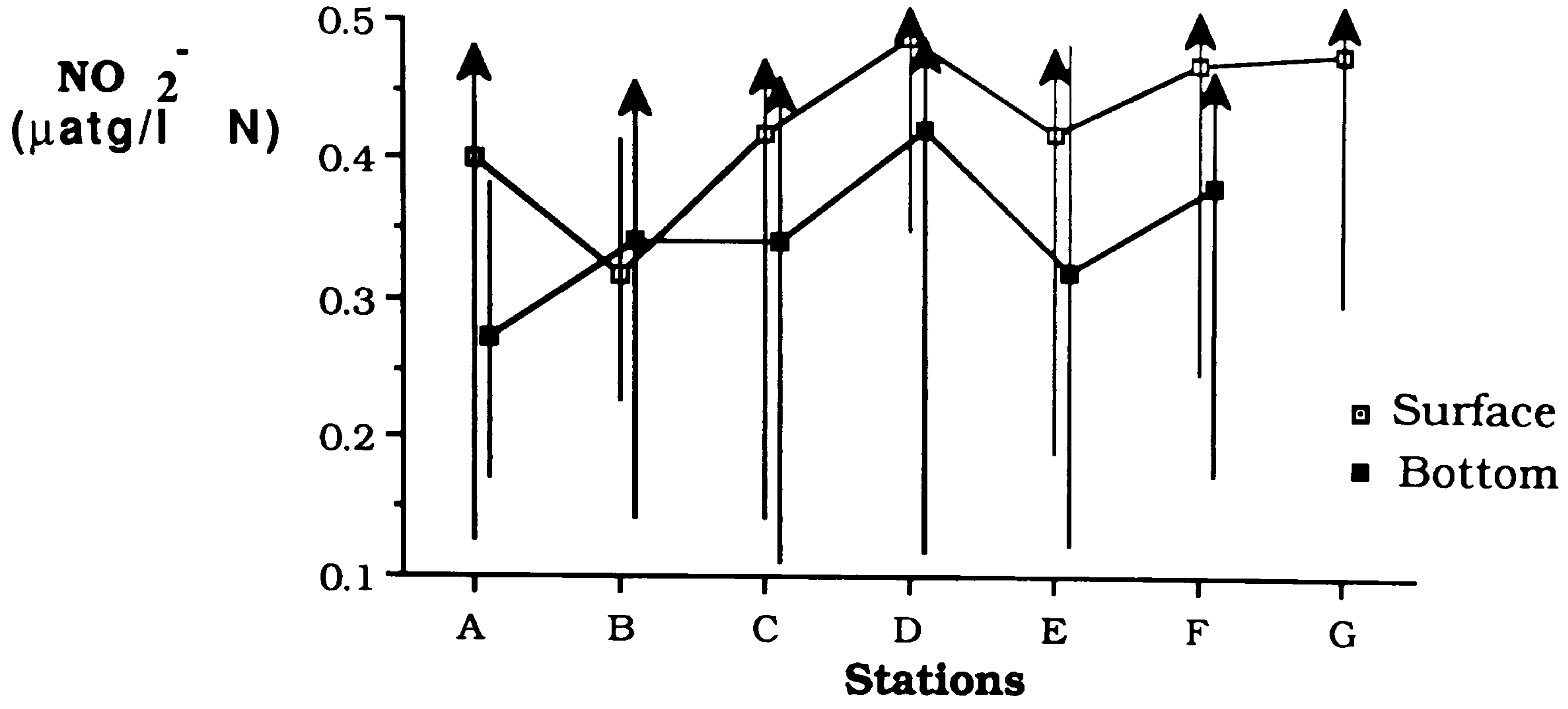


Figure 2.14 - Sado estuary. Spatial variation of the nitrites (NO_2^-) at the surface and near the bottom. The arrows indicate the value of the standard deviation above the mean (station A, E and G - surface value, B - bottom value and C, D and F - surface and bottom value). The stations are plotted on an arbitrary scale, according to their relative position from the estuarine entrance.

Finally, phosphate concentrations (figure 2.15), emphasize the difference of station D, again with the highest concentration and annual variation. Among the other stations, phosphate mean concentrations tend to be similar in the whole estuary.

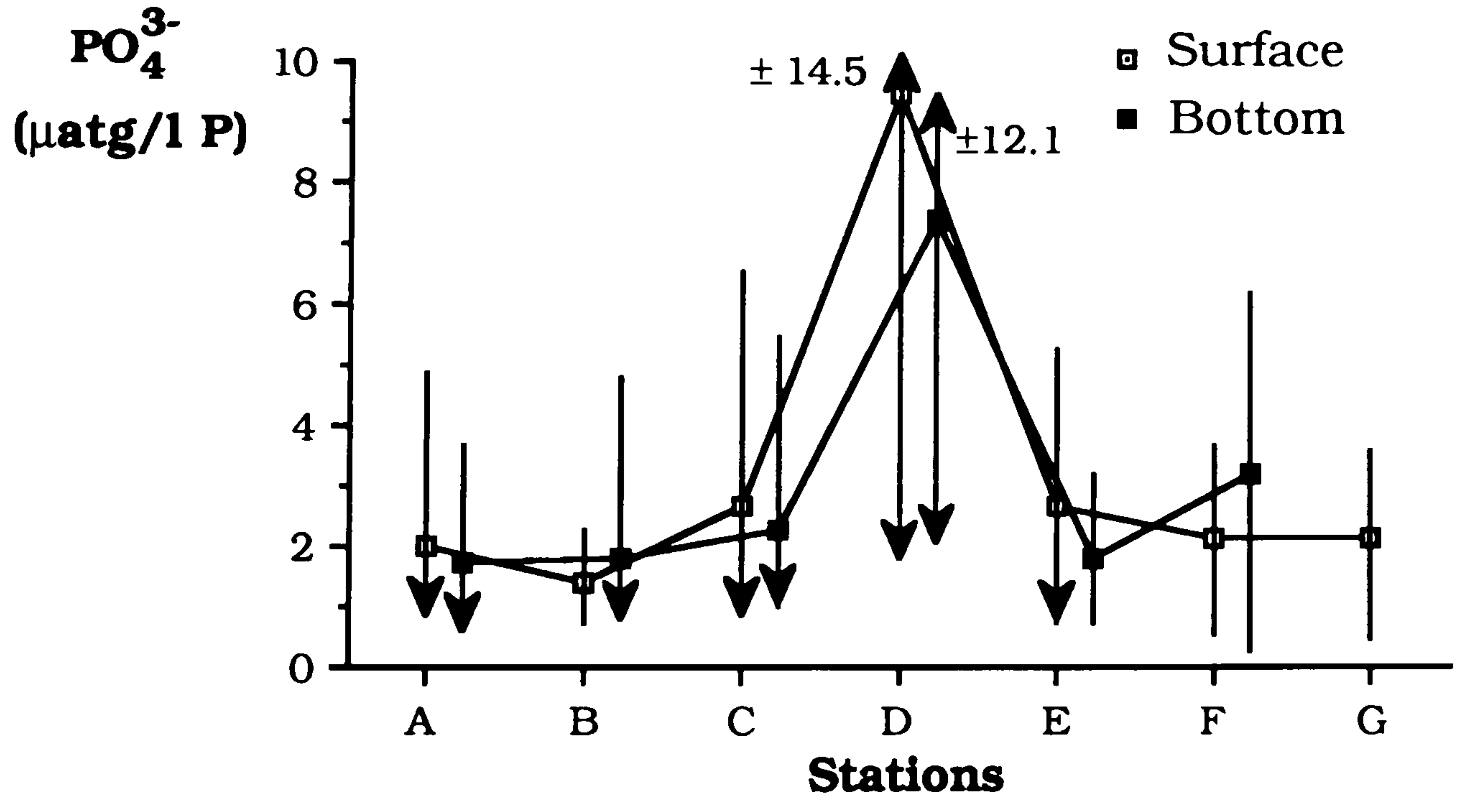


Figure 2.15 - Sado estuary. Spatial variation of the phosphates (PO_4^{3-}) at the surface and near the bottom. The arrows indicate the values of the standard deviation: stations A and C - below the mean, B and E - below the mean, respectively bottom and surface value, station D - surface value ± 14.5 and bottom ±12.1. The stations are plotted on an arbitrary scale, according to their relative position from the estuarine entrance.

In summary, the spatial distribution of physico-chemical parameters of the water column of the outer Sado estuary showed:

1 - clear natural gradients along the longitudinal axis of the estuary in respect to temperature and salinity. From seaward to inland regions, temperature tends to increase while salinity tends to decrease;

2 - a slight increasing gradient for the suspended solids concentration, from seaward to inland localities;

3 - in general, similar surface and bottom values, especially at station A, which emphasizes the slight vertical stratification of the water column;

4 - with the exception of temperature and salinity, the other chemical parameters considered show some deviant values in the stations located in the northern channel, under the apparent influence of anthropogenic inputs, namely the urban effluent - station B - and the effluent of a pesticide/herbicide and fertilizer factory - station D. For these parameters, this waste input introduces a locally variable component in the expected natural longitudinal variability of physico-chemical descriptors. The southern channel does not shows (according to the spatial variation analyses) the effect of this waste input to the northern channel.

2.5.2 - Monthly variation

Figures 2.16 to 2.24 show the monthly variation during 1987 of each the physico-chemical descriptors for stations A to G.

In general, temperature and salinity (figures 2.16 and 2.17) show a clear seasonal pattern in all the stations, increasing from spring to summer and decreasing afterwards. The lowest values were found during February at stations A to E and during March at stations F and G (at these two stations there is no data from January and February).

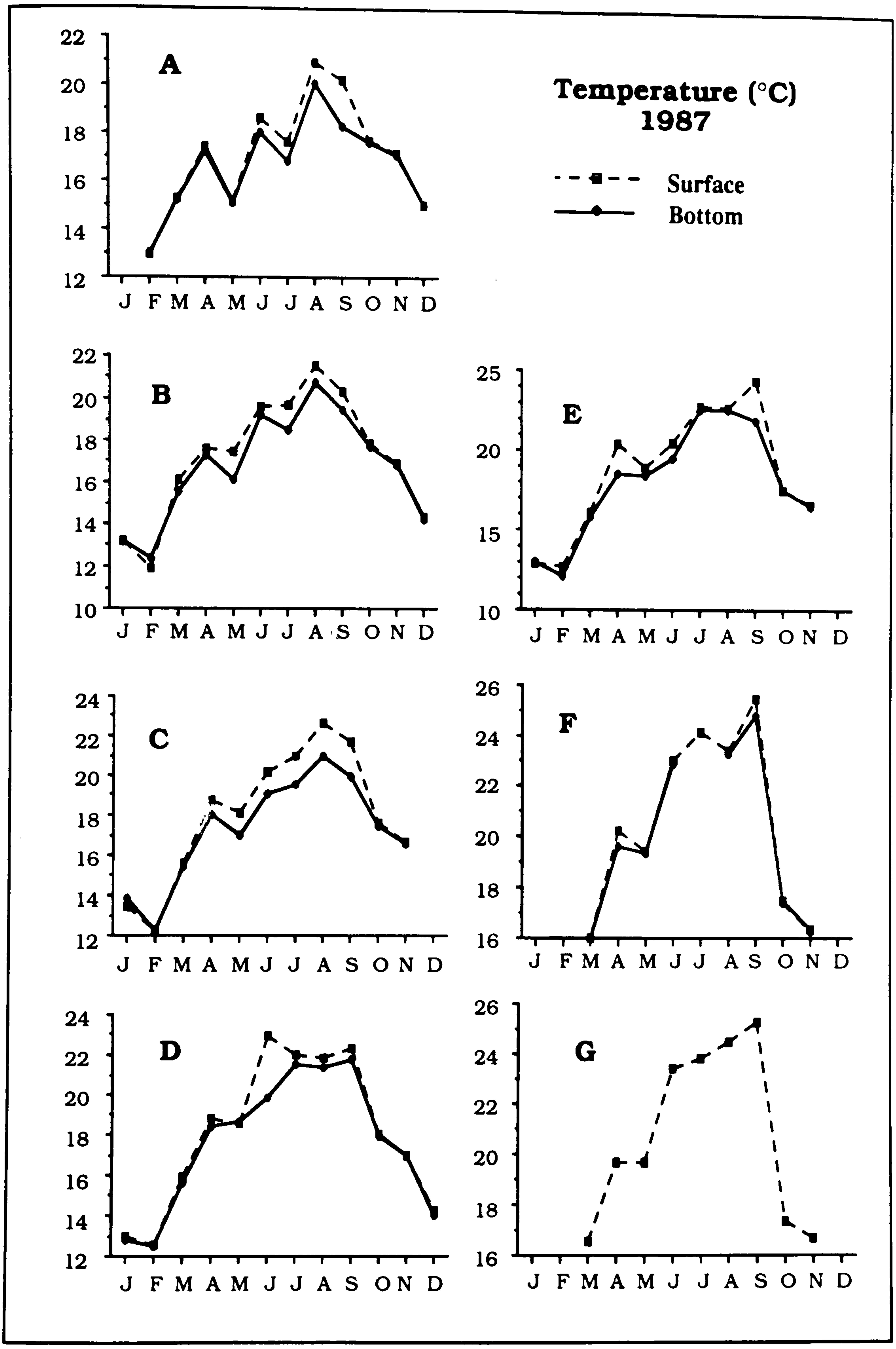


Figure 2.16 - Sado estuary. Temporal variability of the water temperature in the sampling stations A to G.

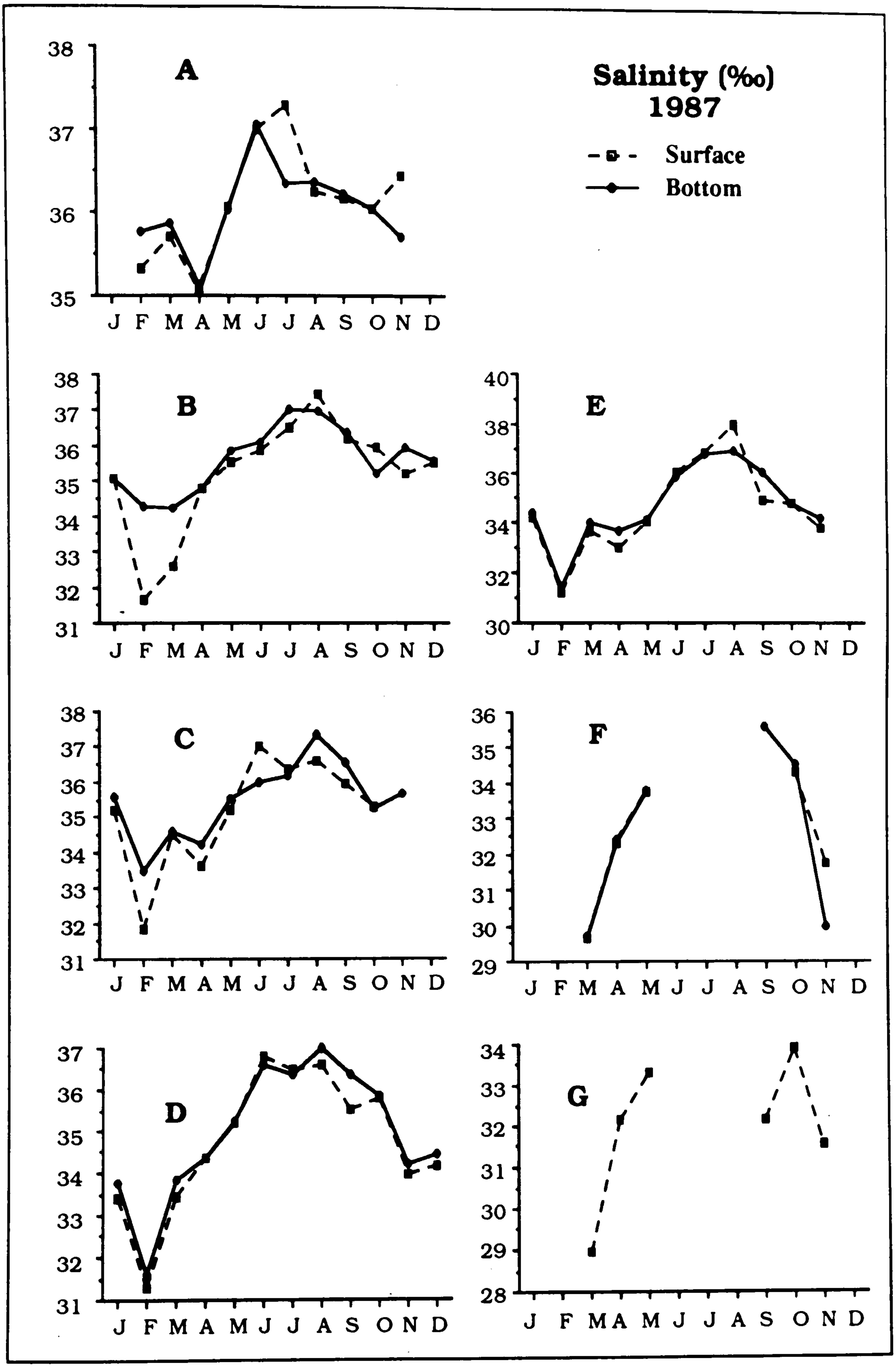


Figure 2.17 - Sado estuary. Temporal variability of the salinity at the sampling stations A to G.

The minimum temperature value was 11.93 °C (surface value, station B, February) and 12.10 °C (bottom value - station E, February) and the maximum 25.45 °C (surface value, station F, September) and 24.81 °C (bottom value, station F, September). The range between the maximum and the minimum value, increases slowly from station A to D and slightly decreases from station F and G. For salinity the minimum value found was 28.96‰ (surface value, station G, March) and 29.69‰ (bottom value, station F, March) and the maximum was 38.02‰ (surface value, station E, August) and 37.37‰ (bottom value, station C, August) (annex I).

The remaining physico-chemical descriptors do not show such consistent seasonal patterns. Nevertheless, some features may be pointed out.

The lowest values of dissolved oxygen (DO) for all the stations are more or less regularly observed in August or September, when water temperature reaches its maximum values (figure 2.18). The lowest values for DO occur at station B - urban effluent - and in a specific month, February. Although this corresponds to high BOD values in that month (figure 2.19), these values do not account for such a low value in DO.

In respect to BOD (*cf.* figure 2.19), most of the sampling stations tend to show maximum values during, August or September. Sampling stations B and D in the northern channel and station C, in the southern channel, also show high values for this descriptor during late winter - February and late spring - May/June.

Suspended solids (figure 2.20) show the highest values at sampling station D, near the chemical plant effluent, and at sampling station G, at the beginning of Alcácer channel, in the inner estuary. In most cases, the maximum peak occurs in the bottom water, with the exception of sampling station A, near the entrance of the estuary, and station D, in the northern channel. There is a regular peak at all the sampling stations during August, with the maximum value found at station D, near the chemical plant. During 1987, May, June and July were almost dry months in the estuary, with little or no rain at all.

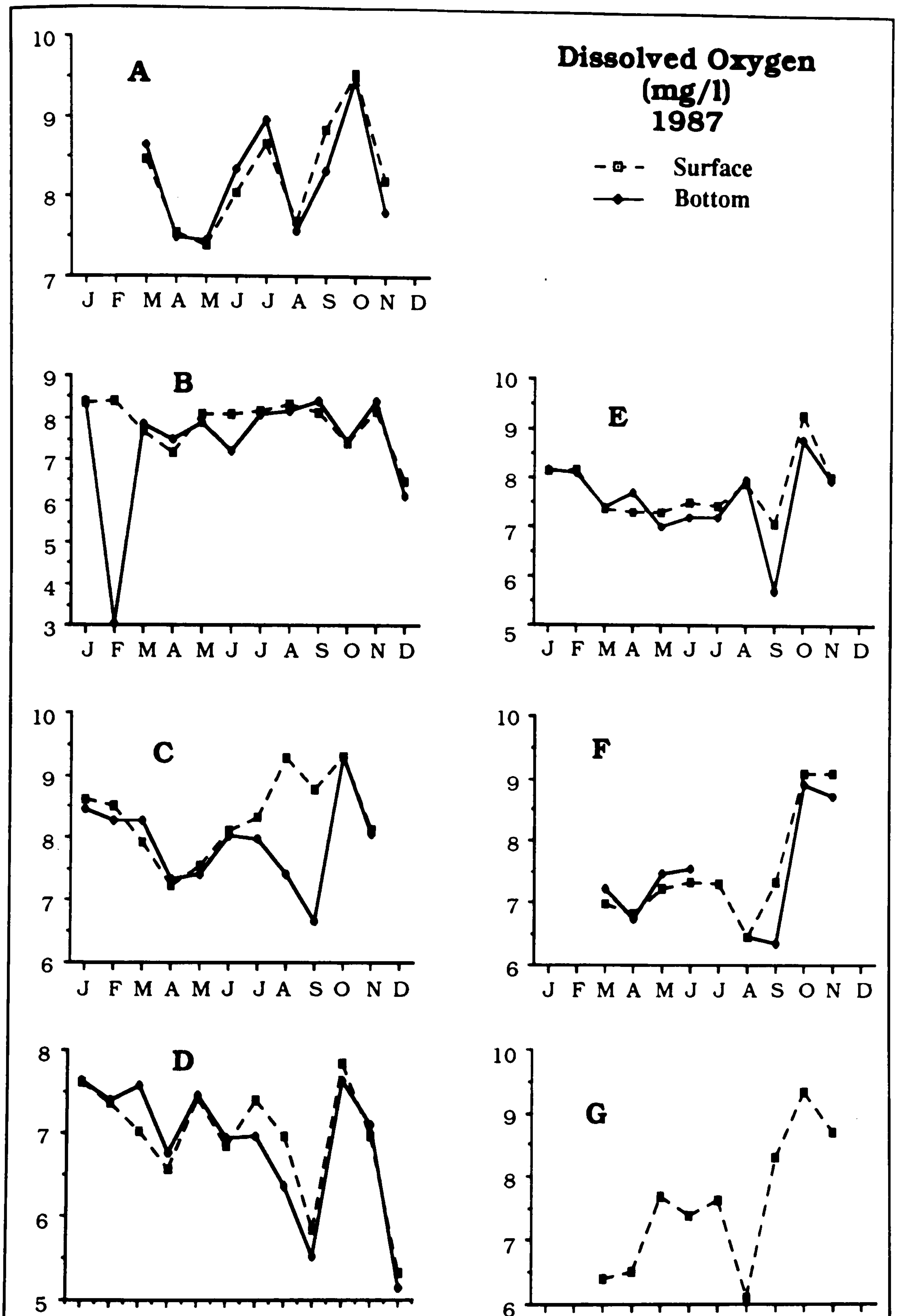


Figure 2.18 - Sado estuary. Temporal variability of the dissolved oxygen in the water column at the sampling stations A to G.

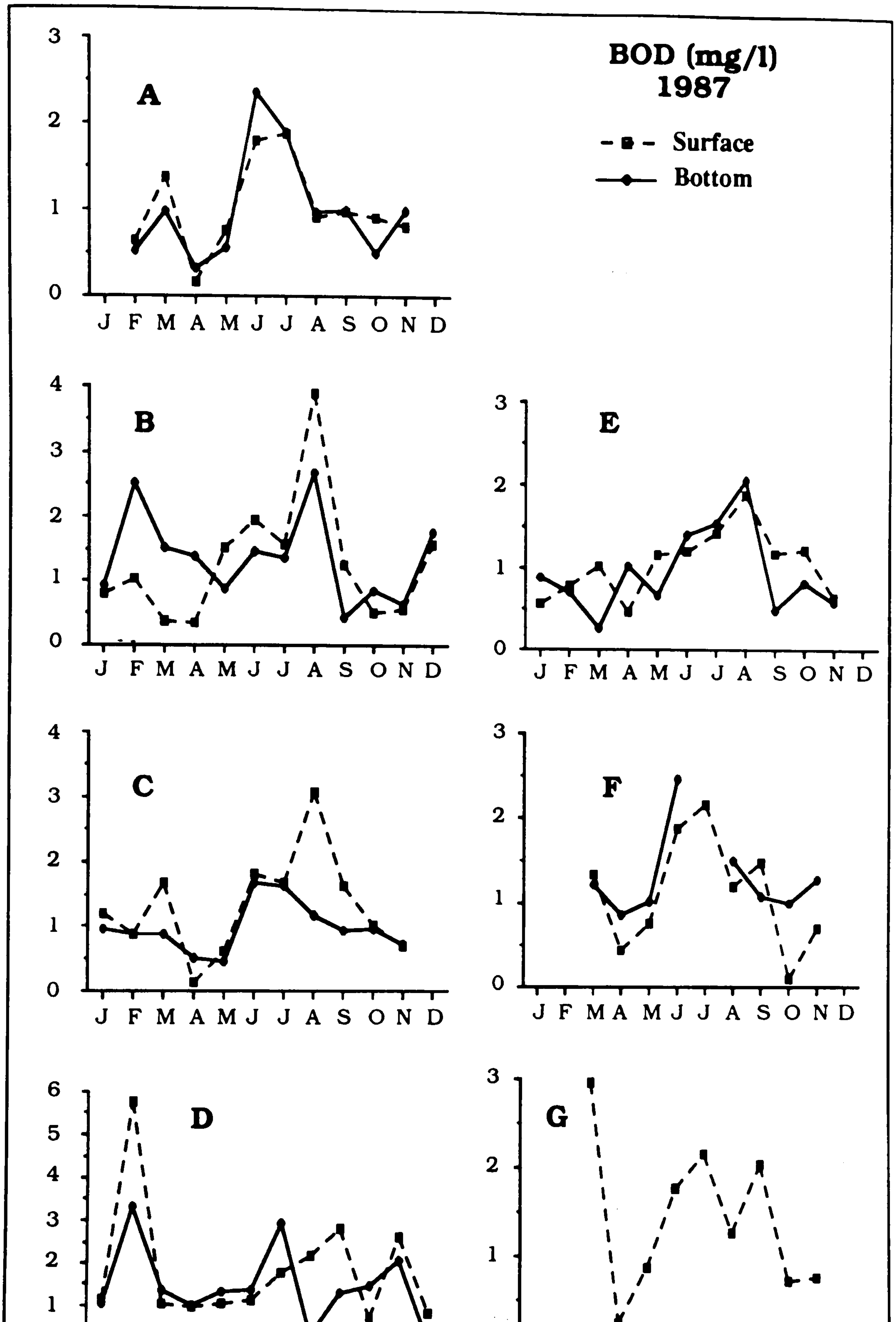


Figure 2.19 - Sado estuary. Temporal variability of the biological oxygen demand in the water column at the sampling stations A to G.

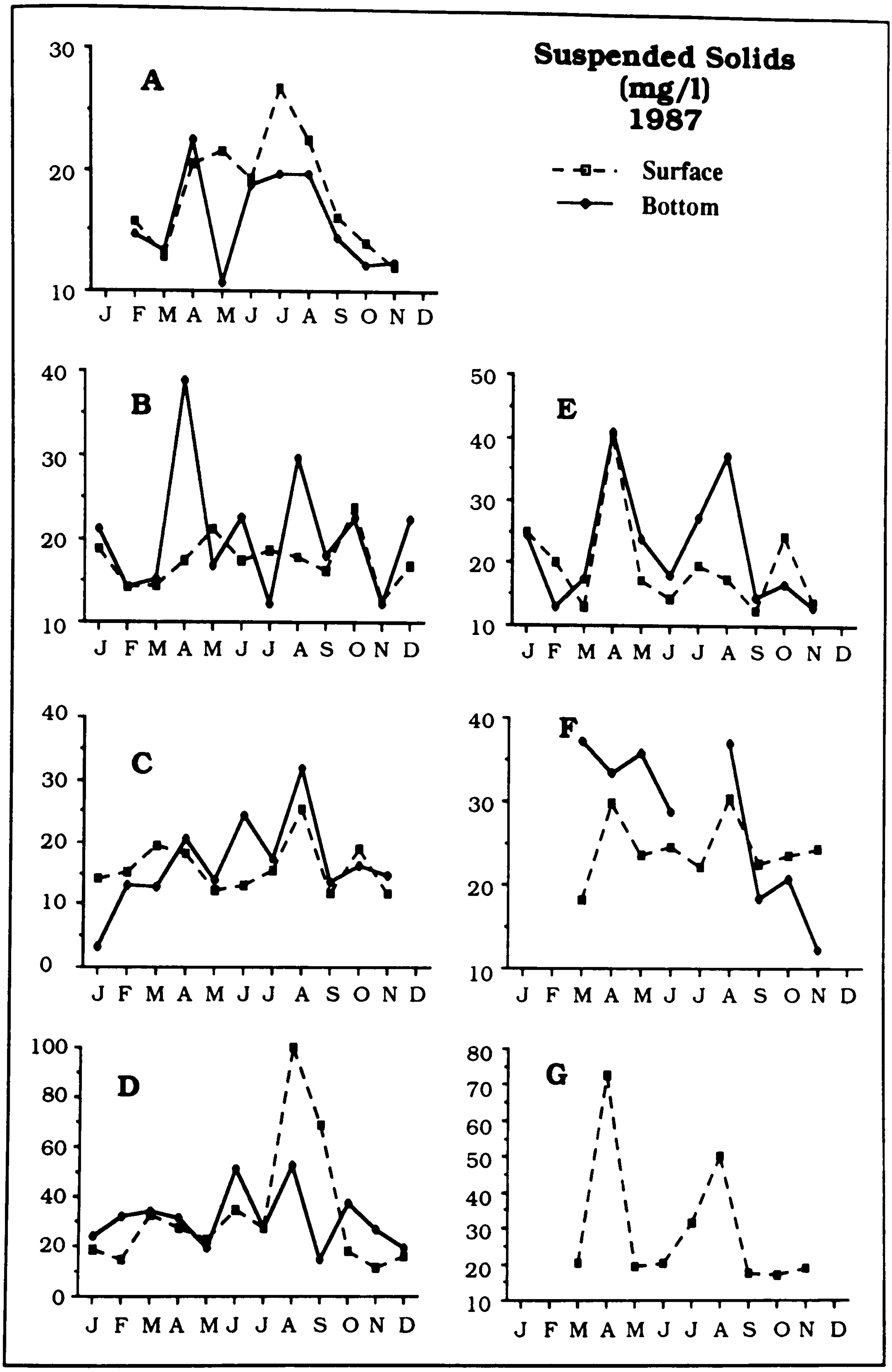


Figure 2.20 - Sado estuary. Temporal variability of the suspended solids in the water column at the sampling stations A to G.

Total precipitation during August was also very low (10.8 mm near Setenave and 9.2 mm near Setúbal - INMG Setúbal and Setenave meteorological stations), which, together with the fact that the highest value of suspended solids was observed in the northern channel, means it is very unlikely that the August peak in suspended solids would be the result of river discharges or runoff waters. The regular April maximum at all the sampling stations might be more related to runoff, since the maximum value was obtained upriver, in station G, and that, after the relatively dry month of March (51 mm near Setenave and 22 mm near Setúbal), April was a normal rainy month (71 mm near Setenave and 69 mm near Setúbal - INMG Setúbal and Setenave meteorological stations).

In respect to nutrients, figures 2.21 to 2.24 clearly show the effect of anthropogenic sources. With the possible exceptions of nitrites (figure 2.23), ammonia, nitrates and phosphates show the highest values near the chemical plant effluent, at sampling station D (figures 2.21, 2.22 and 2.24). At this station a peak occurred in both surface and bottom water during February, in all three parameters. The values obtained are from 2 to 40 times higher than in the rest of the estuary.

Regarding ammonia, there are also values at least 5 times higher than in the rest of the estuary at station D during July and during September (figure 2.21). It is interesting to note that the maximum peaks for ammonia at the other sampling stations are observed a month later, i. e. during August and during October, when the ammonia values at station D were much lower.

In respect to nitrates (figure 2.22) peaks occur throughout the estuary, during February, June and October/November. Again, the highest values are found at station D but there is not the time delay previously noted for ammonia, with the possible exception of the February maximum which was observed at the most inward station only during March (figure 2.22). The October maximum is in fact somewhat different because the highest value occurred at sampling station E, and not at station D.

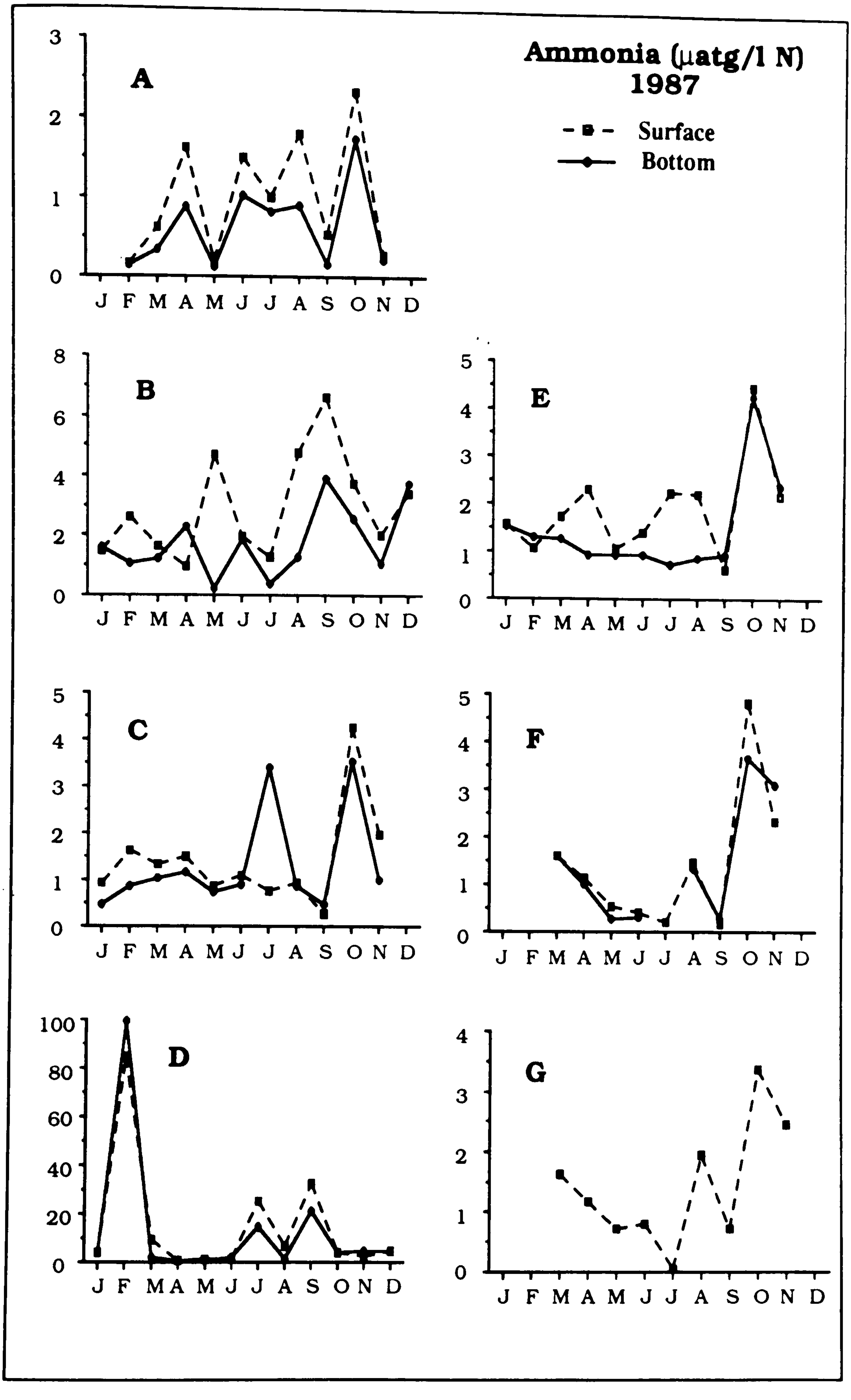


Figure 2.21 - Sado estuary. Temporal variability of the ammonia in the water column at the sampling stations A to G.

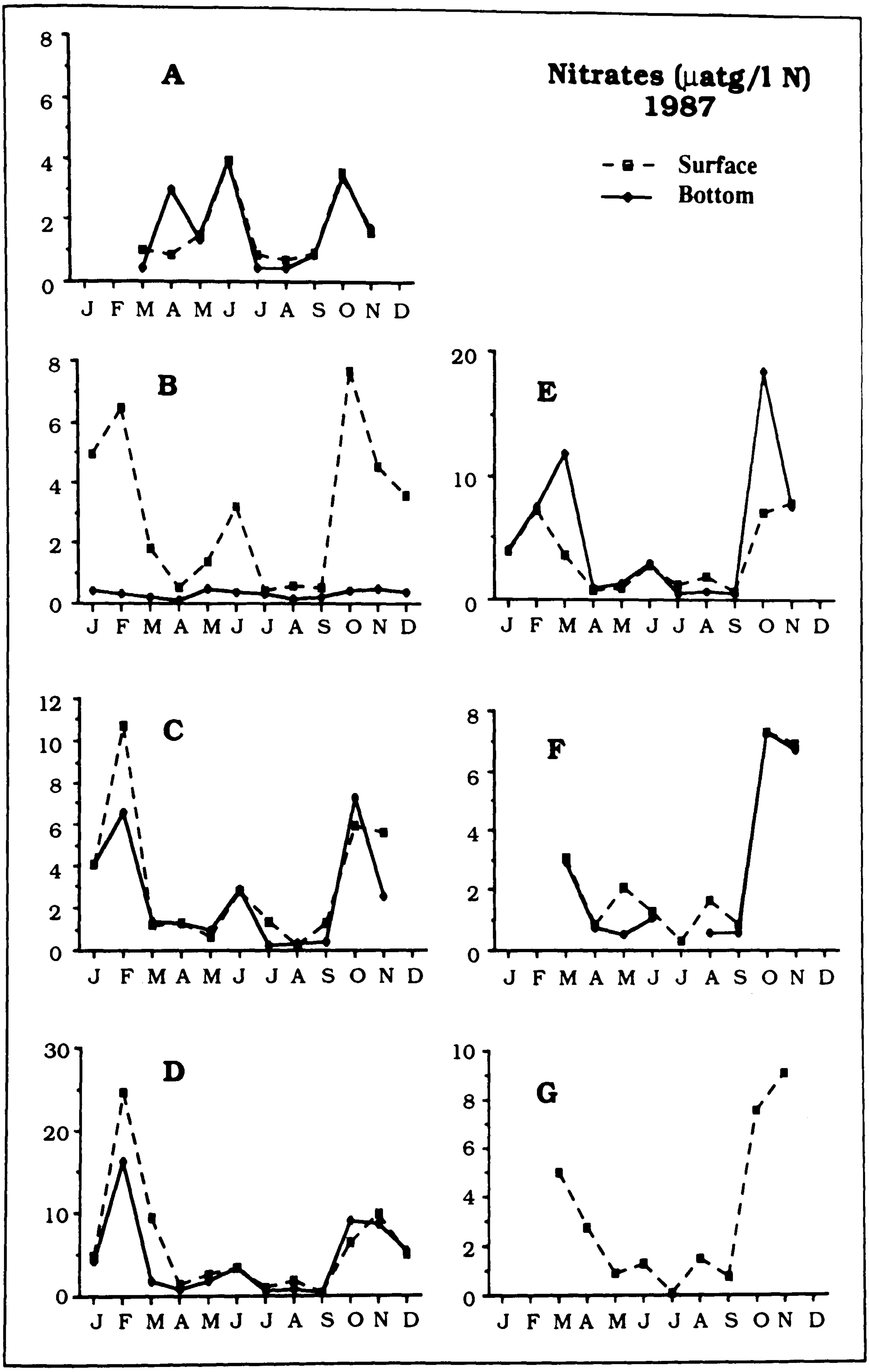


Figure 2.22 - Sado estuary. Temporal variability of the nitrates in the water column at the sampling stations A to G.

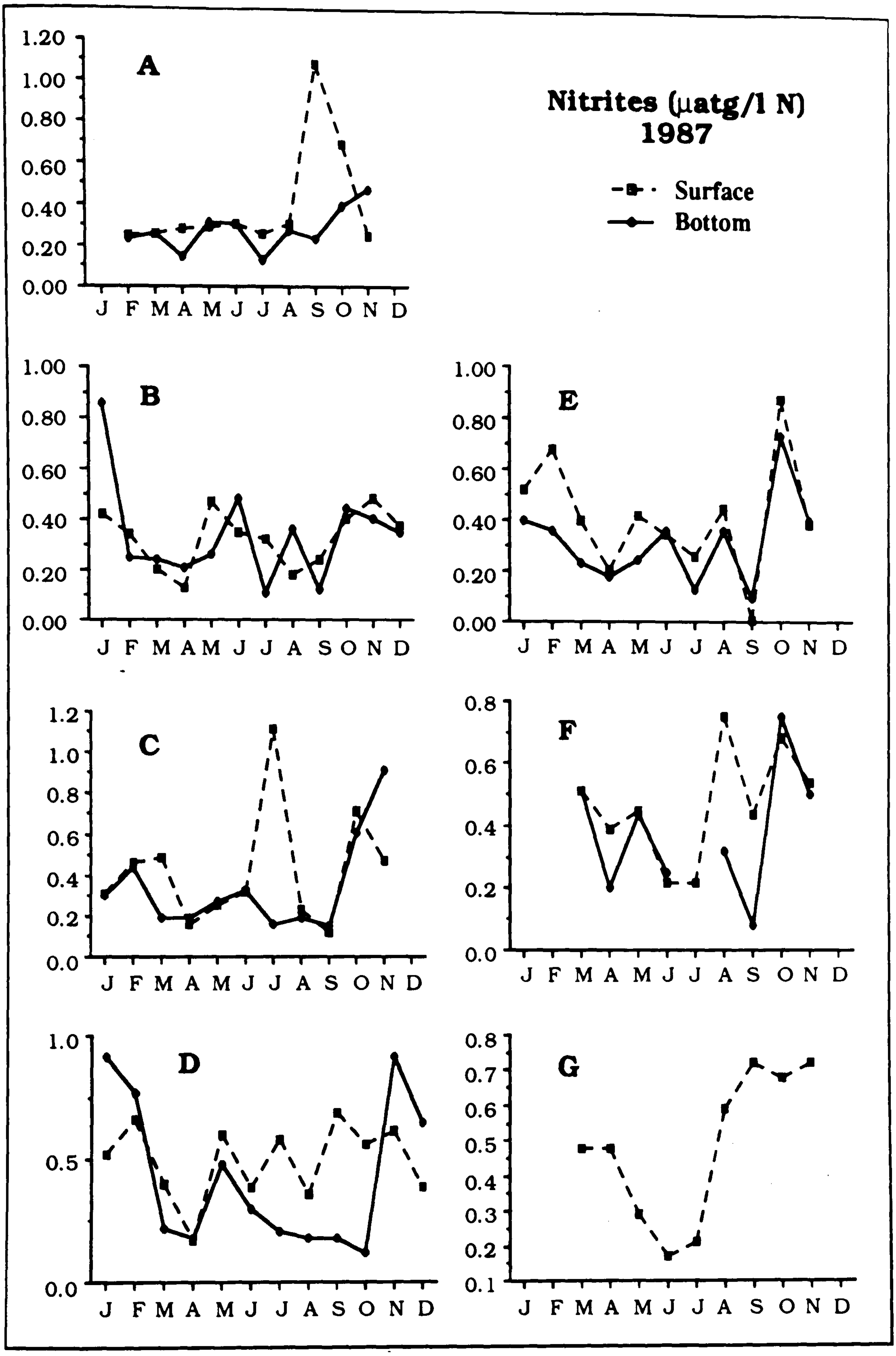


Figure 2.23 - Sado estuary. Temporal variability of the nitrites in the water column at the sampling stations A to G.

With phosphates (figure 2.24), the situation seems to be similar to that shown by ammonia. There are three peaks throughout the estuary. At station D, where these peaks attain the maximum values, they occur in February, July and September, as with ammonia (*cf.* figure 2.21). The February peak, though the highest at this station, is almost unnoticeable in the rest of the estuary, with the possible exception of sampling stations A, E, F and G, where a small peak occurs a month later, in March. The July peak is clearly observed at the seaward sampling stations A, B, C and D, but only a month later, during August, at the inward ones, E, F, and G. The September peak at station D is observed in the rest of the estuary only a month later, during October.

These observations, even if not conclusive, do suggest the nutrient load due to the chemical plant waste effluent could influence the whole outer estuary and eventually play a major role in the nutrient balance of the estuary. If so, this would mean that, at least for some chemical parameters, the anthropogenic input to the northern channel could reach and be detected in the southern channel, even if the water flow is much stronger through the latter.

The spatial and the temporal variation of the physico-chemical parameters in the water column allow a distinction to be made between those gradients being determined by natural conditions and by anthropogenic inputs.

For the descriptors and the sampling stations considered, both temperature and salinity appear to be related to natural climatic conditions, while oxygen and nutrients show a close relation to anthropogenic effects. It should be noticed that in the immediate vicinity of the thermal power plant, northern channel, the water temperature also shows very different values from those expected and presented in this study. Here, the water temperature are significantly higher during the whole year (values not shown). Nevertheless, this effect appears to be restricted in a spatial scale, since sampling station D, located upriver but close to the thermal power plant, does not present irregularly high temperature values. Apparently, the nutrient load due to anthropogenic sources has a much longer and wider effect in the outer estuary.

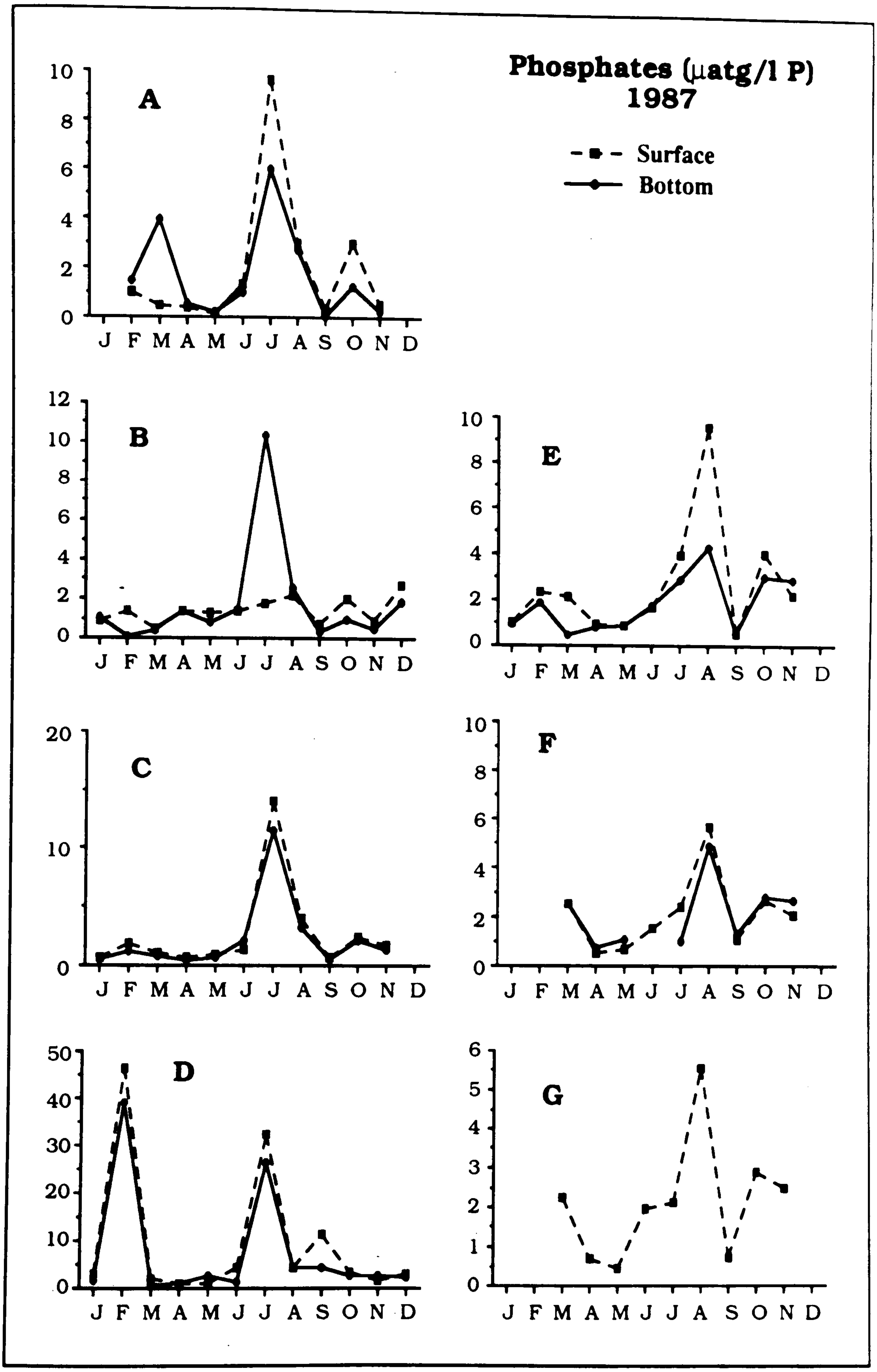


Figure 2.24 - Sado estuary. Temporal variability of the phosphates in the water column at the sampling stations A to G.

2.6 - SEDIMENT METALS CONTAMINATION

The assessment of metals content of sediments and water column has been studied in the Sado by several authors (besides others, Vale & Sundby, 1982, Moita & Quevauviller, 1986, *in*: Quevauviller *et al.*, 1989; Quevauviller *et al.*, 1986, 1988, 1989, Bordalo Costa & Peneda, 1989). Despite the fact that these authors used different sampling devices, performed the analyses on different fractions of the sediment and used different detection methods, the results suggest similar conclusions concerning metal concentration patterns in the Sado estuary.

Vale & Sundby (1982) showed that whilst Si, Al, Fe and Mg did not show any particular distribution pattern in the estuary, Ca, Mn, Zn, Cu and Pb presented a clear spatial pattern. Ca values were higher than 1%, at the seaward end of the outer estuary, and lower than 1% landward, in the inner estuary, with exceptionally high concentrations near Ilha do Cavalo in the vicinity of the oyster beds. Zinc content showed a decreasing gradient from the inner estuary to the outer estuary, with the lowest values near Setúbal and Cu, Pb and Mn, showed their highest concentrations in the outer estuary, mainly in the region of the northern channel correspondent to the industrial complex and in the vicinity of Setúbal.

The results of Quevauviller *et al.* (1986) obtained in the superficial sediments emphasise the high concentrations of Cu and Pb in the northern channel in the industrial area and near Setúbal, and of Zinc in the Alcácer channel which was also found but in a lower level, near the industrial complex. These authors also found that in general, while the corer analyses for copper and zinc concentrations, revealed higher values near the surface and a gradual decrease up to the 30-50 cm layer, beyond which the content of these two metals was relatively constant, the lead concentration did not show significant vertical variations in almost all the cores.

Moita & Quevauviller (1986, *in* : Quevauviller *et al.*, 1989) and Quevauviller *et al.* (1989), emphasize some of the previous results pointing out two major sources of metals to the estuary: the Sado river itself, which drains a mineralized area (Iberian pyrite belt) together with three mining zones (Caveira, Lousal and Aljustrel) and the local anthropogenic activity, mainly the effluents of the industrial complex on the northern margin and in Setúbal city. The former could explain the high concentrations of Cd, Cu, Zn, Pb and Hg detected along the course of the river (Quevauviller *et al.*, 1989).

The work of these authors also suggest that the sediment content of Cu and Zn and probably of Cd, could depend on the rates of water discharge, showing higher levels in winter during flood periods and that the decreasing vertical content of Zn and Cu in cores (Quevauviller *et al.*, 1986, 1989), could be attributed to the effects of the beginning of industrial development (in the 1860s) a hypothesis enhanced by the sediment deposition rate determined for the outer estuary by Quevauviller (1987), of about 1 to 2 mm year $^{-1}$.

Quevauviller *et al.* (1988) suggest that all the metals entering the estuary through industrial wastes are strongly adsorbed onto organic particles and in some cases in organo-metallic forms, as they observed for Sn. In this respect, they reported sediment concentrations of organotin compounds ranging from 180-2000ng/g of MBT, 55-9600 ng/g of DBT and 21-500 ng/g of TBT in sediments of the industrial area, attributing butyl-tin species to the shipyard's wastes antifouling paints and degradation products, whereas methyl-tin species could originate in methylation processes. The presence of tributyltin in the Sado estuary sediments was suggested by Phelps (1989) as a possible cause of the shell deformations found in the Portuguese oyster (*Crassostrea angulata*) and also for the failure of its reproduction.

Further work on heavy metal contamination of the Sado estuary superficial sediments was developed by Bordalo Costa in 1986 (Bordalo Costa & Peneda, 1989). The spatial distribution of Cr, Ni, Cu, Zn, As and Pb showed distinct enriched areas of which, the northern channel presents the highest concentrations. Nevertheless according to the authors only the sediment concentration factors of Fe and at a lower level Zn, were higher than the recommended values by IAEA (1985) for sediments of coastal areas.

The results presented by the several authors on the metals content in the sediments of the outer Sado estuary suggest the general features:

1 - The highest metals concentrations were always found in the sediments of the northern channel. This accumulation can be attributable either to a range of natural conditions resulting from the low transient and residual water current velocities together with high sediment organic content in this channel (see Chapter 4), or to anthropogenic inputs due to the industrial complex and Setúbal activities (see also section 2.3). The spatial distribution of some elements suggests an input of lead from Setúbal effluent and the northern shore industrial complex. The industrial effluents, mainly from the industries of the central part of the outer estuary, also seem to contribute cadmium, copper, and manganese.

2 - The river Sado itself is an important source of metals to the estuary, mainly of Zn, Cd and, to a lower level, of Cu (see also section 2.3), since it drains the Iberian pyrite belt and mining regions.

3 - The increasing content of Cu and Zn in the upper 30 cm of the sediment seems to be related to the development of industrial activity and urban development in the estuary.

4 - Organotin compounds were found in the sediments, mainly those around the industrial complex near shipyards, and it has been suggested that these compounds could be the cause of shell deformations and failure of reproduction of *Crassostrea angulata*, the Portuguese oyster.

5 - Comparing the results obtained for the northern channel, it seems that from 1979 to 1986 the Zn and Pb concentrations increased (315 to 539 ppm and 75 to 98 ppm, respectively), and that Cu and Fe content has decreased (128 to 102 ppm and 6.2 to 3.9%, respectively). Nevertheless this could also be due to the different location and number of sampling stations of the studies.

CHAPTER 3

METHODOLOGY

3.1 - SAMPLING

The Sado estuary subtidal macrozoobenthic and sedimentary characterization was based on the analysis of 133 samples collected during June/July 1986, covering the entire outer estuary, as shown in figure 3.1.

At each location the ship was anchored and two grab samples were taken, one for the macrofaunal analysis and the other for the sediment analysis. A Smith-McIntyre grab was used, of 0.1m^2 bite-area and total weight (with additional weights) of 90 Kg. It has doors on the top of the body allowing the access to the relative undisturbed superficial sediment.

The grab proved suitable for use in all the sediment types of the Sado estuary. All grab samples containing less than 2/3 of its full volume or arriving at the surface with open jaws were rejected.

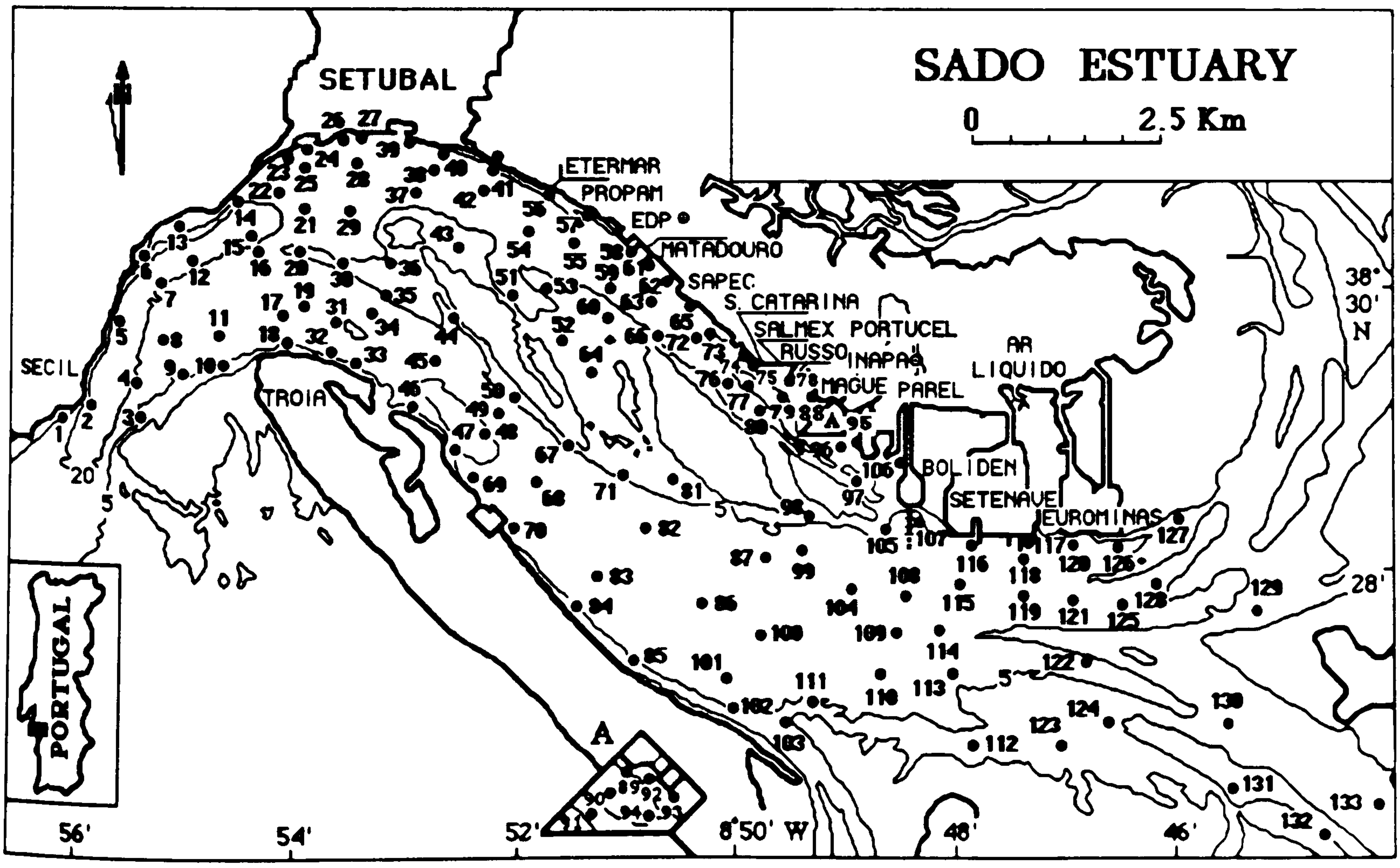


Figure 3.1 - Sado estuary. Bio-sedimentary sampling locations. Depth in meters.

For the granulometric analysis, a sub-sample of approximately 200 or 500 grams wet-weight was collected from the top 10 cm of each grab sample, depending if the sediment was, respectively, muddy or sandy. For the total organic matter determination a quantity of aproximately 15 grams of sediment (wet-weight) was collected from the upper 3-5 cm and frozen on board.

For the macrofaunal analysis, one grab sample was emptied into a large tray and scraped clean. Then a marked sample bucket lid and water was added to the tray and if needed, and before being washed, the sediment was broken by hand. The samples for faunal studies were sieved through a 1mm mesh sieve and the material retained was preserved in 10% borax buffered formalin and stained by Rose Bengal.

General principles regarding macrozoobenthic remote sampling and sample handling aboard followed those described by Hartley & Dicks (1987) and FRPB (1988).

3.2 - LABORATORY PROCEDURES

3.2.1 - Sediments

3.2.1.1 - Granulometry

The grain-size analysis was performed by dry sieving. Sample pre-treatment consisted of the following steps:

- Washing of the sediment with distilled water followed by chemical destruction of the organic matter with H_2O_2.
- Determination of the total dry weight of the sample, at 110°C (=P_1) untill the obtention of a constant weight (≈24h), followed by continual chemical dispersion of the sediment for 24 hours in tetra-sodium pyrophosphate (30 g/l) and wet sieving through a 63 µm mesh screen.

- Measurement of a second dry weight of the material left on the mesh (=P_2) and calculation of the dry weight of the fraction under 63 µm (=fines), by difference (=P_1 - P_2).

- Dry mechanical sieving of the P2 fraction using sieves with mesh screens ranging from 63 µm (4ϕ) to 8000µm (-3ϕ), at 1 ϕ intervals (ϕ = - $\log_2$ of the particle size in mm: Krumbein, 1934; Gray, 1981 - mesh-size to phi-notation conversion is shown in table III.1).

- Weighing of the fractions retained in each sieve. Removal, manually by eye or under a microscope, and weighing of the biogenic fraction (mainly mollusc shells), in the material retained in the sieves with a mesh screen ≥ 1mm (=P_3).

- Calculation of the final total dry weight of each sample, P_t (=P_1-P_3). For a given sample, the values of each of the 9 grain-size classes thus obtained is a percentage of P_t.

ϕ units	µm
4	63
3	125
2	250
1	500
0	1000
- 1	2000
- 2	4000
- 3	8000

Table III.1 - Mesh-size to Phi-notation conversion.

3.2.1.2 - Total organic matter, carbon and nitrogen

In the laboratory, the samples were kept at -20 °C. After bringing to room temperature, the sediment samples were oven dried at 110 °C and then ground. Total organic matter (TOM) by loss on ignition was determined as the weight difference between the dried sample at 110 °C and the combusted sample at 450 °C.

For this, a sub-sample of 1 gramme of dried sediment was incinerated in a muffle furnace at 450 °C until constant weight was obtained, which occured after a period of approximately 5 hours.

Before weighing, the samples were left for 30 minutes in a desiccator. It was noticed that variations in the 30 minute cooling period could introduce considerable differences in the final weight obtained. For this reason the 30 minutes period was carefully checked in each analysis.

Because the weight of the evaporation dishes varies with temperature, prior to the TOM measurements, the weight of each dish was determined for the analytical temperature (450 °C). For this, each evaporation dish was identified and exposed empty to 450 °C for 5 hours and then left in a desiccator for the same period as the sediment samples (30 minutes) before being weighed. This operation was repeated once a week.

Carbon and nitrogen content were also measured in 69 sediment samples, using 0.9 to 0.2 grammes of dried and ground sediment following the method by Byers *et al.* (1978) and Kristensen & Anderson (1987), which involves the use of a CHN analyser and a muffle furnace.

Two subsamples of the same sediment were analysed, one directly in the CHN analyser, which allowed the measurement of total carbon, and another one in a muffle furnace at 450 °C for the combustion of the organic matter. The latter subsample was then analysed in the CHN analyser thus providing a measure of the inorganic carbon content. The organic carbon was then obtained by difference. A Perkin-Elmer model 240 Elemental Analyser was used, and procedures were adopted following the manufacturers recommendations.

Kristensen & Anderson (1987) consider this to be one of the most reliable methods to determine organic carbon in sediment samples, since no pre-treatment of the sample is involved. It should be noticed though that beyond 400 - 500°C there is the risk of volatizing inorganic carbon, which in some cases may affect the value obtained for the organic content.

Also, Gomez-Parra & Frutos (1987), state that it is impossible to achieve complete weight stabilization when drying sediment samples. I noticed this difficulty with increasing quantities of sediment, and it becomes virtually impossible to measure total organic matter in a sample of 5 grammes of dried sediment. I agree with these authors that the total organic matter data should be considered as a relative measure useful to compare samples, but not an absolute value of the organic content of sediments. Several of the routine procedures to obtain total organic matter content may in fact be subject to considerable error if not fully checked and always repeated in the same way.

3.2.2 - Macrofauna

In the laboratory, the macrofauna sample was washed through a 1 mm sieve to remove the preservative, and the residue placed into a white tray with water for sorting. The animals and the part animals were identified to species level whenever possible and enumerated.

Identifications were made using low-power and high-power microscopes and using dissecation techniques when required. The main taxonomic texts used are listed in Annex II and specimens were sent to other taxonomists for identification when necessary.

Incomplete animals which had the anterior end missing were not recorded as individuals but they were included in the total biomass determinations.

The biomass of the fauna was recorded to species level on a wet-weight (blotted), dry weight and ash-free dry weight basis.

For the wet-weight determinations the specimens were placed on tissue-paper and then weighed in a Mettler electrobalance to 0.0001 g.

The wet-weight was determined for every species. In some cases, namely molluscs and species either represented by very different individual size-classes or very few specimens, all the individuals were weighed. For the remaining, the wet-weight was measured in all the specimens from 53 sampling stations covering the whole sampled area. The weight obtained was used to estimate the wet-weight of the individuals in the remaining sampling locations. The biomass of incomplete animals was also determined and assessed when possible to the respective species. When the identification was not possible the weight was considered only for the total biomass of the station.

The dry weight and the ash-free dry weight biomasses were obtained by drying the specimens to constant weight at 60 °C and ashing them at 520 °C for six hours as recommended in Rees *et al.* (1990).

Conversion factors from wet weight to ash-free dry weight were calculated this way for 56 species, covering all the different taxonomic groups identified. They were then used to estimate the ash-free dry weight biomasses of the remaining species.

3.3 - DATA TREATMENT

3.3.1 - Hydrodynamic variables: current velocity, water flow and shear stress

The simulation of the general hydrodynamic characteristics of the Sado estuary was developed by Neves (1985a), using a system of two coupled models: a bidimensional model, integrated in the vertical, for the region between the 50m isobath and the Alcácer Channel, which includes the initial part of the continental shelf, the estuarine entrance and the outer estuary, and a unidimensional model for the Alcacer Channel, the inner estuary.

The spatial grid used by the author is of 200 meters in the 2-D model and of variable lengh in the 1-D model, being in this case locally determined by the width of the channel. The temporal step used is 120 seconds.

The hydrodynamic model solves the shallow water equations for the mass conservation and the two horizontal velocity components in the 2-D model and for the flow rate in the 1-D model (Abbott, 1979).

The interaction between the flow and the bottom generates the so called shear stresses (τ_x), given in each horizontal direction by:

$$\tau_x = C_f \, |U| \, U_x$$

$$\tau_y = C_f \, |U| \, U_y$$

U is the current velocity and C_f is the bottom friction coefficient. This coefficient is computed using the Manning rugosity, which depends on the type of sediment distribution. In the Sado estuary, Neves (*op. cit.*) considered a constant Manning rugosity of 0.022 $m^{1/3}s^{-1}$. This value is suitable for the subtidal areas. In intertidal areas, a different value could be more appropriate. However, there is no available data to choose a more convenient value for such areas, and since the objectives of this work do not require details of the flow in the tidal flats this problem has been ignored. From the hydrodynamic point of view, these regions are important because of their capacity to store water during the flood tide.

The numerical scheme used by Neves (*op. cit.*) to solve the model equations is a semi-implicit method which solves 6 finite-difference equations at each time step. According to the author, the technique has very good stability and accuracy characteristics.

The benthic survey area covered by this thesis work corresponds to the estuarine region for which Neves (*op. cit.*) developed the 2-D hydrodynamic model. A cooperation with Neves was established in the course of this thesis work, in order to obtain from his model the current velocities, water flow and shear stress data for the sites of the biosedimentary survey. This specific data is to be mainly used in the interpretation of the sedimentary structure of the Sado estuary, obtained by the present work (Chapter 4), and in a direct gradient ordination analysis together with the biological data issued from the benthic survey (Chapter 6).

With this model, a full lunar cycle (28 days), was simulated. The results of this cycle showed a residual flow quite similar to the one produced by a simulation of the M2 tide, which corresponds to an average amplitude tide. Given the much lower time consumption to run the M2 tide (1/56 of the lunar cycle), these were the results used in our analysis.

The values of the hydrodynamic variables thus obtained for each sampling point correspond to the integration of all the partial values furnished by the model with a time step of 2 minutes, over a simulated 12h25 running time period of the model (= M2 tide).

For each sampling location, the "type value" of each variable was retained, corresponding to the arithmetic mean of all the instantaneous absolute values furnished for that site during the simulated running time period. This value differs from the residual value in two main senses:

1 - the residual value for a given site corresponds to the arithmetic value of the resultant vector of the whole set of observations furnished by the model for that site during the recquired running time period, and

2 - the residual value contains the information on the direction of the vector to be plotted in the diagram.

The residual velocity gives the dominant direction of the flow. The respective diagrams thus identify the dominant pathway of the sediments. The "type value" of a variable, on the other hand, gives its mean strengh, so giving information on the capacity to transport sediments. Another hydrodynamic property considered was the maximum value of the shear stress observed in the simulated running time period. This value gives an idea of the maximum grain size that can be transported at each site.

To obtain a correspondence between the location of the biosedimentary sampling stations and the coordinates of the model points, Neves's original 200m spatial grid was used. This grid is marked on a map of the estuary which is exactly the same map version used to position the biosedimentary sampling stations, thus allowing a fairly good location correspondence between both situations.

However, some difficulties arose that are worth mentioning. Due purely to computational needs, Neves had to consider that whenever a 200m quadrat comprised more than 50% of land, the whole quadrat would be assigned to the terrestrial environment. For this study several sampling stations were deliberately placed as close as possible to the margin, near outfalls or in sites where the estuarine margin is totally artificial due to harbour or similar constructions. Thus some of these sampling locations are not covered at all by the 2-D hydrodynamic model.

This also happened in sampling sites where the estuarine margins are almost entirely undeveloped, namely along the southern channel. In these cases, the value of the closest quadrat had to be considered. This inevitably introduced some subjectivity into the choice of the values, leading to some loss of accuracy in the present hydrodynamic model in the vicinity of the estuarine margin, where in fact the majority of the anthropogenic inputs are located. To overcome this, a smaller spatial grid closer to the margin would be needed. This was beyond the objectives of the work undertaken with Neves within the scope of this thesis work.

3.3.2 - Sediments

3.3.2.1 - Granulometry

The baseline granulometric data consists of a matrix of 133 stations x 9 sediment classes [under 4ϕ, 4ϕ-3ϕ, 3ϕ-2ϕ, 2ϕ-1ϕ, 1ϕ-0ϕ, 0ϕ-(-1ϕ), (-1ϕ)-(-2ϕ), (-2ϕ)-(-3ϕ), and above (-3ϕ)], each corresponding to a percentage of the total dry weight of the sample, excluding the biogenic fraction.

The sediment was characterized in relation to its percentage of fines (< 63 μm), sand (< 2000 μm; ≥ 63 μm) and gravel

($\geq$ 2000 µm) content, as also through the median (P_{50}), which may be defined as the diameter which has half the grains (by weight) finer, and half coarser (Trask, 1930).

This parameter was calculated through a program developed by two colleagues for the Apple Macintosh, A. Afonso and V. Quintino, which gives other classical grain-size parameters: the mean (M_Z, Folk & Ward, 1957), the sorting coefficient (σ_I, Folk & Ward, 1957), the dispersion deviation sorting (σ_ϕ, Otto, 1939 and Inman, 1952), the inclusive graphic skewness (sk_I, Folk & Ward, 1957), the skewness (α_ϕ, Inman, 1952), the inclusive graphic kurtosis (K_g, Folk & Ward, *op. cit.*) and the kurtosis (β_ϕ, Inman, *op. cit.*). Nevertheless, excepting the median, none of the other parameters were considered. This was because in most of the stations the necessary percentile values could not be calculated, due to the fact that the silt+clay fraction was not analysed in detail.

The final classification of the sediments adopted is summarized in table III.2, and considered the Wentworth scale (Doeglas, 1968) and an adaptation of Larsonneur (1977).

Median (φ)	Sediment classification		Fines content (%)		
			< 5	5 - 25	25 - 50
(-1) - 0	Sand	Very coarse	Clean	Silty	Very silty
0 - 1		Coarse			
1 - 2		Medium			
2 - 3		Fine			
3 - 4		Very fine			
> 4	Mud		above 50 %		

Table III.2 - Sediment classification, adopted from Wentworth (Doeglas, 1968) and Larsonneur (1977).

3.3.2.2 - Total organic matter

The results obtained for the total organic matter content were related to the fines content and the organic and inorganic carbon content, through regression analysis. This technique is presented in section 3.3.4.1.

3.3.3 - Macrofauna

3.3.3.1 - Primary and derived variables

The faunal data from each sampling location were analysed through the evaluation of primary variables (species richness, abundance and biomass) and by the calculation of secondary variables, like the Shannon-Wiener index (Shannon & Weaver, 1963), the eveness (Pielou, 1966), the abundance ratio (A/S) and the size ratio (B/A) (Pearson *et al*, 1982).

This procedure was applied to the global faunal data and to the most important individual taxonomic groups: the polychaetes, the crustaceans and the molluscs, in order to assess their respective contribution to the global results.

For the purpose of this work, the species richness and abundance of individuals of a sample are defined as the total number of species and the total number of individuals found in that sample. The biomass is the wet, the dry or the ash-free dry weight of the total number of specimens in a certain unit of area. In this work, species richness, abundance and biomass are expressed in relation to the sampling surface, $0.1m^2$.

The diversity indices are based on the concept of the diversity of a system, derived from information theory, and they give a measure of the species composition of a sample or an ecosystem, based on the species richness and the relative abundance distribution of the individuals for the different species (Legendre & Legendre, 1984).

The Shannon-Wiener is perhaps the most widely used diversity index in ecology. For a given sample, it may be calculated by the expression:

$$H' = -\sum_{i=1}^{s} p_i \log_2 p_i \quad \text{and} \quad p_i = \frac{q_i}{Q}\text{ , being}$$

S the total number of species, q_i the number of individuals of the i^{th} species and Q the total number of individuals. It is expressed in "bits" (binary digit).

H' will take the minimal value zero when only one species could be sampled, so when the probability of sampling a given species is maximum ($P=1$; $q_i=Q$ and $\log_2 p_i=0$). H' gets a maximal value when all the species have the same probability to be sampled. The maximum diversity value (H'_{max}) is given by $\log_2 S$ (Legendre & Legendre, 1984), being thus directly related to the total number of species in a sample.

Generally, higher values of diversity are found in more complex and developed biological systems. Nevertheless, diversity index values may be higher or increase when the ecosystems are subject to disturbance, induced either by natural (Quintino, 1988) or anthropogenic factors (Rees *et al.*, 1990). Also the same H' values may be found in totally different biological communities. In this context, H' should only be used as an information measure, with no strict biological significance (*cf.* Frontier, 1985, Rees *et al.*, 1990).

The eveness index (J) was proposed by Pielou (1966), according to the expression:

$$J = \frac{H'}{H'_{max}} = \frac{H'}{\log_2 S}$$

As in H', J also has the two diversity components, the number of elements ($\log_2 S$) and the regularity of their distribution by the different species (J): $H' = J.\log_2 S$.

J always varies between 0 and 1, and so it may be useful to compare diversity indices from samples with different species richness. However, since H'_{max} is a function of S, when comparing samples with very different species richness, similar values of J' would only be obtained if the observed diversity H' would vary accordingly to H'_{max}, which is hardly observed in nature. This has led to the concept that marine benthic communities tend to show an increasing dominance (= 1 - J) with increasing diversity (Birch, 1981). Despite this, it is generally accepted that low eveness values mean that the sample is dominated by few species, so that there is a high irregularity in the distribution of the considered parameter.

The fact that in ecology the concept of a maximum diversity (H'_{max}) is artificial and so that the relation H'/H'_{max} has no ecological meaning, caused Lloyd & Ghelardi (1964) to propose an equitability measure instead of that of eveness. Equitability is based on the relation between the species number of a McArthur model (broken stick) with the same diversity of the sample being analysed and the number of species obtained in this sample.

As this proposed measure is based on theoretical concepts not always verified in ecosystems, like the Pielou eveness index, and since the latter is the most commonly used, it will be used in this work.

The abundance ratio (A/S) corresponds to the mean number of individuals per species in the sample and the size ratio (B/A) to the mean weight of each individual in the sample (Pearson *et al.*, 1982). Along a gradient of increasing organic enrichment, the two indices tend to show opposite tendencies, the size ratio decreasing while the abundance ratio increases.

3.3.3.2 - Production

The relationship between production and mean annual biomass is given by the turnover ratio $P/\bar{B}$. According to Waters (1969), this ratio varies between 2.5 and 5, for temperate freshwater benthic invertebrates, while McLusky (1989) considers that it ranges from less than 1 to well over 5, for estuarine animals also from temperate areas.

Two different approaches for measuring secondary production are described in Crisp (1984). In one the growth increments of all the members of the population under study during a certain period of time are considered and in the other the production is derived from the biomass increment over the period under study, plus the mortality due to all causes.

Because such measurement of secondary production is a lengthy process, only possible by following the life history of a cohort, several authors have tried to develop alternative methods. McNeil & Lawton (1970) showed that the annual production of a broad size range of eukaryotic organisms is logarithmically related to annual respiration, while Robertson (1979) showed a relationship between $P/\bar{B}$ ratio and the life-span of benthic animals and Schwinghamer *et al.* (1986) concluded that it seems possible to obtain reasonable estimates of production from a knowledge of biomass and the size structure of the population.

Schwinghamer *et al.* (*op. cit.*) derived allometric scaling equations for calculating production from biomass, using data published in the literature which presented production for various benthic populations and for which they could calculate the mean individual body size. They then established a relation between the mean individual body mass (M), expressed in kilocalorie equivalents, and $P/\bar{B}$ values. For macrofauna they obtained the equation: $P/\bar{B}=0.525\ M^{-0.304}$, with a correlation coefficient $r=-0.50$. In their paper, a certain variability occurs around the line derived from macrofauna data, largely drawn from studies of organisms in boreal areas. It is possible that the inclusion of more results from studies undertaken in coastal systems with higher temperatures, such as the Sado estuary would result in a slightly different slope to the line for the macrofauna and thus slightly alter the equation obtained (Pearson, *comm. pers.*). Nevertheless, Schwinghamer *et al.* (*op. cit.*) found reasonably good estimations of production values.

The analytical expression given in Schwinghamer *et al.* (1986) was used in the present work to estimate $P/\bar{B}$ ratios in each of the sampling stations, for which the mean individual body mass was calculated, expressed in g afdw. The value obtained was then multiplied by the corresponding biomass (though knowing that this biomass value is not a true annual mean measure) to obtain the annual production estimate for each sampling location.

Schwinghamer *et al.* (*op. cit.*), used mean individual body mass expressed as kilocalories equivalence. For the conversion of the ash free dry weight biomass into kilocalorie values, a single factor was used for all the macrofauna. This option was taken since the mean calorimetric value of 1g of ash free-dry wt. for 123 species presented in Dauvin (1984), was 4.92 and that the conversion factors given by this author for separate groups (polychaetes, amphipods, other crustaceans, bivalves, other molluscs and echinoderms), varied from 5.05 to 4.63. Also, McLusky (1989) presented general conversion units for estuarine invertebrates, namely: 1g ash free dry weight approx. = 21 KJ and 1cal=4.184 J, from which we obtain 1g afdw approx. = 5 kcal.

In the present work the mean individual biomass expressed in g afdw, was converted into kilocalories by multiplying it by the factor 5.

3.3.3.3 - Trophic groups

Apart from the more traditional way to characterize communities based on species composition and abundance (Thorson, 1957, Pérès & Picard, 1964, Bellan, 1964) several authors also used species feeding habits with the same aim (e. g. Hunt, 1925 and Savilov, 1957 and Turpaeva, 1957, all *in*: Pearson 1971a, Pearson 1971a, Pearson *et al.*, 1982, Dauvin, 1984, Cancela da Fonseca 1989), and demonstrated the relation between environmental factors and feeding strategies of the benthic fauna (Pearson, 1971a, Pearson *et al.*, 1982, Fauchald & Jumars, 1979, Wildish, 1985, Hily, 1983, Pearson & Rosenberg, 1987).

Pearson & Rosenberg (1987) further advanced the notion that food availability could be the most important variable for the structuring of benthic communities.

The classification of species into trophic groups is not however a straightforward procedure. This is mainly due to the lack of knowledge regarding the feeding methods of some species, to the fact that borderlines between the different trophic modes are often unclear and finally because species may feed in a variety of ways, depending on the relative availability of different food items.

The most widely accepted classification distinguishes four major trophic groups: filter feeders, deposit feeders, carnivores and herbivores (Pearson, 1971a). Nevertheless, each of these groups can be subdivided, depending on individual choice, which on most occasions results in a compromise between existing knowledge of the set of species and the kind of information which an author wants to attribute to the groups, for example, type and selectivity of food taken, feeding habits, food-gathering techniques, motility, etc.

The classification into trophic groups of the macrofauna of the Sado estuary, considered the classifications proposed mainly by Pearson (*op. cit.*), Fauchald & Jumars (*op. cit*), Hily (*op. cit*), Dauvin (1984) and Eleftheriou & Basford (1989), the information given by these authors on the feeding modes of the species and also on personal communications by Dr. T. Pearson and the papers by Enequist (1950), Muus (1967), Wolff (1973), McLusky & Elliott (1981), Pihl & Rosenberg (1984), Josefson (1986) and Cancela da Fonseca (1989).

For the trophic group analysis, the macrofauna sampled in the Sado estuary was attributed to eight trophic groups:

Filter feeders (FF) - species which feed by filtering particulate matter and plankton from the water column overlying the sediment;

Surface deposit feeders (SDF) - species which feed on particles of detritus at or on the sediment-water interface;

Sub-surface deposit feeders (SSDF) - species feeding by ingesting sediment and absorbing the existing nutrient particles;

Filter feeders/Surface deposit feeders (FF/SDF) - species feeding by filtering the water overlying the sediment and by taking particles from the sediment-water interface;

Carnivores (C) - species which are mainly predators or actively moving carrion feeders;

Carnivores/Deposit feeders (C/DF) - species feeding in both ways;

Herbivores (H) - feeding on benthic diatoms and algae, and

Herbivores/Deposit feeders (H/DF) - feeding in both ways.

The choice of the groups including two types of trophic modes, was followed due to the difficulty in subdividing the abundances into percentages attributable to the different trophic strategies. In this way all the species considered in each group are mutually exclusive. The exception was the cirratulid *Tharyx* sp. and the Sipunculids, both classified as surface and sub-surface deposit feeders. In these two cases the abundance and the biomass in each sampling station was partitioned and 50% was included in each of the two trophic groups. This procedure was followed because only these two species were considered to belong to both the surface and sub-surface deposit feeders.

The data for the trophic groups analysis did not consider the entire set of species sampled in the estuary but only the top ten most abundant species in each sampling station. In some situations, the top ten species represent the whole set of species in a given station, sometimes they only omit species represented by one or two individuals. This choice was taken mainly for two reasons:

- The set of species omitted is essentially made up of rare species which inevitably increases the uncertainty of classification into trophic groups, and
- The most abundant species per site should be representative of the major feeding strategies in each sampling location.

3.3.4 - Macrobenthos - Environment Relationships

3.3.4.1 - Regression analysis and data transformation

Regression analysis is a commonly used technique in ecology. Its principal objective is to search the relation between a biological (dependent) variable and one or several environmental (independent) variables, thus leading to simple or multiple regression analysis.

In regression analysis however, it is not possible to use simultaneously several dependent variables, as it is in the case of ordination techniques, which will be presented elsewhere in this chapter. The principles of regression analysis, together with the cautions and usefulness of the method in ecology are discussed by ter Braak & Looman (1987).

Linear and the second order polynomial regressions were used with the data. In some cases, the polynomial regression was the only one retained, even if the linear regression also showed significant values. This was the case when the parabola significantly improved the fit of the data over the straight line, which was assessed by analysing if the extra parameter obtained by polynomial regression, b^2, was or was not significantly equal to zero. A t test was used for this purpose, which considers the estimate of b^2 divided by its standard error (ter Braak & Looman, *op. cit.*).

For the regression analysis, a statistical software package was used which gives the regression parameters and the ANOVA table, from which it is possible to know how well the regression equation explains the dependent variable. The ANOVA table gives the values of the R^2_{adj} (adjusted coefficient of determination), the F value (the variance ratio) and the t value, with the associated probabilities. The R^2_{adj} corresponds to the percentage of variation of the dependent variable explained by the independent variable and it is a recommended modification of the unadjusted coefficient of determination (R^2), which does not takes into account how many parameters are fitted as compared to the number of observations (ter Braak & Looman, 1987). Usually the R^2_{adj} gives lower values than the R^2.

The variance ratio (F value) was used to test statistically (F test) if the variance of the dependent (biological) variable is or not related to the variability of the independent (environmental) variable. The t test, as mentioned, was used to test statistically if the parabola significantly improved the fit of the data over the straight line (ter Braak & Looman, 1987).

The biological data obtained in the Sado estuary presents many zero and many small to moderate values, while there are only a few extremely large values, which is a common situation with ecological quantitative data. Either the distribution of the total species abundance (or biomass), or the distribution of the individual abundances (or biomasses) presented by each species in the sampling stations, tends to be very asymmetric (figs. 3.2 and 3.3).

This type of distribution tends to present increasing variance with increasing mean values, which demands that the original data should be transformed to stabilize the variance and to normalize the data (Daget, 1979, Legendre & Legendre, 1984).

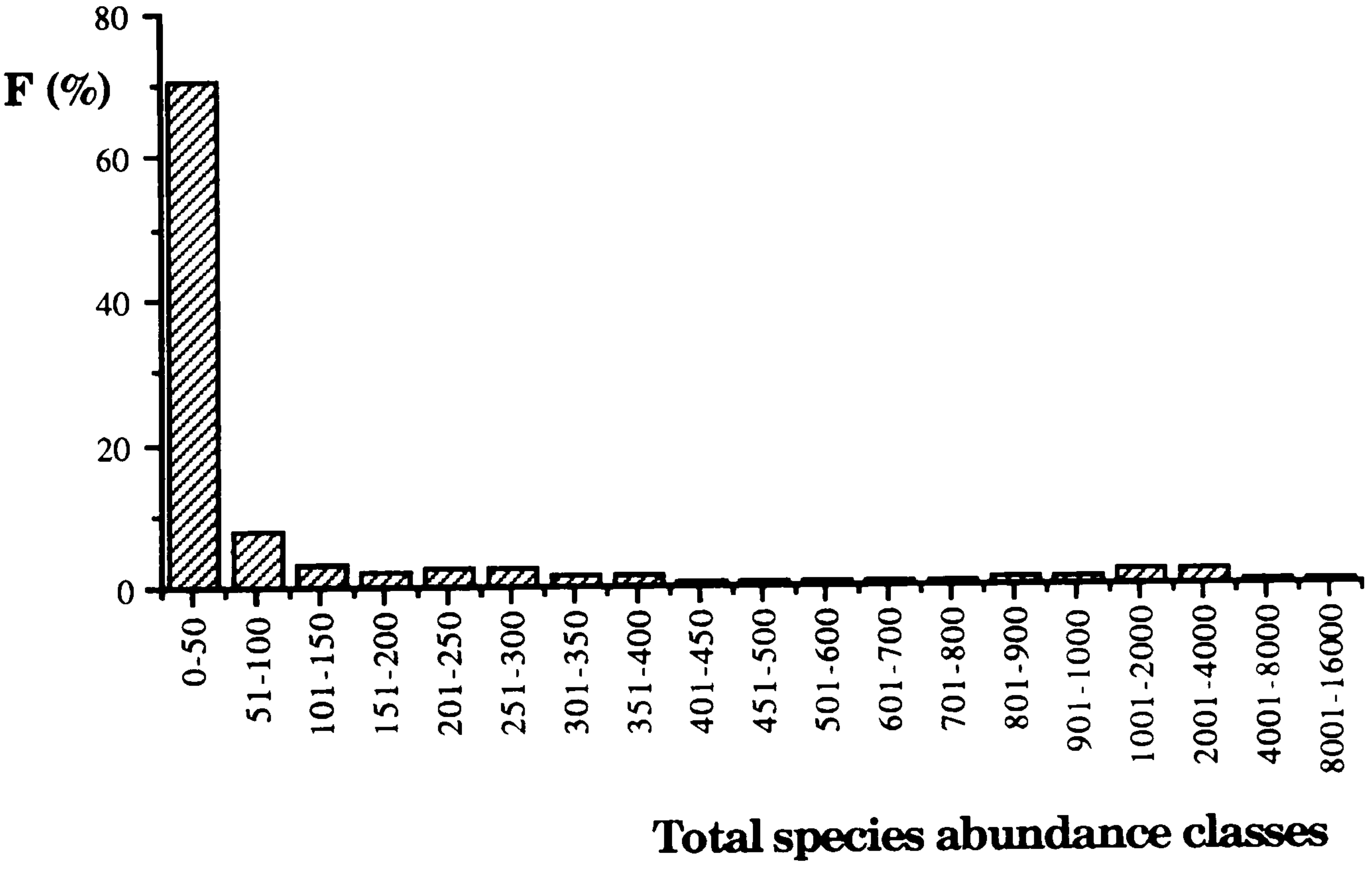


Figure 3.2 - Sado estuary. Frequency (F) of the total species abundance classes.

Apart from allowing the use of parametric statistics, this transformation also tends to diminish heterogeneity in the data, thus ensuring that both univariate analyses, e. g. regression, and multivariate analyses, e. g. ordination, will be less influenced by the extreme values in the data set (*cf.* Jongman *et al.*, 1987).

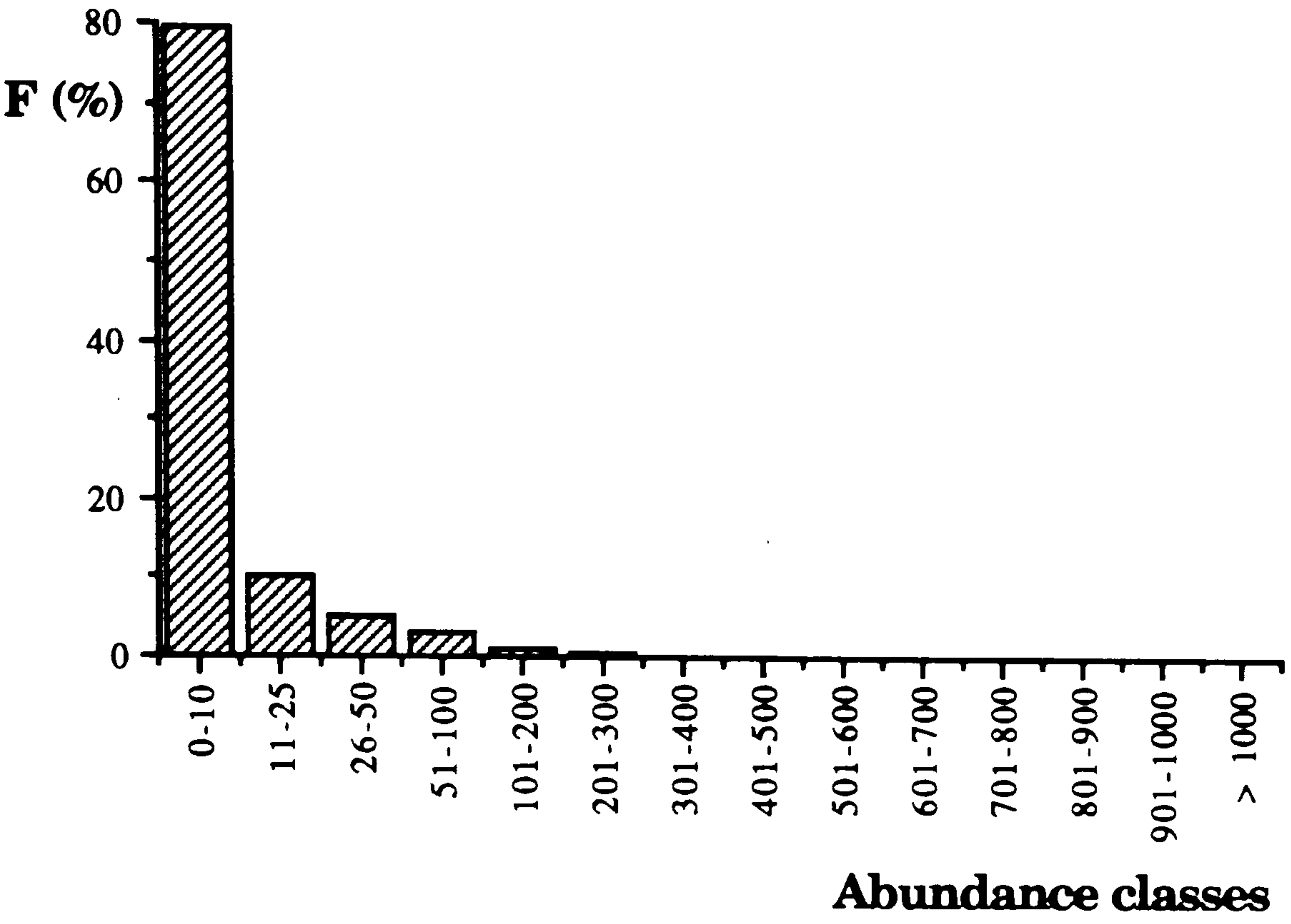


Figure 3.3 - Sado estuary. Frequency (F) of the individual species abundances in all the sampling locations.

The logarithmic transformation y' = ln (y+1) was used, given the high asymmetry in the data (*cf.* figures 3.2 and 3.3) (Legendre & Legendre, 1984). This is the most powerful tranformation commonly used with ecological data (however less powerful than ln y, Clarke & Green, 1988), which maintains the quantitative information contained in the data (Jongman *et al.*, 1987).

3.3.4.2 - Cluster analysis and community classification

The purpose of cluster analysis is to classify data, i.e. to identify groups in the raw data and help to find structure in it. One of the major drawbacks of such methods arises from the fact that even if the data shows a continuous structure, a discontinous system of types or classes will be forced. Gauch (1982) gives an extensive presentation of several classification methods.

In the present work the classification method TWINSPAN (Two Way INdicator SPecies ANalysis), developed by Hill (Hill *et al.*, 1975, Hill, 1979) was used. The method and the program use, are also described in Gauch (1982), and van Tongeren (1987).

The choice of this method lay in the fact that it is a programme widely used for ecological purposes, which gives interpretable solutions in most cases, and also for practical reasons, the program was available in a version which runs on a personal computer.

TWINSPAN is a divisive, hierarchical method of classification and is based on the partitioning of the first axis of a correspondence analysis. It lies on the fact that each group of sites can be characterized by a certain group of species. As this is a basically qualitative concept, to use the method with quantitative data each species abundance is replaced by a presence of one or more pseudo-species (a presence-absence variable), defined by a minimum of abundance (cut level).

The more abundant the species is the higher the number of pseudo-species generated. This is a way of transforming quantitative data into presence-absence of a certain number of pseudo-species and has, as its main disadvantage, the choice of the cut levels, which is arbitrary.

In this work the cut levels used were 0, 5, 10, 20, 40. They were choosen for three main reasons:

- the limitations to the number of pseudo-species imposed by the programme version used, prohibiting the inclusion of another cut level between 0 and 5,
- the analysis made on the original data of the abundance matrix and the number of observations included in each of the cut levels and,
- the similarity groups emphasized by the method with these cut levels, which agreed very well with what was already known from the analysis of the biological, the sedimentary and the hydrodynamical aspects of the various estuarine regions (Chapters 4 and 5).

These cut levels are very close to the default ones accepted by the method (0, 2, 5, 10, 20). The data matrix used, 131 stations x

275 species, is derived from the original one, 131 x 362, by eliminating all the species only present once.

TWINSPAN constructs an two-way table by ordering firstly the stations and then classifying the species according to the site classification, on the basis of the degree to which species are confined to particular groups of sites.

This table allows an easy assessment of the relationship between groups of stations and preferential species. In the present work, however, this table was not available due to the large size of the data matrix and the programme version used, which only allows the classification of a maximum of 260 species while the data matrix used includes 275.

Since the classification of species by TWINSPAN is essentially based on the fidelity of the species to the groups of stations identified, we used the constancy and fidelity criteria proposed by Retière (1979) to do the same, and thus to see which species could be the most important for each group of stations.

The species constancy and fidelity were characterized according to the scales presented in Table III.3 (Retière, 1979).

Constancy (C)		
	$C \leq 12.5\%$:	rare species
	$12.5\% < C \leq 25.0\%$:	occasional
	$25.0\% < C \leq 50.0\%$:	common
	$C > 50.0\%$:	constant
Fidelity (F)		
	$F \leq 10.0\%$:	accidental species
	$10.0\% < F \leq 33.3\%$:	accessory
	$33.3\% < F \leq 66.6\%$:	indifferent
	$66.6\% < F \leq 90.0\%$:	preferential
	$F > 90.0\%$:	elective

Table III.3. Sado estuary. Species constancy and fidelity scales.

The constancy (C_iA) (Retière, 1979) of a species in a community, is given by the relation between the total number of presences of the species in the community (N_iA) and the total number of sampling locations comprising the community (NA):

$$C_i\,A = \frac{N_i\,A}{NA}\,100 = ...\%$$

The fidelity (F_iA) (Retière, 1979) of a species to a community, corresponds to the relation between C_iA and the sum of C_iA with the strongest constancy of that species in the whole studied region:

$$F_i\,A = \frac{C_i\,A}{C_i\,A + C_i\,B}\,100 = ...\%$$

We have also used the notion of the representation of the sampling frequency of a species in a community (R_iA), given by the relation between the number of presences of the species in the community (N_iA) and the total number of presences of the species in the analysed region (N_i) (Quintino, 1988):

$$R_i\,A = \frac{N_i\,A}{N_i}\,100 = ...\%$$

For the purpose of this work the term community is applied to a particular assemblage of organisms of a specific category, sampled with a given device and inhabiting an area influenced by a particular set of abiotic factors (Lambshead *et al.*, 1983). Thus in practical terms, and according to the methodology used to characterize the affinity groups, two distinct communities (assemblages) present a different set of dominant and characteristic species (constant elective / constant preferential and/or common elective / common preferential species), and inhabit regions with distinct predominant environmental factors.

3.3.4.3 - Ordination analysis

Ordination analysis comprises a group of multivariate techniques which arrange sites (and species) along axes of variation on the basis of data on species composition. The axes maximize the dispersion of the points to extract the dominant pattern of variation in community composition (ter Braak, 1987a).

The result of ordination in two dimensions (two axes) is a diagram in which sites are represented by points in two-dimensional space in such a way that points that are close together correspond to sites that are similar in species composition and points that are far apart correspond to dissimilar sites in species composition.

The way in which environmental variables influence the biological data may be analysed either in an indirect or direct way. With indirect gradient analysis, sites (and species) are firstly arranged along ordination axes, which may be seen as hypothetical environmental variables. These are then interpreted, *a posteriori*, on the basis of what is known about the environmental characteristics of the sites.

With direct gradient analysis, the pattern of variation in species composition is imposed by a particular set of measured environmental variables. A comprehensive review of these and other ordination related subjects is presented in ter Braak (1987a) and ter Braak & Prentice (1988).

The ordination analyses performed in this work made use of the program CANOCO, CANOnical Community Ordination, by Cajo ter Braak (1988). CANOCO provides several ordination methods, assuming both linear or unimodal response models of the species in respect to the environment.

I made particular use of canonical correspondence analysis, in which the ordination axes are chosen in the light of the variability of measured environmental variables. It is a direct gradient ordination method, which assumes a unimodal response model between species and the environment. CANOCO and (canonical) correspondence analysis are extensively treated by ter Braak (1985, 1986, 1987b, 1987c, 1988, 1990).

The solution presented by this method is an ordination diagram, where samples and species are represented by points and environmental variables by vectors. The length of the vectors indicate their strength in determining the variability of the biological data, while the direction of the vectors points out the highest value of the variables.

The vectors are centered in the origin of the representation, where each variable takes its mean value. Positive deviations from the mean lie in the direction of the head of the vector, whereas negative deviations lie in the opposite direction, not represented in the diagram. Vectors pointing more or less in the same direction indicate a positive correlation between the respective variables, while if pointing in opposite directions indicate negative correlations. Vectors crossing at right angles indicate almost a zero correlation.

The relation between a point-species or a point-station in the diagram and a given environmental variable may be approached by projecting a perpendicular from the point to the vector. The further the distance from this projected point to the origin of the diagram, the more it is related to the environmental variable, either in a positive way, if the projection lies on the side of the head of the vector, or in a negative way, if the projection lies on the opposite side of the vector's head.

When using CANOCO, it is possible to test statistically if the species are related to the supplied environmental variables, by using a Monte Carlo permutation test. This tests if the canonical axes obtained (constrained by imposing a given environmental variability), have or have not a statistical validity.

We used CANOCO version 3.1 (ter Braak, 1990), which also performs a forward selection of the environmental variables in order to see which best explain the species data. The method does this by first running the analysis with one environmental variable at a time, and then ranks them by diminishing order of the amount of variation in the biological data explained by each.

As soon as the strongest environmental variable is accepted, the method checks among the remaining for the one that best complements the already explained variation in the biological data. If, for example, there are two environmental variables more or less related to the same biological data variability, when one is included in the set of the accepted explanatory variables, the other will take a much lower position in the described ranking.

It is possible to test the statistical significance of the amount of variance added by each variable at a time, through the Monte Carlo permutation test. After fitting the biological data, the test is based on the null hypothesis of the exchangeability of the residuals of the species. This test then furnishes an F-ratio which is compared to the F-ratio obtained with the true residuals. After setting the number of permutations to be used (19 permutations will allow a significance analysis at the probability $P = 0.05$; 99 permutations at $P = 0.01$), the true F-ratio is compared with all the others. Under 19 permutations, if one gives an F-ratio higher than that obtained with the true data, then the variable is considered non-significant at $P = 0.05$, and the variable is not included in the analysis.

If the Monte Carlo test is run each time before a new variable is added to the model, then at a given time it is possible to come up with a pool of remaining environmental variables which explain no more than a non significant part of the variability of the biological data that can be assessed with the set of environmental variables considered. Those variables may then be excluded from the analysis and introduced as passive variables, which means that they will not have power to define canonical axes, but will be represented in the diagram in their right position. The Monte Carlo permutation test and the F-type criterion are presented by ter Braak (1990). Finally, the method gives the absolute and the relative amount of variation of the species data explained by the supplied environmental data (*cf.* ter Braak, 1990).

The choice of (Canonical) correspondence analysis as the major ordination technique used in this work, was based on the following reasons:

- the data was collected over a wide range of habitats and so a nonlinear nonmonotonic relationship between the biological and the environmental variables would be expected, suggesting the use of unimodal response models to relate species to the environment (ter Braak, 1987c),
- the main interest lay on the analyses the extent to which the measured environmental variables could explain the variability of the biological data and which kind of gradients where emphasized, and finally
- to compare the results obtained by this method and those from the classification method, based solely on biological data.

The data matrix used with CANOCO was the same utilized in TWINSPAN (131 stations x 275 species), but considering station 26 (urban sewage outfall) as a supplementary station. This procedure was followed since this site presents a strongly different and very high abundance value, which distorts the analysis, despite the ln (y+1) transformation. It permits this station to be plotted in the diagram in its right position, but *a posteriori*. The environmental variables used were: fines, sand, gravel, total organic matter, temperature, flow, shear stress, current velocity and depth (Chapter 4).

The data treatment, regression, classification and ordination analysis, were performed in a MacIntosh Plus personal computer, with 1 Mb of RAM memory, and equiped with a 70 Mb external hard disk.

3.3.5 - Benthic communities disturbance analysis

The analysis of the state of disturbance of the Sado estuary subtidal benthic communities is based on the characterization of primary and derived variables of these communities, the composition and spatial distribution of affinity assemblages and their relation to the prevailing hydrophysical and sedimentary estuarine conditions.

The evaluation of the state of disturbance is thus redrawn from community level parameters of composition and structure and evokes methods directed to the analytical study of diversity, namely the distribution of individuals and biomass among species.

Among the several methods presented in the literature, those which are the most widely accepted have been used, though recognizing that this is a field of controversy among authors (see namely Gray, 1985, Lambshead & Platt, 1985), and that continual effort in interdisciplinary research at several levels of biological organization will probably be the best way to assess pollution induced disturbance of the marine environment (see namely Bayne *et al.*, 1988).

In the present work we combined the Shannon-Wiener diversity index (Shannon & Weaver, 1963), and the rarefaction diversity measurement proposed by Sanders (1968) and modifyed by Hulbert (1971), with the descriptive SAB model and indicator species (Pearson & Rosenberg, 1978) together with the comparative analysis of the abundance ratio (A/S) and the size ratio (B/A) (Pearson *et al.*, 1982). The analysis was complemented by tracing diversity-dominance plots, such as the K-dominance curves (Lambshead *et al.*, 1983, Shaw *et al.*, 1983), and their extension in the abundance - biomass comparison curves, ABC curves (Warwick 1986, Warwick & Ruswahyuni 1987, Warwick *et al.*, 1987). Finally, an assessment of the trophic structure of the estuary, the distribution of the rare species (see namely Gray *et al.*, 1990), in the groups previously identified, and an analysis of the biological characteristics of the most important species is also introduced.

The SAB model (Pearson & Rosenberg, 1978), details the fluctuations of the primary biological variables (Species richness, Abundance, Biomass) in the benthic succession along an organic enrichment gradient. Along a decreasing organic enrichment gradient, in time or space, the model proposes a grossly polluted, a polluted and a transitory area, by comparison to a "normal" area, at the end of the gradient and corresponding to the undisturbed community. The grossly polluted area has no macrofauna. The polluted area presents lower species richness than the observed in the undisturbed community, the highest abundance value due to the presence of opportunistic species and a peak value of biomass. Finally, the transition area shows the highest values for both the biomass and the species richness, while abundance is still higher than in the"normal" area, but lower than in the polluted area.

The Shannon-Wiener index typically varies from 0 in a highly stressed environment to over 5-6 in a clean environment (Reish, 1984). However its use as a scale of pollution effects has been controversial and agreement exists that care should be exercised in its use, since identical diversity index values may be found in totally different biological communities (Boesh, 1977, Rees *et al.*, 1990). Nevertheless, the results of this index have generally shown good agreement with the pollution effects (e. g. Pearson, 1975, Rosenberg, 1976, Ware, 1979, *in*: Reish, 1984, McLusky, 1989) and it is widely used as an informative measure.

The rarefation technique of Sanders (Sanders, 1968), instead of representing diversity in a single number like the Shannon-Wiener index (with which it presented good agreement - Sanders 1968), it is a graphic method, independent of sample size, that represents the interpolation curve of the number of species existing in samples with fewer specimens than the original sample but keeping its abundance frequencies: in general a steep rarefaction curve indicates high diversity in the sample as a shallow curve represents high dominance. This technique has been improved by Hulbert (1971), and the curves which will be presented in this work have been constructed according to this correction.

In the K-dominance curves the abundance frequencies of the species in the y axis are cumulatively represented and the curve always increases from the starting point (Lambshead *et al.*, 1983). They are analysed looking their starting point and the shape, which gives an indication of the first ranked species dominance and the hierarchical structure of the sample: the higher the slope the less regular is the distribution of abundances (or biomass) among species. Also the terminal part of the curve could give an indication of how the abundance is distributed among the less frequent components of the community (rare species). A non-disturbed sample should produce a curve with a longer tail than a disturbed sample in which rare species tend to be less frequent.

Although rare species are an ecological concept difficult to rationalise and work with, their presence is becoming more recognised as an important tool in the ecological diagnosis of disturbance in the marine environment. Their systematic disappearance has been observed along gradients in which environmental conditions become more severe both by natural (Quintino 1988) or anthropogenic causes (Gray *et al.*, 1990).

The ABC curves exploit the relative position of the abundance and the biomass curve. In samples from enriched and high disturbed areas the abundance curve lies above the biomass curve, due to the high number of individuals found in these areas and their relative small size. With moderate levels of enrichment and disturbance the two curves approach each other and overlap and finally in non-disturbed areas the biomass curve lies above the abundance curve due to the dominance of relative large but low abundance organisms (Warwick, 1986, Warwick & Ruswahyuni, 1987, Warwick *et al.*, 1987).

In general, these graphical methods which are based on the analytical study of community structure patterns, tend to show consistent results with disturbance effects, when these are due to the preferential development of certain species, usually small and low individual weight opportunistic species. However, the ABC method has been shown to give the same answer to either natural or pollution induced disturbance (Warwick & Ruswahyuni, 1987, Warwick *et al.*, 1987), to respond to species recruitment as to opportunistic species development (Beukema, 1988) or to indicate undisturbed structures when pollution prevents the development of opportunistic species (Meire & Dereu, 1990, and the present study).

CHAPTER 4

ENVIRONMENTAL VARIABLES: HYDRODYNAMICS AND SEDIMENTOLOGY

4.1 - INTRODUCTION

This chapter presents the original environmental data obtained in the course of this thesis work. It comprises two main parts, the characterization of the superficial sediments and the hydrodynamics of the estuary.

The major hydrodynamic characteristics of the Sado estuary have been presented in Chapter 2, and were drawn essentially from Neves (1985a) and Ferreira & Neves (1987). The results of subsequent work directly undertaken with Neves is reported here. This consisted of the calculation of current velocities and water flow data furnished by the 2-D hydrodynamic model for the sites covered by the benthic survey, and the calculation of shear stress data for the same sites. Current velocities and water flow data were the basis of the global hydrodynamic characterization of the Sado estuary presented in Chapter 2. The shear stress data is entirely original and was specifically calculated to be used in connection with this work.

The hydrodynamic data derived from the model will be used for the interpretation of the sedimentary structure of the Sado estuary, obtained by the present work, and in a direct gradient ordination analysis together with the biological data obtained from the benthic survey (Chapter 5).

The superficial sediment characterization includes the granulometric structure, fines, sand and gravel content, the identification and the distribution of the several subtidal sediment types in the estuary, and also the total organic matter content and the sediment temperature. The results obtained will be presented essentially in the form of distribution maps covering the area of study.

4.2 - CURRENT VELOCITY,WATER FLOW AND SHEAR STRESS

Current velocities, water flow and shear stress data for the sites covered by the biosedimentary survey were calculated using the 2-D hydrodynamic model for the tidal flow and residual circulation of the Sado estuary (Neves, 1985a), and according to the methods presented in Chapter 3.

The figures for the maximum and the residual shear stress will be presented in this section. They are essentially similar to the flow figures and follow the same basic considerations (see chapter 2), so no further detailed comments regarding the hydrodynamics of the estuary will be made.

Notice however in figure 4.1 representing the maximum shear stress values the clear distribution of the highest values for the maximum shear stress in the entrance of Marateca, along the southern channel and finally in the estuarine entrance, while the Alcacer channel and the northern channel present much lower shear stress maximum values (the arrows represent the observed value and the direction in which it was obtained).

In the residual shear stress diagram (figure 4.2), notice the two main gyres present in the estuary, their close meeting point in the southern channel, near California, and the larger gap in the northern channel.

The inner residual shear stress gyre, is anti-cyclonic and shows stronger values near the northern margin at the entrance of Marateca and along the southern channel, particularly bordering the southern margin of the intertidal sandbanks. The lowest values correspond to some locations in the southern margin, close to the Comporta entrance, and also to some locations in the northern margin, near Setenave and Eurominas.

The outer residual shear stress gyre, is cyclonic and shows stronger values near the entrance of the estuary and in the southern channel. In the northern channel, the highest residual shear stress

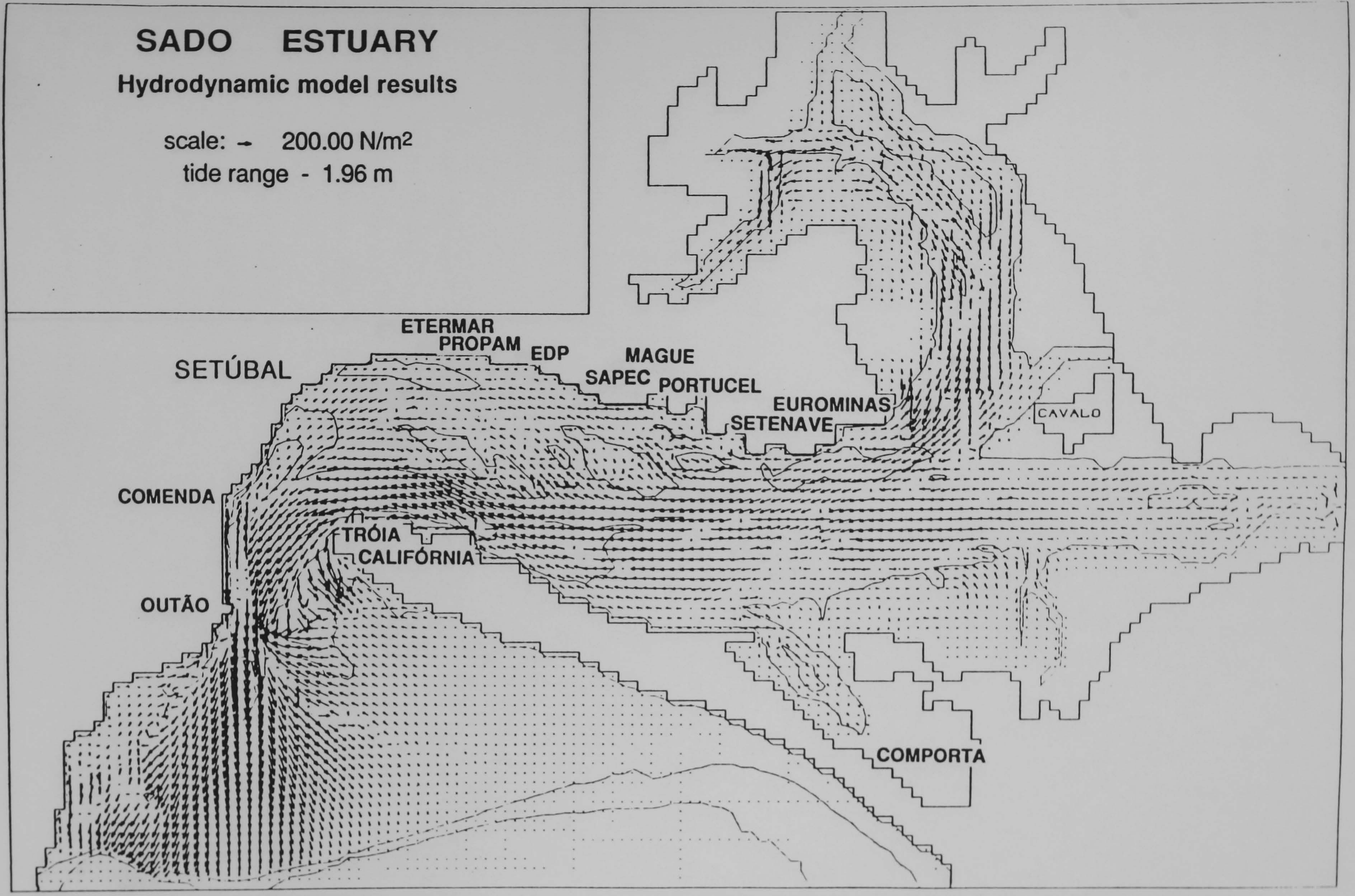


Figure 4.1. Sado estuary. Maximum shear stress values observed during the M2 tide.

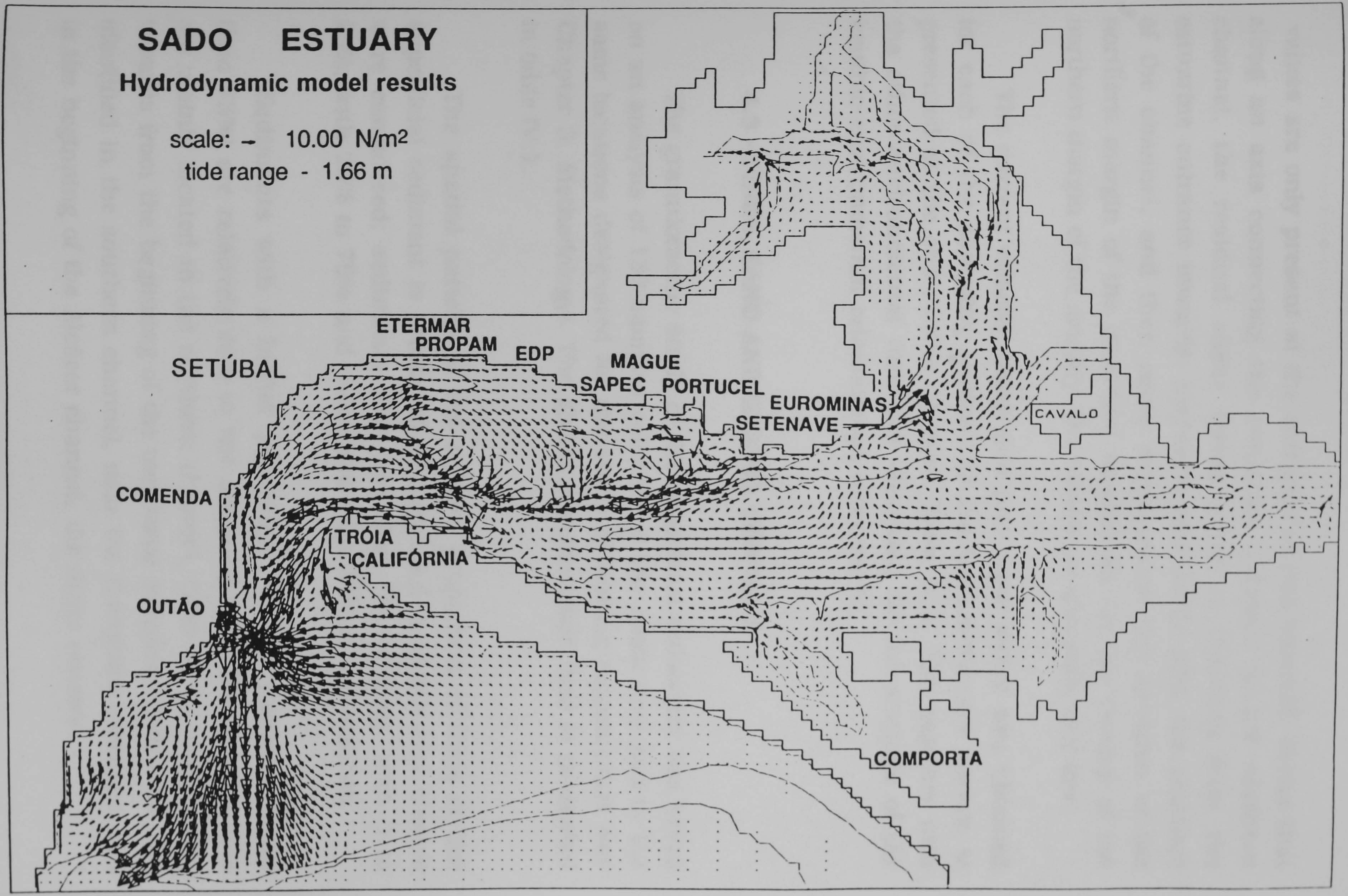


Figure 4.2. Sado estuary. Residual shear stress observed in a simulated M2 tide.

values are only present at the entrance of this channel. Notice that along an axis connecting the estuarine entrance to the northern channel, the residual shear stress tends to diminish from the estuarine entrance inwards, increases afterwards near the entrance of the channel, and then again decreases in the direction of the northern margin of the intertidal sandbanks. In the vicinity of the northern margin of the estuary, the values are generally very low.

The current velocity, water flow and shear stress data obtained for each of the sampling stations of the biosedimentary survey, is presented at the end of this Chapter, Table IV.4. This together with the other environmental variables was used for the analysis of the benthic-environmental relationships (Chapter 6).

4.3 - FINES, SAND AND GRAVEL CONTENT

The granulometric study of the superficial sediments was based on an analysis of 133 samples collected at the same time and in the same locations designated for the study of benthic communities (see Chapter 3, Methodology). The global granulometric data is presented in table IV.1.

The spatial pattern of the relative proportion of fines in the superficial sediment is presented in figure 4.3 to which four classes were considered: sediments with less than 5% of fines, with 5 to 25%, with 25% to 75% and with more than 75% of this fraction.

Sediments with a higher percentage of fine particles (more than 75%) are relatively rare in the analysed area. These sediments are mainly located in the northern channel, close to the margin and inwards from the beginning of the industrial complex. They were also identified in the southern channel, near the Comporta entrance, and in the beginning of the Alcácer channel, the inner estuary.

Stations	Granulometric Fractions								
	>4 ϕ	4 ϕ	3 ϕ	2 ϕ	1 ϕ	0 ϕ	(−1) ϕ	(−2) ϕ	(−3) ϕ
	< 63 µm	63 µm	125 µm	250 µm	500 µm	1000 µm	2000 µm	4000 µm	8000 µm
1	5.94	2.03	7.91	10.15	22.53	16.37	6.96	13.34	14.78
2	1.09	0.13	0.48	1.90	53.45	21.24	11.84	9.61	0.26
3	1.52	0.19	2.16	49.73	34.57	11.14	0.69	0.00	0.00
4	2.56	0.67	6.21	53.34	16.69	7.01	5.82	5.32	2.37
5	6.31	0.59	3.32	13.09	24.49	22.24	14.68	11.12	4.15
6	3.89	6.77	63.78	20.97	3.01	1.24	0.30	0.05	0.00
7	0.99	0.06	0.20	10.89	82.41	5.08	0.33	0.05	0.00
8	1.52	0.17	1.68	21.14	40.35	22.87	6.50	3.60	2.17
9	3.83	0.62	4.16	26.78	36.79	18.09	7.04	1.59	1.10
10	1.92	0.16	4.08	29.83	48.15	15.70	0.15	0.00	0.00
11	0.94	0.06	0.43	26.82	55.77	13.82	1.61	0.55	0.00
12	1.93	0.17	1.70	46.65	41.37	8.00	0.18	0.00	0.00
13	33.48	34.16	19.87	5.42	4.80	2.19	0.07	0.00	0.00
14	43.38	5.78	36.20	9.02	2.99	2.45	0.16	0.00	0.00
15	1.66	0.11	2.40	46.53	44.94	4.24	0.12	0.00	0.00
16	6.82	1.43	22.60	55.12	11.02	2.92	0.09	0.00	0.00
17	27.46	2.00	4.75	25.38	11.34	4.15	2.75	7.03	15.13
18	8.10	5.36	47.64	29.45	8.20	1.18	0.03	0.03	0.00
19	4.04	1.03	18.51	27.33	26.2	11.24	3.36	2.24	6.04
20	7.81	0.85	62.00	27.56	1.47	0.32	0.00	0.00	0.00
21	3.19	0.42	3.71	7.82	66.82	17.30	0.62	0.12	0.00
22	10.00	1.00	12.83	22.00	30.42	17.89	4.76	1.11	0.00
23	18.65	5.75	21.59	22.93	11.09	4.75	1.71	0.72	12.82
24	64.69	18.97	13.46	2.21	0.42	0.25	0.00	0.00	0.00
25	37.06	6.60	38.17	10.33	3.88	3.09	0.30	0.58	0.00
26	36.54	6.81	23.15	17.14	6.69	4.59	3.90	1.18	0.00
27	67.48	6.95	13.54	6.73	3.08	1.80	0.20	0.23	0.00
28	14.77	1.34	5.38	7.25	31.75	27.61	6.98	3.21	1.74
29	23.16	1.50	9.43	23.05	38.40	3.85	0.51	0.13	0.00
30	10.52	2.04	34.71	48.52	2.97	1.24	0.00	0.00	0.00
31	0.78	0.05	0.16	26.77	63.29	8.15	0.70	0.10	0.00
32	2.16	0.14	4.76	72.63	17.40	2.60	0.17	0.14	0.00
33	2.70	0.39	3.00	20.30	36.39	15.55	6.71	4.38	10.59
34	6.04	1.37	21.13	33.55	26.48	10.69	0.73	0.00	0.00
35	9.61	1.67	5.33	61.78	18.59	3.02	0.00	0.00	0.00
36	35.68	2.80	10.77	35.17	13.75	1.80	0.00	0.03	0.00
37	11.02	0.76	2.52	9.73	47.78	22.21	3.89	2.08	0.00
38	10.18	1.06	5.58	10.22	47.09	20.91	3.42	1.20	0.34
39	31.29	9.24	15.37	4.16	38.46	1.30	0.10	0.08	0.00
40	56.46	2.57	10.85	24.23	4.99	0.67	0.09	0.14	0.00
41	63.63	16.62	10.97	2.38	2.20	4.03	0.18	0.00	0.00
42	26.48	1.13	3.18	8.45	46.61	13.55	0.58	0.00	0.00
43	8.16	1.94	37.83	40.34	9.73	1.96	0.03	0.00	0.00
44	20.40	3.45	26.02	25.73	21.03	3.36	0.02	0.00	0.00
45	26.13	1.59	6.20	21.11	23.81	17.00	3.85	0.31	0.00
46	3.32	0.71	14.09	26.08	37.68	16.13	1.56	0.42	0.00
47	1.84	0.11	2.87	25.33	44.05	24.13	0.88	0.00	0.78
48	1.32	0.08	0.65	31.26	42.76	21.75	2.09	0.09	0.00
49	1.89	0.14	0.63	25.06	51.98	17.73	2.40	0.15	0.00
50	19.12	2.75	44.63	21.48	10.25	1.74	0.02	0.00	0.00
51	56.02	17.18	8.12	9.25	6.57	2.52	0.34	0.00	0.00
52	52.04	12.11	11.86	6.13	11.90	5.30	0.53	0.13	0.00
53	41.37	2.14	11.13	19.30	19.59	5.78	0.70	0.00	0.00
54	29.27	1.48	12.81	16.59	30.43	7.46	1.53	0.44	0.00
55	37.64	1.36	5.97	10.75	33.08	10.58	0.61	0.00	0.00
56	26.64	4.94	17.67	32.80	15.40	2.39	0.15	0.00	0.00
57	83.91	10.22	4.75	0.53	0.26	0.32	0.00	0.00	0.00
58	93.93	3.44	0.86	0.83	0.58	0.31	0.05	0.00	0.00
59	45.65	2.16	11.96	14.69	19.98	5.36	0.19	0.00	0.00
60	41.64	6.24	33.02	8.68	7.27	3.12	0.02	0.00	0.00
61	87.92	5.51	3.12	2.64	0.48	0.29	0.04	0.00	0.00
62	89.15	7.66	2.71	0.26	0.12	0.11	0.00	0.00	0.00
63	80.89	4.58	6.96	3.50	2.68	1.30	0.08	0.00	0.00
64	40.39	9.45	17.68	18.45	11.27	2.66	0.11	0.00	0.00
65	78.95	5.53	8.48	3.08	2.39	1.05	0.51	0.00	0.00

Table IV.1. Sado estuary. Granulometric data, expressed as a percentage of the dry weight of the total sample.

Stations	Granulometric Fractions								
	>4 φ	4 φ	3 φ	2 φ	1 φ	0 φ	(−1) φ	(−2) φ	(−3) φ
	< 63 µm	63 µm	125 µm	250 µm	500 µm	1000 µm	2000 µm	4000 µm	8000 µm
66	43.47	2.15	9.68	21.34	18.37	4.87	0.12	0.00	0.00
67	3.14	0.24	0.96	22.55	49.30	20.45	3.18	0.17	0.00
68	0.60	0.04	0.46	14.37	80.88	3.64	0.01	0.00	0.00
69	24.68	1.04	12.26	42.30	16.06	3.42	0.16	0.08	0.00
70	31.43	0.83	9.54	29.83	22.27	6.00	0.11	0.00	0.00
71	11.53	1.33	10.70	34.42	30.10	10.01	1.42	0.49	0.00
72	63.43	5.13	9.34	16.42	4.38	1.25	0.05	0.00	0.00
73	75.23	20.81	3.46	0.32	0.14	0.05	0.00	0.00	0.00
74	29.32	1.85	6.40	21.43	24.26	12.57	3.49	0.67	0.00
75	9.85	0.97	3.09	22.26	40.04	18:71	4.20	0.88	0.00
76	62.35	2.92	7.02	12.92	11.18	3.53	0.08	0.00	0.00
77	49.50	4.55	10.95	15.48	14.14	4.74	0.55	0.10	0.00
78	72.47	15.59	8.80	0.97	1.04	1.01	0.00	0.13	0.00
79	16.22	2.64	11.58	30.27	28.66	10.05	0.44	0.13	0.00
80	52.70	2.43	15.16	11.23	13.04	4.51	0.85	0.08	0.00
81	6.29	0.86	5.57	35.51	40.11	10.88	0.77	0.00	0.00
82	35.78	1.64	4.74	23.22	27.51	6.61	0.50	0.00	0.00
83	7.56	0.58	5.12	44.52	28.37	13.61	0.24	0.00	0.00
84	12.42	1.05	30.20	38.87	13.56	3.65	0.24	0.00	0.00
85	37.33	1.80	15.16	25.64	12.16	6.28	1.40	0.22	0.00
86	12.91	0.66	11.44	45.02	25.32	4.61	0.03	0.00	0.00
87	28.92	0.84	11.5	24.51	22.27	9.14	2.20	0.61	0.00
88	17.55	3.32	11.56	26.79	26.65	10.92	2.47	0.73	0.00
89	12.96	1.73	7.42	30.01	32.09	12.42	2.43	0.94	0.00
90	73.58	4.71	9.34	4.68	4.93	2.54	0.22	0.00	0.00
91	17.45	1.91	13.24	31.8	27.5	7.49	0.52	0.09	0.00
92	96.28	2.56	0.69	0.22	0.18	0.06	0.00	0.00	0.00
94	42.75	3.83	21.84	18.24	10.08	2.51	0.22	0.00	0.53
95	93.41	4.21	1.23	0.58	0.24	0.27	0.06	0.00	0.00
96	3.62	0.51	7.62	33.68	36.24	16.9	1.39	0.04	0.00
97	22.63	2.42	28.05	21.51	16.30	7.70	1.40	0.00	0.00
98	13.67	1.25	4.49	21.77	34.25	16.48	4.79	1.84	1.47
99	7.57	0.75	25.16	28.75	25.16	9.97	2.37	0.27	0.00
100	28.72	2.31	10.17	21.31	23.47	12.27	1.68	0.07	0.00
101	30.40	1.20	10.06	29.76	22.42	6.14	0.01	0.00	0.00
102	93.75	4.49	0.99	0.42	0.21	0.14	0.00	0.00	0.00
103	22.33	0.57	2.95	28.97	40.11	4.96	0.11	0.00	0.00
104	2.77	0.29	8.25	41.5	37.32	9.36	0.45	0.06	0.00
105	19.92	1.40	5.34	24.96	28.89	13.79	3.75	1.94	0.00
106	95.99	1.79	1.79	0.33	0.07	0.02	0.00	0.00	0.00
107	89.93	3.55	4.01	2.11	0.36	0.04	0.00	0.00	0.00
108	6.83	0.79	38.11	33.04	14.65	6.10	0.47	0.00	0.00
109	27.72	1.01	7.38	42.87	16.54	4.37	0.11	0.00	0.00
110	26.28	0.86	2.14	31.01	33.24	6.10	0.37	0.00	0.00
111	27.54	4.30	5.98	23.06	32.65	6.42	0.06	0.00	0.00
112	22.23	4.18	16.11	35.30	18.56	3.50	0.11	0.00	0.00
113	29.09	1.84	9.56	30.02	24.42	4.74	0.20	0.13	0.00
114	22.60	1.02	18.24	45.14	7.99	4.25	0.56	0.19	0.00
115	1.70	0.10	1.05	36.55	48.38	11.48	0.74	0.00	0.00
116	12.00	0.77	5.13	38.64	30.90	7.90	3.02	1.11	0.53
117	62.75	0.95	1.63	11.77	18.91	3.55	0.43	0.00	0.00
118	8.20	0.94	4.87	31.64	36.51	11.88	3.17	2.55	0.23
119	1.59	0.18	3.34	41.50	40.79	7.89	1.53	1.16	2.01
120	93.48	2.41	1.47	1.21	1.11	0.32	0.00	0.00	0.00
121	13.12	0.27	2.77	16.75	33.37	22.28	8.37	3.08	0.00
122	32.9	1.45	2.81	26.73	27.63	7.18	1.21	0.08	0.00
123	2.41	0.24	9.38	60.53	25.27	2.18	0.00	0.00	0.00
124	26.23	0.74	8.81	40.85	17.17	4.16	1.17	0.88	0.00
125	9.60	0.32	6.42	52.13	25.65	4.98	0.91	0.00	0.00
126	16.36	1.27	19.67	41.07	13.06	5.49	1.69	1.38	0.00
127	1.93	0.09	0.33	23.27	69.29	5.04	0.05	0.00	0.00
128	7.86	0.55	6.72	45.91	33.18	5.34	0.40	0.03	0.00
129	24.01	2.56	11.94	36.16	21.94	3.32	0.07	0.00	0.00
130	47.07	2.84	7.46	28.12	10.71	3.51	0.29	0.00	0.00
131	5.38	0.44	9.62	51.65	20.25	7.18	3.38	2.10	0.00
132	48.07	1.79	10.11	25.45	9.07	5.02	0.35	0.14	0.00
133	84.02	7.34	3.30	1.47	1.65	2.21	0.00	0.00	0.00

Table IV.1. (Continued)

Sediments with a lower percentages of fines (less than 5%) correspond essentially to the estuarine entrance and the beginning of the northern and southern channels. These sediments were also detected in 4 locations in the upper part of the outer estuary, in front of Setenave/Eurominas. The spatial distribution of fines also shows that the cleaner sediments tend to extend to the inside the estuary essentially through the southern channel.

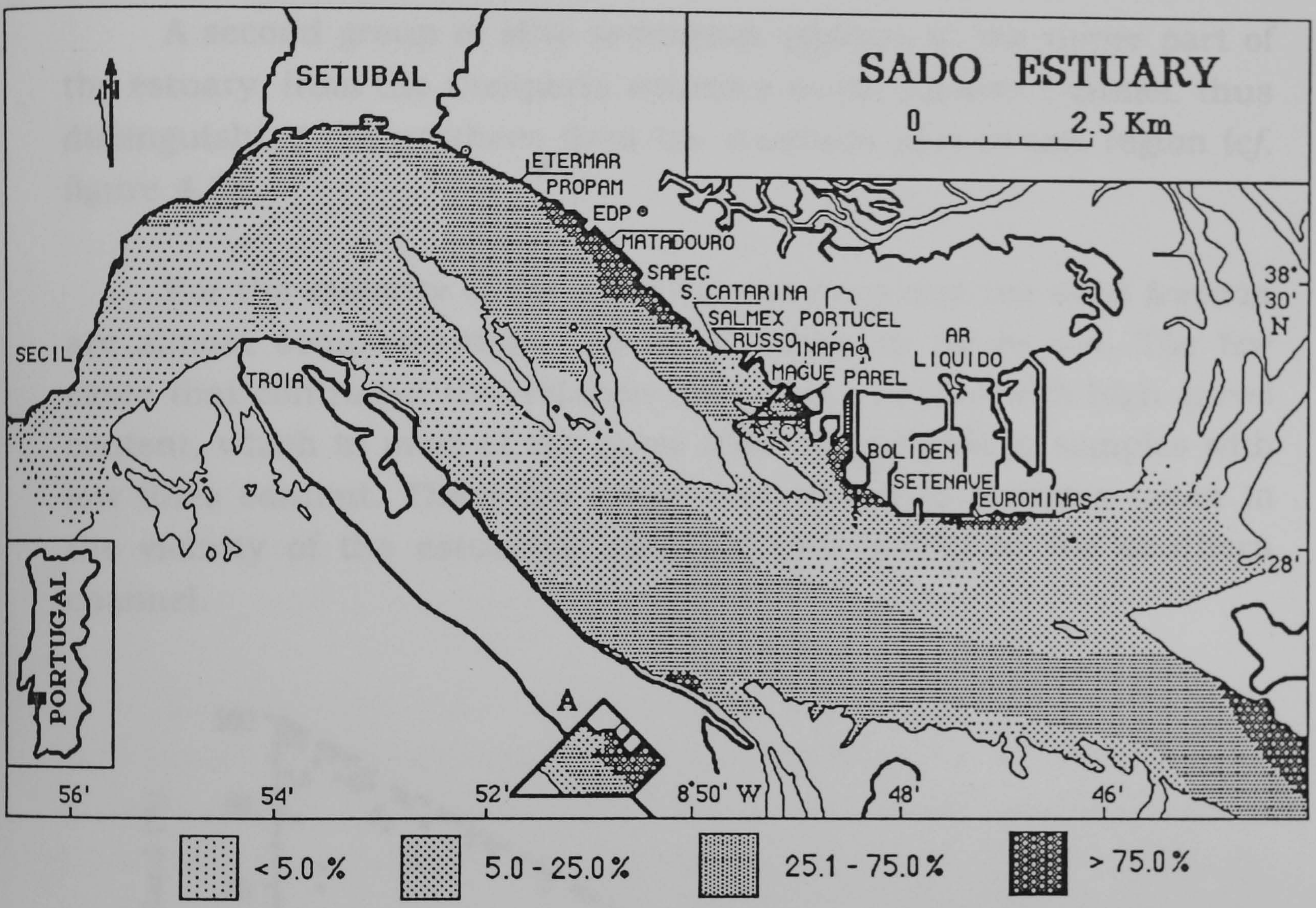


Figure 4.3. Sado estuary. Spatial distribution of fine particules (< 63 µm) in the subtidal superficial sediments.

The Sado estuary subtidal sediments show several increasing gradients of fines content. The most important one follows the longitudinal axis of the estuary with an increasing proportion of the silt+clay fractions from the estuarine entrance towards inward regions. In the vicinity of the intertidal sandbanks, this gradient splits into two major components, one directed towards the northern channel and the other towards the southern channel.

In the northern channel, the high proportion of fines in the sediments located close to the margin, establishes a clear lateral decreasing gradient of the silt+clay fraction, in the direction from the margin toward the sandbanks.

The spatial pattern of fines content clearly distinguishes the northern and the southern channel subtidal sediments, the former with a much higher proportion of the silt+clay fraction.

A second group of silty sediments appears in the upper part of the estuary, from the Comporta entrance to the Alcácer channel, thus distinguishing the northern from the southern part of this region (*cf.* figure 4.3).

For the majority of the samples, the fines and the sand fraction are almost complementary, which is shown in figure 4.4. The few cases that contradict this relation consist of samples with high gravel content, which in most of the cases also corresponds to samples with low fines content. These few cases correspond to samples taken in the vicinity of the estuarine entrance and locally in the southern channel.

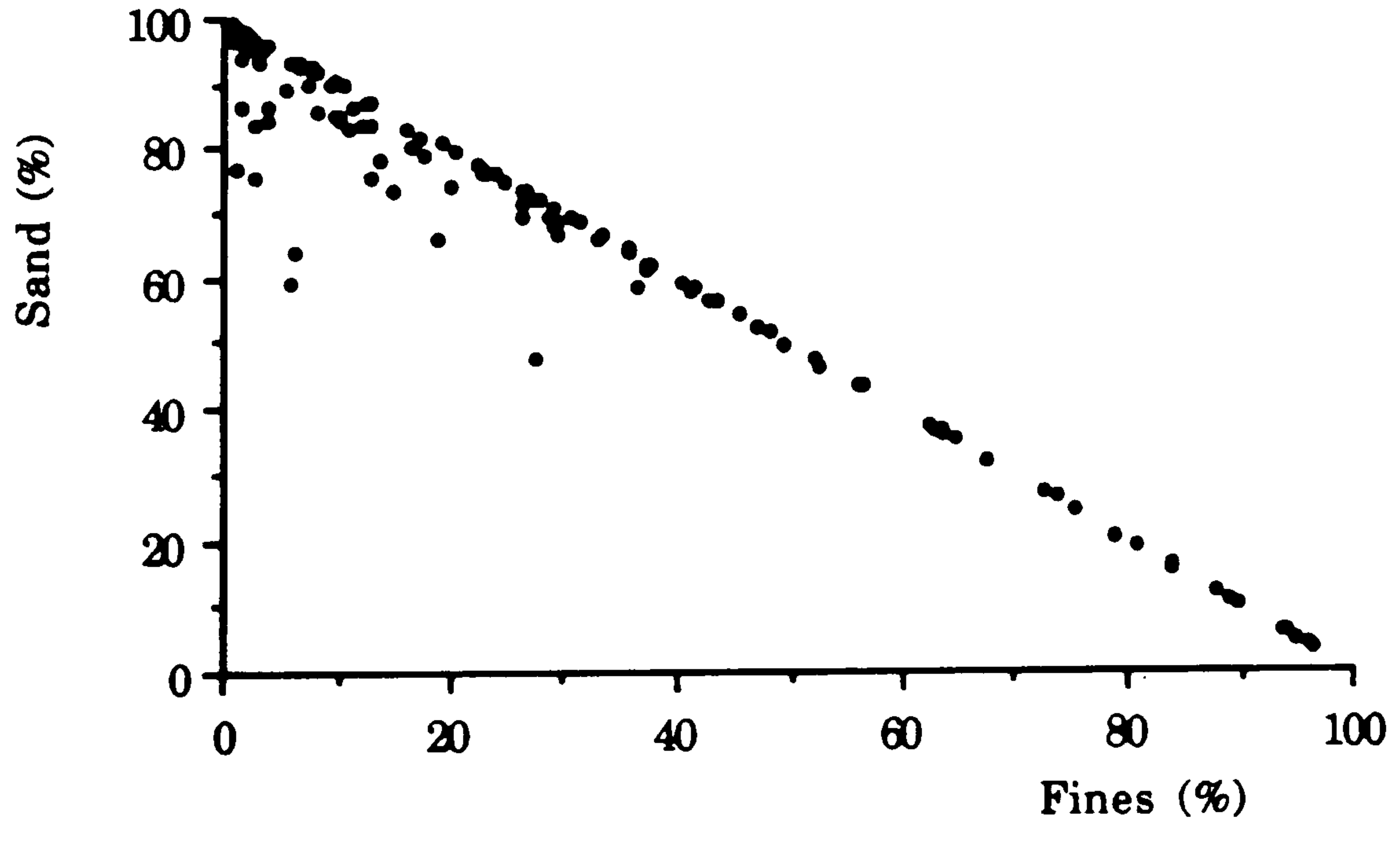


Figure 4.4. Sado estuary. Relation between the fines and the sand fraction in the subtidal superficial sediments.

The distribution of fines, and the almost complementary distribution of the sand fraction, agree remarkably well with the hydrodynamical characteristics of the Sado estuary which can be assessed in particular through the maximum and the residual shear stress pattern illustrated in figures 4.1 and 4.2, and the transient and residual flow presented in figures 2.3 to 2.5.

In fact, the cleaner sediment path connecting the mouth of the estuary to the entrance of Marateca, through the southern margin of the intertidal sandbanks (figure 4.3), clearly corresponds to the sites where the hydrodynamic variables also show the highest values.

The southern channel region where the two main vortices meet, near California (figures 2.5 and 4.2), also corresponds to the innermost distribution limit of the cleaner sediments which extend inward from the estuarine entrance. These two main vortices roughly correspond to the split of the subtidal sediments into the groups which have more and less than 5% fines content (*cf.* figure 4.3).

The northern channel region where sediments contain more than 25% of fines also agrees with the wide gap between the two vortices in this channel, and with the low maximum shear stress values observed in this region (*cf.* figures 2.5 and 4.1 to 4.3).

The Setenave vortex could also explain the fact that the siltier sediments in the upper part of the estuary tend to be located closer to the southern margin, where both the maximum and the residual shear stress are weaker, and also the fact that the cleaner sediments tend to border the southern margin of the intertidal sandbanks, where they are stronger (*cf.* figures 4.2 and 4.3).

Also, the region in front of Setenave, where sediments present less than 5% of the fines content, corresponds to the meeting place of the main Setenave vortex with a smaller one (*cf.* also figure 2.5). The fact that the water flows in the same direction when the two vortices meet, could account for the washing of the superficial sediment and thus the coarser and less siltier sediments near Setenave.

Finally, the smaller vortices near the upper southern margin of the estuary, in the vicinity of the entrance of Comporta, and between this place and the Alcacer channel, could account for the deposition of fine particles near the entrance of Comporta and thus the small patch of very silty sediments found there and for the erosion in some small patches in the southern margin in the vicinity of the entrance of the Alcacer channel and the corresponding cleaner sediments of this area. This particular aspect is well represented by the residual shear stress pattern (see figures 4.2 and 4.3).

This close qualitative relation between the hydrodynamic variables and the fines and sand content of superficial sediments was quantitatively confirmed by the significant statistical relation between the two sets of variables. Both the fines and the sand content are however more strongly related to the shear stress than to the current velocity or the flow, which agrees with the theoretical stronger relation of this variable with the superficial sediments.

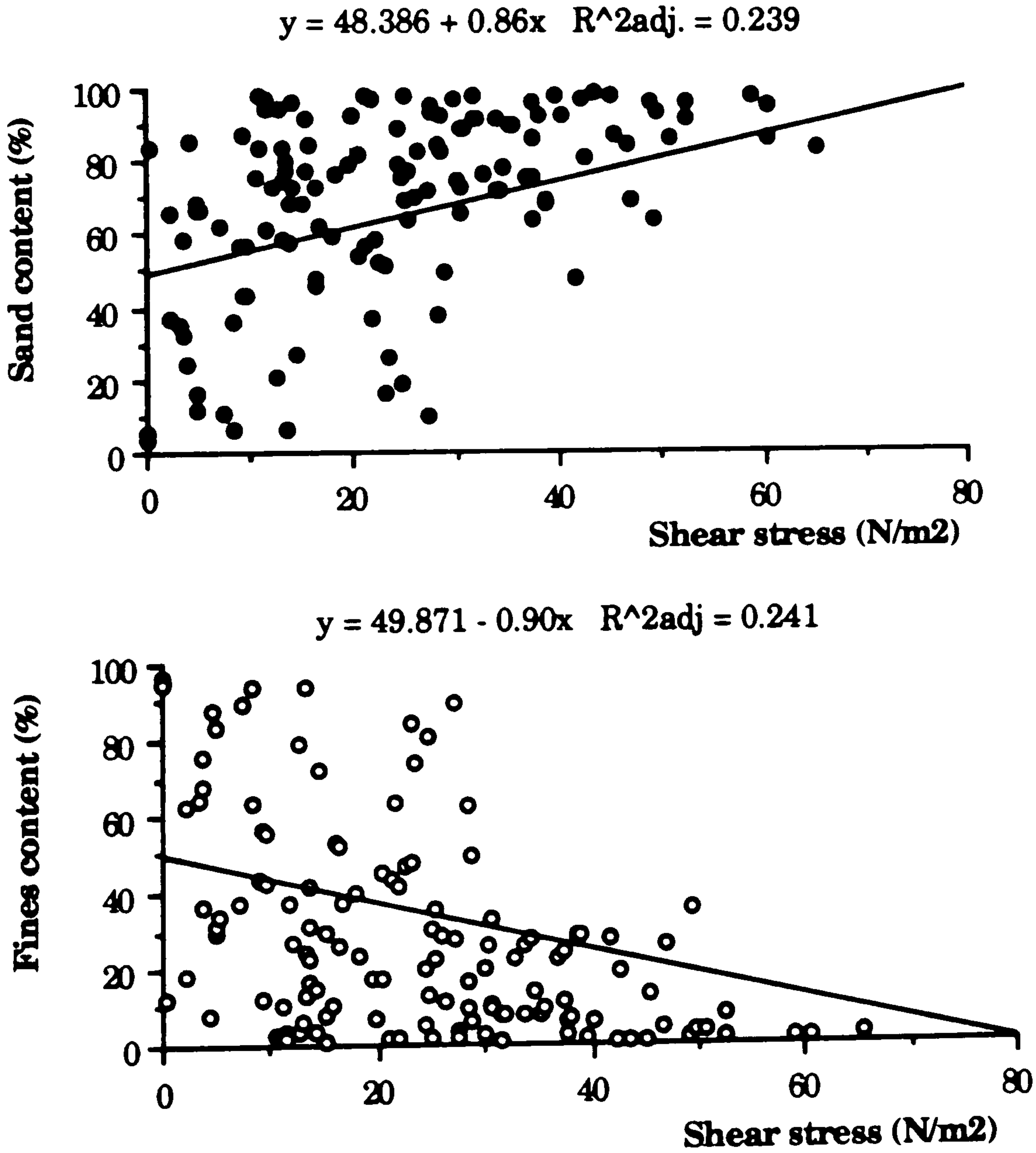


Figure 4.5. Sado estuary. Relation between shear stress type values and the fines and sand content of the superficial sediments. Linear regression lines and equations are shown with the R^2 adjusted value.

A linear regression analysis between [shear stress - fines] and [shear stress - sand], shows that the hydrodynamic variable explains 24% of the variation of both sedimentary variables. In both cases, the fines and the sand content are significantly related to shear stress ($P< 0.001$, F test, figure 4.5).

4.4 - SUPERFICIAL SEDIMENTS CHARACTERIZATION

The estuarine superficial sediments characterization was adapted from the Wentworth median scale (*cf.* Doeglas, 1968) and the Larsonneur (1977) criteria, regarding the sediments fines content (*cf.* Chapter 3). A simplified chart for the spatial distribution of the estuarine subtidal sediments is presented in figure 4.6. The construction of this figure and the classification of the sediments was based solely on the Wentworth median scale.

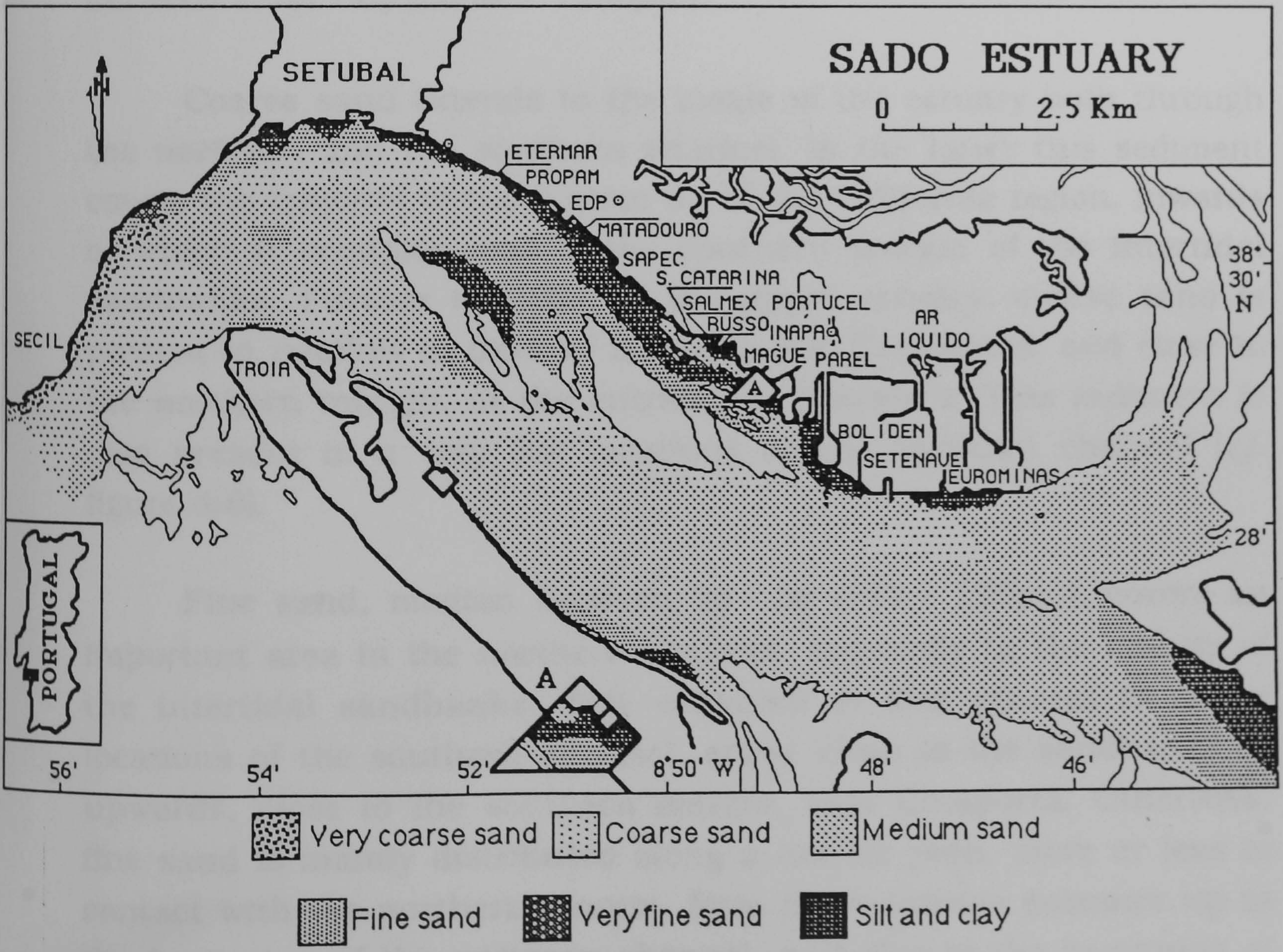


Figure 4.6. Sado estuary. Classification and spatial distribution of the subtidal superficial sediments.

The majority of the subtidal bottom of the Sado estuary is covered by medium sand, median between 1ϕ – 2ϕ (500 - 250μm). This sediment occupies almost exclusively the inner half of the southern channel and the whole upper basin of the outer estuary.

In these two regions, medium sand is only absent from the southern margin of the intertidal sandbanks, the entrance of Comporta, the beginning of the Alcácer channel, a few locations close to the northern margin, near Setenave and Eurominas, and in front of Setenave (*cf.* figure 4.6). Medium sand also covers an important area between the estuarine entrance and the beginning of the north and south channels.

The mouth of the estuary is characterized by a large extent of coarser sediments, the majority of which is coarse sand, median between 0ϕ - 1ϕ (1000 - 500μm), with patches of very coarse sand, closer to the northern margin and in deeper bottoms, median between (-1ϕ) - 0ϕ (2000 - 1000μm).

Coarse sand extends to the inside of the estuary both through the northern and the southern channel. In the latter this sediment covers the majority of the bottom up to the California region, inwards of which it occupies mainly the southern margin of the intertidal sandbanks. Further inwards, in the upper estuary, coarse sand is present in patches in front of Setenave and Eurominas, and close to the northern margin, at the entrance of Marateca. This sediment is also present in a very few locations of the northern channel (*cf.* figure 4.6).

Fine sand, median between 2ϕ - 3ϕ (250 - 125μm), covers an important area in the northern channel, especially in the vicinity of the intertidal sandbanks. This sediment is also present in a few locations of the southern channel, either close to the sandbanks or upwards, close to the southern margin, near Comporta. Otherwise, fine sand is mainly distributed along a narrow path, more or less in contact with the northern margin, from the estuarine entrance up to the beginning of the northern channel, and also in the beginning of the Alcácer channel, the inner estuary (*cf.* figure 4.6).

Very fine sand, median between 3ϕ - 4ϕ (125 - 63μm), is a rare sediment in the estuary. It is present only in a very few locations, of which the most important is a very sheltered beach on the northern margin, in the vicinity of the mouth of the estuary (*cf.* figure 4.6).

Muds, median > 4ϕ (< 63μm), are almost exclusively found in the northern channel, mainly near the margin. This sediment is also present at the entrance of Comporta, southern channel, and upwards, in the beginning of the inner estuary, the Alcácer channel (*cf.* figure 4.6).

The characterization and the spatial distribution of the subtidal superficial sediments emphasizes the distinction between the two channels, the northern one with much finer and muddier sediments.

Some of the remarks presented earlier in respect to the fines distribution, become more clear with the median spatial pattern, inherent to the sediments represented in figure 4.6.

The northern channel sediments inward from the beginning of the industrial complex are finer overall, which agrees with the gap between the two main vortices of the residual shear stress (*cf.* figure 4.2). Also, the sediments close to the southern margin of the intertidal sandbanks tend to show a coarser median value than those in the northern margin of the same banks and in the centre of the south channel. This agrees with Neves (1985a) conclusion in respect to the fact that the intertidal sandbanks tend to grow from the north and erode from the south.

A more detailed representation of the subtidal superficial sediments of the Sado estuary is given in figure 4.7. This figure combines the Wentworth median scale with an adapted classification of Larsonneur's criteria, regarding the fines content of each sediment type identified.

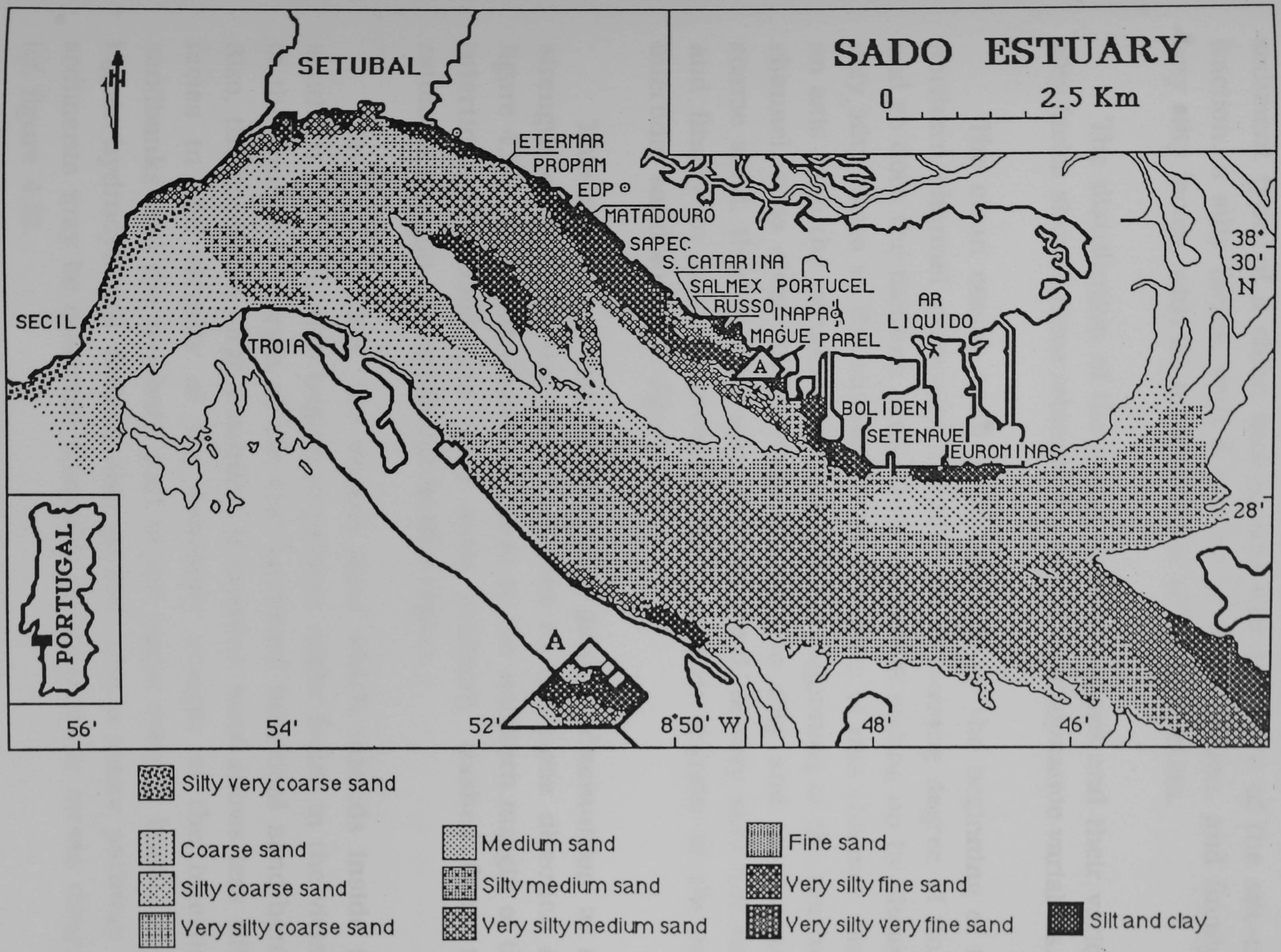


Figure 4.7. Sado estuary. Detailed classification and spatial distribution of the subtidal superficial sediments.

In this representation it is clear that the subtidal sediments of the estuary, though dominated by medium sand, present variable fines content, which allows the distinction, within each major sediment type, of a clean facies, with less than 5% of the silt+clay fraction, a silty facies, with 5 to 25% of that fraction, and finally a very silty facies, with 25 to 50% of the silt+clay fraction.

The distribution of the major sediment types and their various silty facies show a close relationship to the hydrodynamic variables.

The clean coarse sand which extends to the beginning of the northern channel gradually includes an increasing degree of fines, and so does the medium sand, both sediments ending up by showing very silty facies in the vicinity of the entrance of this channel. Along an axis from the estuarine entrance to the beginning of the northern channel, it is clear the passage of clean to silty and to very silty coarse sand, then to very silty medium sand, to very silty fine sand and finally to muds, bordering the northern margin of the first intertidal sandbank (*cf.* figure 4.7).

This sucession corresponds to a gradual diminuition in the strength of the residual shear stresses in the same direction (*cf.* figure 4.2). The muds deposited closer to the northern margin of this intertidal sandbank are thus most probably washed from the estuarine margin and settle out in this region.

On the contrary, the coarse sand which extends inside the southern channel, only begins to present siltier facies in the vicinity of the southern margin of the last landward intertidal sand-banks. Also, the landward large extention of medium sand shows less siltier facies in the vicinity of the southern margin of the intertidal sandbanks and the northern part of the upper estuary basin, where higher hydrodynamic factors also persist, and a major pathway for sediments may be observed from the residual shear stress diagram (*cf.* figure 4.2).

From these considerations it may conclude that:

1 - the physical characterization and the distribution of the subtidal superficial sediments of the Sado estuary are well explained by the prevailing hydrophysical conditions in the estuary,

2 - the outer residual shear stress field of the estuary agrees with the group of sediments dominated by clean coarse sand with clean and silty medium sand,

3 - the inner residual shear stress field of the estuary agrees with the group of sediments dominated by silty to very silty medium sand,

4 - very silty fine sand and muds clearly dominate the subtidal bottoms of the northern channel, in the deposition region between the two main vortices, and

5 - smaller vortices in the upper estuary may account for some detailed sediment distributions, namely muds at the entrance of Comporta, and coarse sands in front of Setenave, at the entrance of Marateca and in some locations in the southern margin before the Alcacer channel,

6 - the distribution of superficial sediments suggests three main origins for the estuarine sediments:

a) marine sediments entering through the mouth and extending mainly through the southern channel,

b) river sediments which after leaving the inner estuary find setting conditions only in the central and southern part of the upper estuary, and

c) sediments coming from the disposal systems along the northern margin, which should considerably enhance the naturally muddy sediments deposited there.

4.5 - TOTAL ORGANIC MATTER CONTENT OF THE SEDIMENT

Total organic matter was analysed by weight loss on ignition, according to the methods presented earlier (Chapter 3). In some of the samples, the total carbon, the organic and the inorganic carbon was also measured, using a CHN analyser. Tables IV.2 and IV.3 present the results obtained by both methods.

Stations	Fines (%)	TOM (%)
1	5.94	0.76
3	1.52	0.54
4	2.56	0.60
5	6.31	0.84
6	3.89	0.46
7	0.99	0.33
8	1.52	0.45
9	3.83	0.51
10	1.92	0.47
11	0.94	0.44
12	1.93	0.79
13	33.48	6.40
14	43.38	4.59
15	1.66	0.57
16	6.82	1.88
17	3.82	0.62
18	8.10	2.18
19	4.04	1.09
20	7.81	1.70
21	3.19	0.51
22	10.00	1.34
23	18.65	3.18
24	64.69	8.58
25	37.06	3.99
26	36.54	9.58
27	67.47	6.78
28	14.77	2.63
29	23.16	2.15
30	10.52	1.97
31	0.78	0.45
32	2.16	0.65
33	2.70	0.86
34	6.05	1.00
35	9.61	1.52
36	35.68	3.00
37	11.02	2.03
38	10.18	2.14
39	31.29	6.34
40	56.46	7.43
41	63.63	7.67
42	26.48	2.85
43	8.16	2.35
44	20.4	2.18
45	26.13	2.88
46	3.32	0.60
47	1.84	0.61
49	1.89	0.46
51	56.02	7.63
52	52.04	4.84
53	41.37	5.38
54	29.27	4.80
55	37.64	4.07
56	26.64	5.22
57	83.91	8.31
58	93.93	10.55
59	45.65	4.74
60	41.64	4.93
61	87.92	7.69
62	89.15	12.06
63	80.89	10.25
64	40.39	4.76
65	78.95	6.93
66	43.47	3.43
67	3.14	0.64
68	0.60	0.53
69	24.68	1.93
70	31.43	2.87
72	63.43	7.07
73	75.23	12.16
74	29.32	2.50
75	9.84	1.33
76	62.35	4.25
77	49.50	5.24
78	72.47	10.31
79	16.22	1.48
80	52.70	3.75
81	6.29	1.34
82	35.78	3.48
83	7.56	1.97
84	12.42	1.32
85	37.33	2.87
86	12.91	1.33
89	12.96	1.51
90	73.58	4.35
91	17.45	1.91
92	96.28	12.39
93	95.00	6.82
94	42.75	1.72
95	93.41	14.88
96	3.62	0.94
97	22.63	3.58
98	13.67	1.95
99	7.57	1.54
100	28.72	4.89
101	30.40	3.33
102	93.75	11.37
103	22.33	2.52
104	2.77	0.77
105	19.92	0.80
106	95.99	14.10
107	89.93	9.67
108	6.83	0.87
109	27.72	2.82
110	26.28	3.52
111	27.54	2.12
112	22.23	1.87
113	29.09	1.86
114	22.60	1.62
115	1.70	0.60
116	12.01	1.39
117	62.75	8.76
118	8.20	1.44
119	1.59	0.71
120	93.48	8.05
121	13.12	0.61
122	32.90	2.63
123	2.41	1.04
124	26.22	2.76
125	9.60	2.24
126	16.36	1.95
127	1.93	0.52
128	7.86	0.98
129	24.01	2.53
130	47.07	5.49
131	5.38	1.18
132	48.07	3.34
133	84.02	6.04

Table IV.2. Sado estuary. Total organic matter (TOM) and fines content, expressed as a percentage of the dry weight of the total sediment sample.

Stations	TC	OC	IC	TOM	Fines
1	2.76	0.15	2.61	0.76	5.94
4	2.21	0.26	1.95	0.60	2.56
5	1.76	0.46	1.30	0.84	6.31
9	0.71	0.05	0.66	0.51	3.83
13	4.35	2.10	2.25	6.40	33.48
16	2.46	0.49	1.97	1.88	6.82
18	2.85	0.36	2.49	2.18	8.10
20	1.66	0.42	1.24	1.70	7.81
21	0.76	0.05	0.71	0.51	3.19
24	3.39	2.39	1.00	8.58	64.69
26	4.50	3.68	0.82	9.58	36.54
27	4.40	1.76	2.64	6.78	67.47
29	1.50	0.78	0.72	2.15	23.16
30	1.86	0.52	1.34	1.97	10.52
33	0.62	0.08	0.54	0.86	2.70
35	1.31	0.35	0.96	1.52	9.61
38	2.19	0.26	1.93	2.14	10.18
39	3.66	1.86	1.80	6.34	31.29
40	2.52	2.10	0.42	7.43	56.46
41	4.84	2.58	2.26	7.67	63.63
42	1.46	0.98	0.48	2.85	26.48
44	1.25	0.21	1.04	2.18	20.40
46	0.73	0.24	0.49	0.60	3.32
47	0.24	0.14	0.10	0.61	1.84
51	2.95	2.34	0.61	7.63	56.02
53	2.76	0.91	1.85	5.38	41.37
55	2.30	1.14	1.16	4.07	37.64
56	2.19	1.51	0.68	5.22	26.64
58	3.09	2.54	0.55	10.55	93.93
59	2.14	1.46	0.68	4.74	45.65
61	3.26	2.75	0.51	7.69	87.92
62	3.78	3.35	0.43	12.06	89.15
64	1.60	0.79	0.81	4.76	40.39
65	2.62	2.38	0.24	6.93	78.95
68	0.21	0.09	0.12	0.53	0.60
70	1.12	0.80	0.32	2.87	31.43
75	0.39	0.30	0.09	1.33	9.84
78	5.22	4.12	1.05	10.31	72.47
79	0.80	0.37	0.43	1.48	16.22
80	1.95	1.26	0.69	3.75	52.70
81	1.33	0.26	1.07	1.34	6.29
83	2.50	0.41	2.09	1.97	7.56
85	1.05	0.66	0.39	2.87	37.33
90	1.81	1.27	0.54	4.35	73.58
91	1.38	0.72	0.66	1.91	17.45
92	4.59	4.45	0.14	12.39	96.28
93	3.79	2.38	1.41	6.82	95.00
94	1.53	0.37	1.16	1.72	42.75
95	3.47	3.12	0.35	14.88	93.41
96	1.18	0.36	0.82	0.94	3.62
97	3.18	1.24	1.94	3.58	22.63
98	1.34	0.52	0.82	1.95	13.67
99	1.38	0.38	1.00	1.54	7.57
100	4.75	0.75	4.00	4.89	28.72
102	3.11	2.86	0.25	11.37	93.75
103	2.11	0.34	1.77	2.52	22.33
107	2.94	2.80	0.14	9.67	89.93
108	0.72	0.24	0.48	0.87	6.83
111	0.70	0.43	0.27	2.12	27.54
113	0.94	0.36	0.58	1.86	29.09
116	0.49	0.25	0.24	1.39	12.01
117	1.94	1.82	0.12	8.76	62.75
118	1.41	0.63	0.78	1.44	8.20
119	0.73	0.52	0.21	0.71	1.59
121	1.11	0.47	0.64	0.61	13.12
124	1.53	0.40	1.13	2.76	26.22
128	1.47	0.20	1.27	0.98	7.86
132	4.75	0.85	3.90	3.34	48.07
133	4.07	1.55	2.52	6.04	84.02

Table IV.3. Sado estuary. Total carbon (TC), organic carbon (OC), inorganic carbon (IC), total organic matter (TOM) and fines content, expressed as a percentage of the dry weight of the total sediment sample.

The spatial distribution of the total organic matter in the superficial sediments of the Sado estuary is shown in figure 4.8. The highest values correspond to the subtidal sediments of the northern margin and northern channel. The Alcácer channel and sediments near Comporta, in the southern margin, also show high percentages of total organic matter.

The regions with lower organic content, less than 1% and between 1.01% and 3.00%, predominate in the estuary and they occupy respectively 20.6 and 52.9% of the total analysed area. The regions with the lowest sedimentary carbon content correspond to the estuarine entrance and to the beginning of the southern channel, up to the California region.

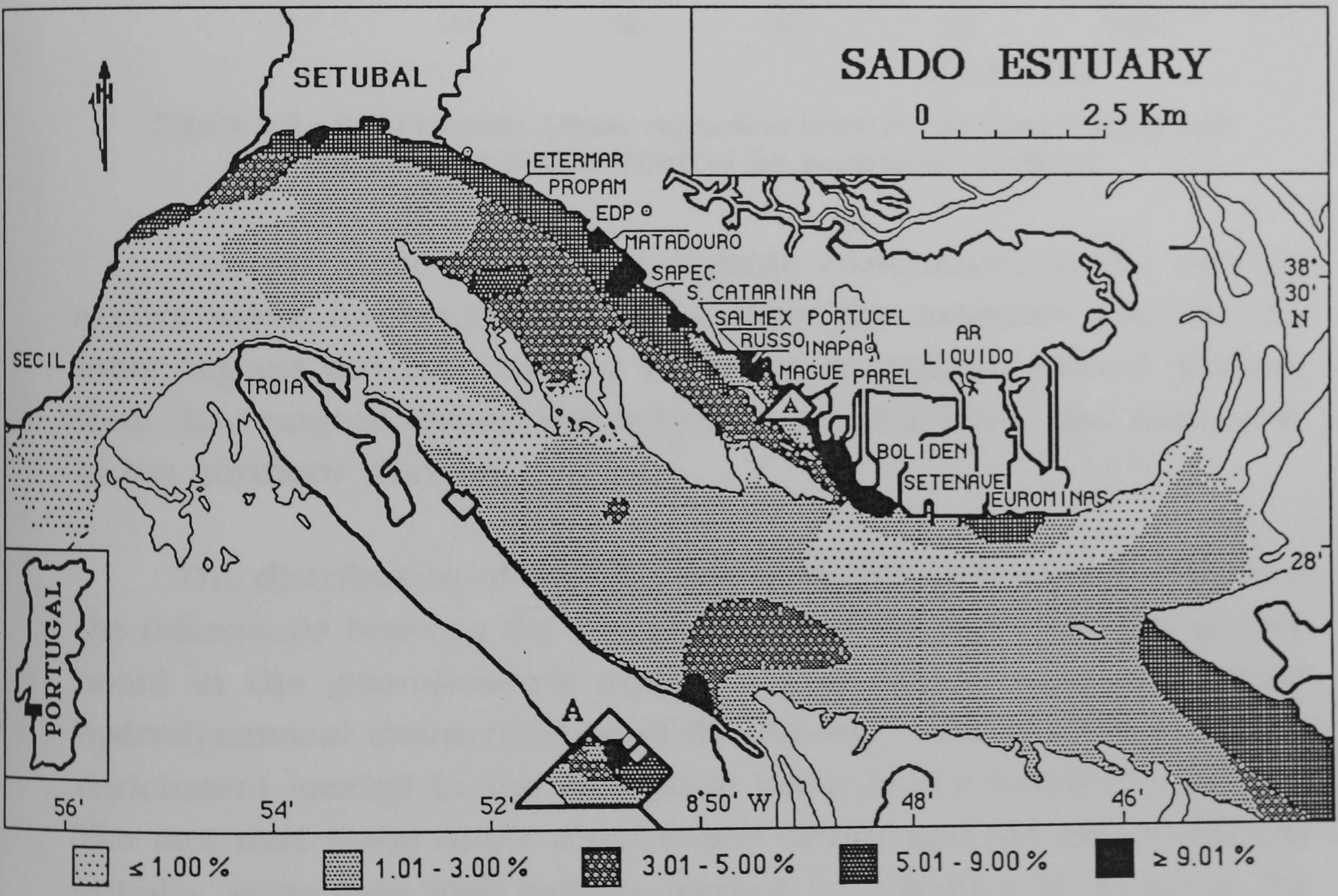


Figure 4.8. Sado estuary. Spatial distribution of the total organic matter content of superficial sediments.

The spatial pattern of total organic matter is very similar to the one obtained for the distribution of the fines fraction and the median of superficial sediments (see also figs. 4.3, 4.6 and 4.7). The close agreement between total organic matter in the superficial sediments and the fines content is clearly demonstrated by the significant statistical relation between both variables, according to which, 83% of the variation of total organic matter is explained by the fines content of sediments ($P << 0.001$, F test, figure 4.9).

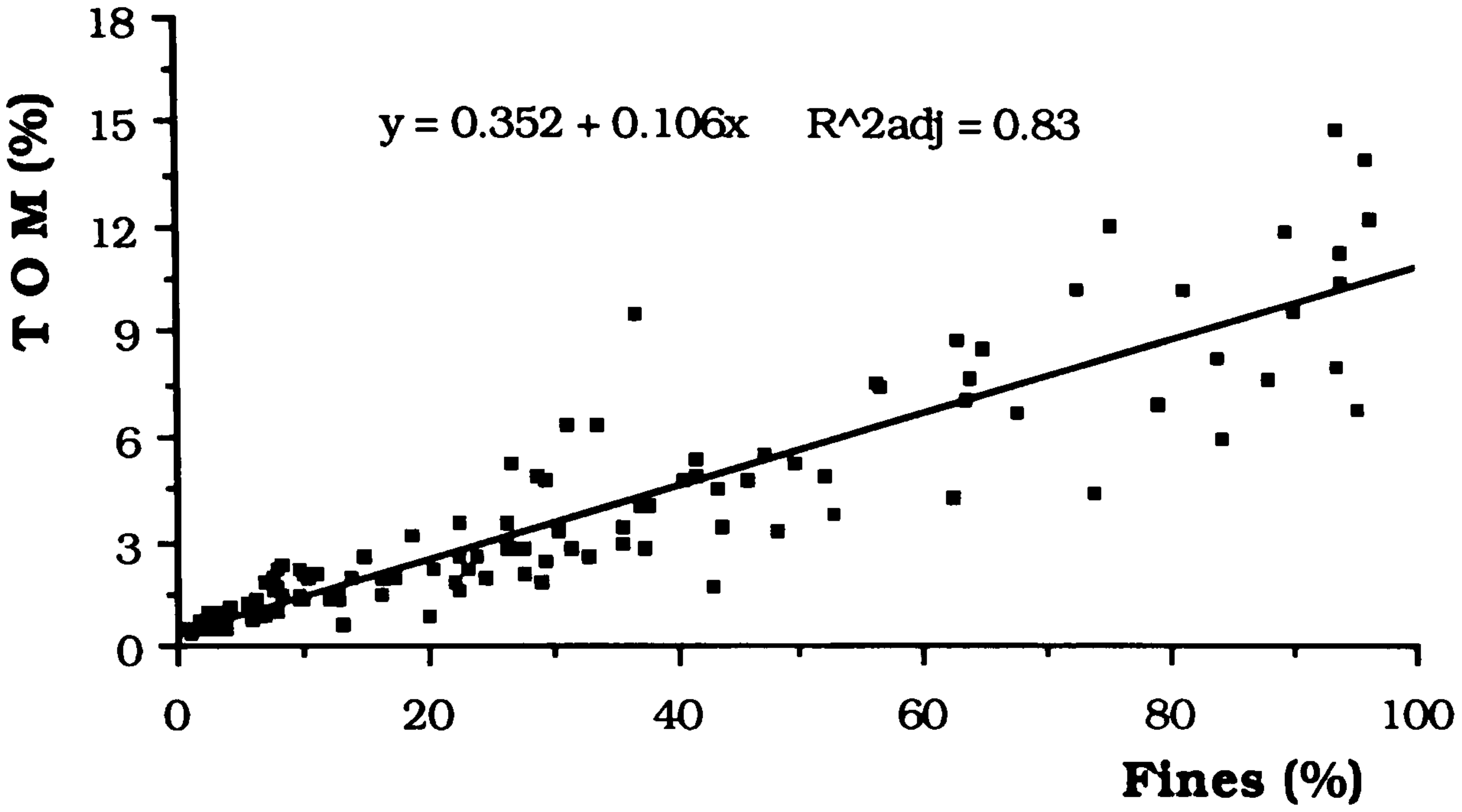


Figure 4.9 - Sado estuary. Linear regression between the fines content and total organic matter (TOM) of the superficial sediments.

The principal gradient of organic enrichment in the estuary occurs along its longitudinal axis, from the entrance towards the inner regions but a transverse reduction in organic content directed from the margins toward the intertidal sandbanks is also noticeable in the northern channel.

The distribution of organic matter in the sediments emphasizes the differences between the two channels of the Sado estuary already noted in the granulometric study. It also agrees with the general hydrodynamical characteristics of the estuary, with the major organic enrichment located in the deposition areas of the northern channel. The fact that these areas also receive urban and industrial effluent outfalls, some with high organic loading (*cf.* Chapter 2), accounts for the marked difference between the organic enrichment of their subtidal sediments and that of the rest of the estuary.

The total organic matter measured by incineration of the sediment and the organic carbon determined using the CHN analyser, show a strong statistical relation ($P << 0.001$, F test, figure

4.10), which is not the case between total organic matter and the inorganic carbon ($P = 0.478$, F test, figure 4.10).

This suggests that, in these samples, there is a negligible influence of inorganic carbon on the measurements of total organic matter by incineration at 450 °C. The values of total organic matter determined in this way are thus considered a reliable approach to the organic content of sediments, even though it is known that above 400 °C the inorganic carbon may vaporise. According to Byers *et al.* (1978) and to Kristensen & Anderson (1987), this is a negligible risk up to temperatures of 500 °C.

These conclusions, together with the fact that it was not always possible to undertake CHN analyses, underlay the decision to use the total organic matter data in the characterization of the sediments and in the direct gradient ordination analysis, in Chapter 6.

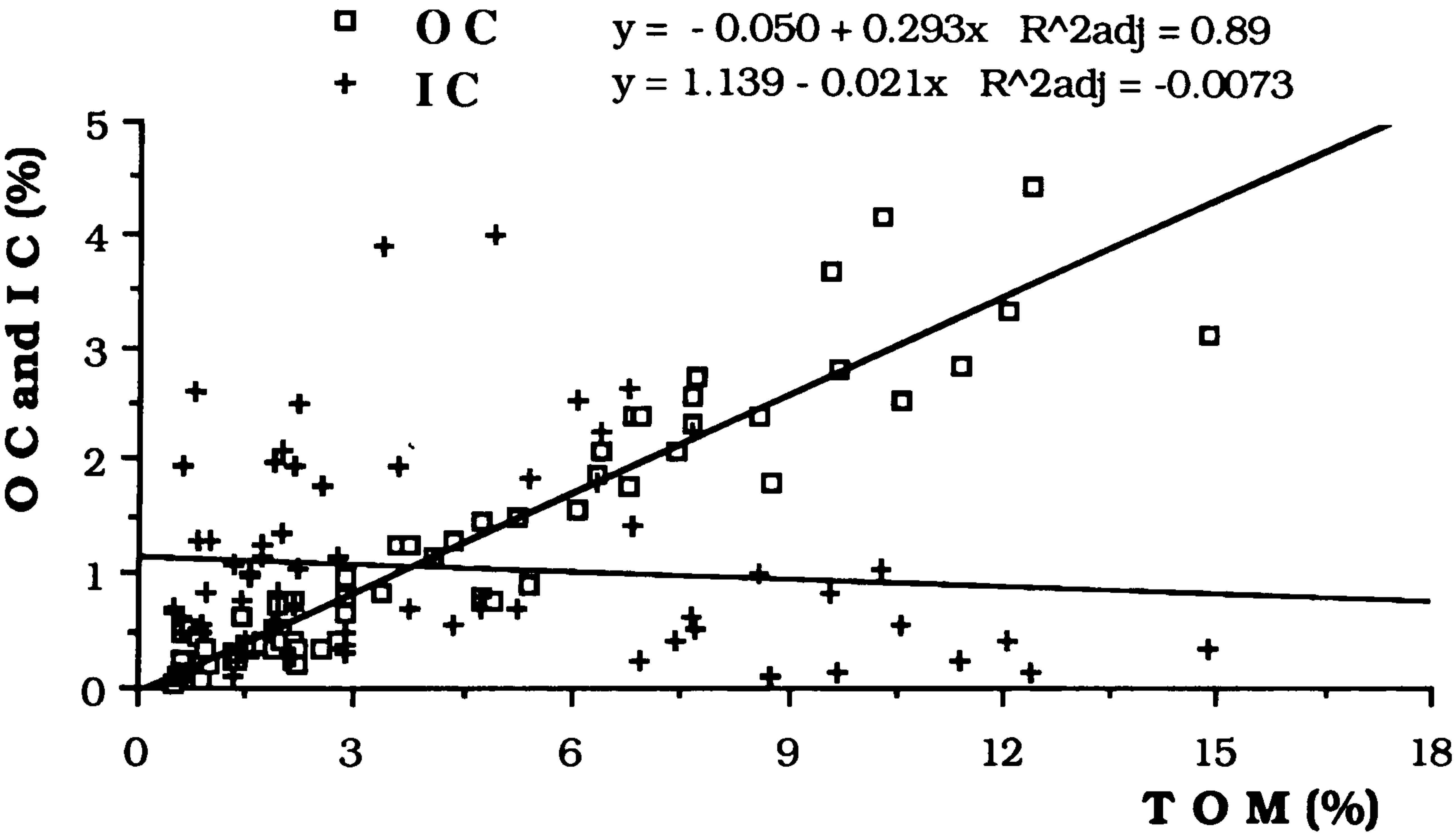


Figure 4.10 - Sado estuary. Linear regression between the total organic matter (TOM) of superficial sediments determined by loss on ignition and the organic (OC) and inorganic carbon (IC) measured with the CHN analyser.

4.6 - SEDIMENT TEMPERATURE

The temperature of the superficial sediments was measured on boardship as soon as the samples were collected. The spatial pattern presented by this variable, shown in figure 4.11, suggests a general tendency for increasing sediment temperatures with increasing distance from the estuarine entrance.

This agrees with the annual mean water temperature distribution in the estuary (Chapter 2), but it should also reflect the fact that samples were taken during the summer season, thus accounting for the high sediment temperatures throughout the estuary, but in particular in the upper part.

As expected, the observed sedimentary temperature range, from 17°C near the mouth and up to 21°C at the beginning of the inner estuary, is much lower than that observed in the water column at a comparable time of season, when the water temperature may reach 26°C and upwards (*cf.* Chapter 2).

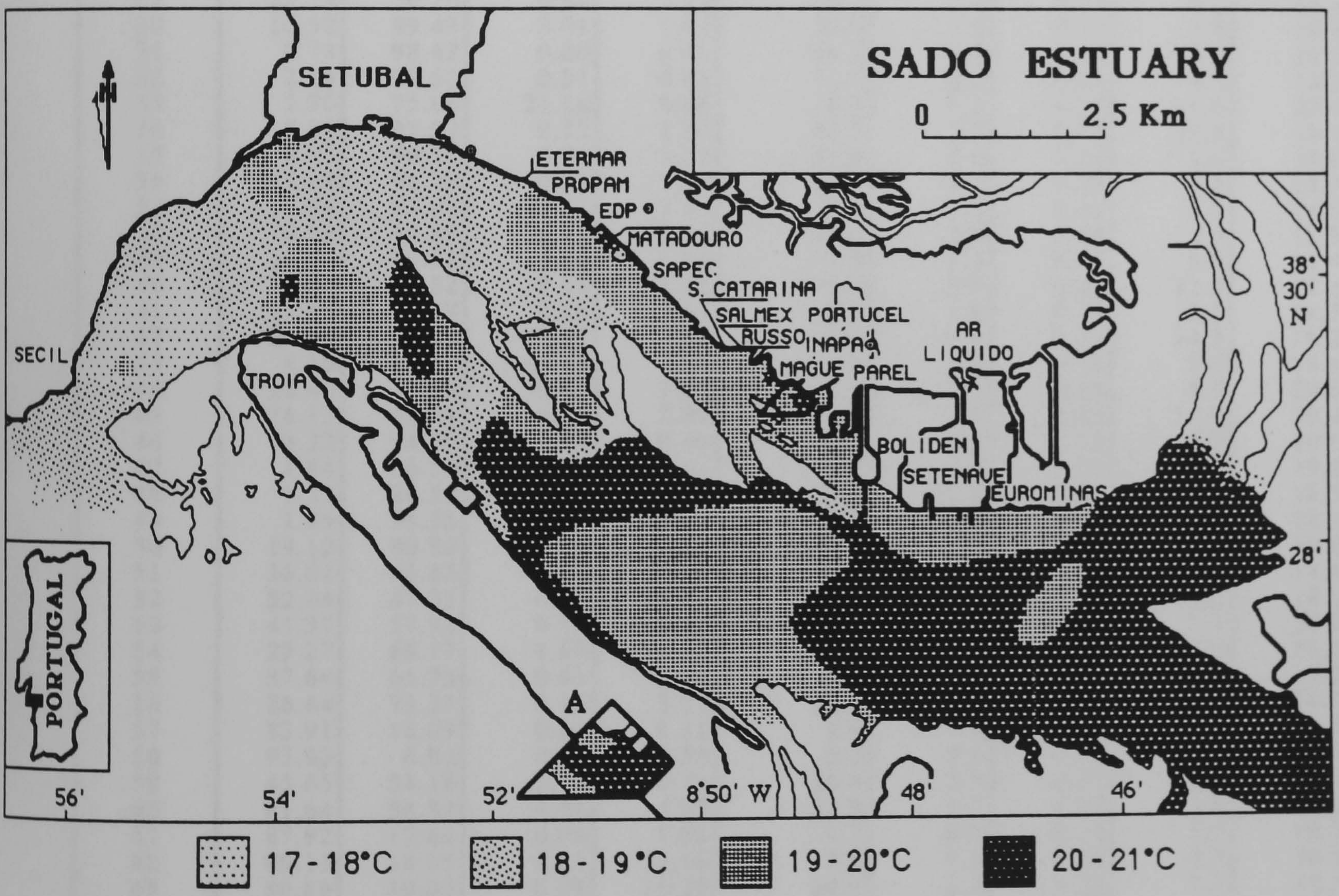


Figure 4.11. Sado estuary. Superficial sediments temperature.

The temperature data is presented in Table IV.4. This table also gives the full set of the environmental data to be used in the macrobenthic-environment relationship analysis (Chapter 6).

Stations	Fines	Sand	Gravel	TOM	Shear s.	Flow	Veloc.	Depth	Temp
1	5.94	58.99	35.08	0.76	13.1	1.3	0.09	4.5	18.5
2	1.09	77.20	21.71	0.47	15.2	8.8	0.10	35.0	18.7
3	1.52	97.78	0.69	0.54	59.0	4.7	0.47	4.5	18.1
4	2.56	83.93	13.51	0.60	65.4	21.9	0.60	15.3	19.5
5	6.31	63.73	29.95	0.84	37.6	4.2	0.35	42.5	18.0
6	3.89	95.76	0.35	0.46	27.4	0.8	0.25	2.0	18.8
7	0.99	98.63	0.38	0.33	31.6	7.5	0.38	21.0	17.9
8	1.52	86.22	12.27	0.45	60.6	9.3	0.52	13.6	17.9
9	3.83	86.44	9.73	0.51	50.8	5.3	0.44	7.5	18.0
10	1.92	97.93	0.15	0.47	39.6	2.6	0.36	4.5	18.0
11	0.94	96.90	2.16	0.44	42.2	7.6	0.43	13.0	18.0
12	1.93	97.88	0.18	0.79	21.0	9.3	0.32	25.0	18.9
13	33.48	66.45	0.07	6.40	5.1	0.6	0.08	2.5	19.0
14	43.38	56.46	0.16	4.59	8.9	0.8	0.04	18.7	19.0
15	1.66	98.22	0.12	0.57	10.9	8.8	0.24	29.7	18.5
16	6.82	93.09	0.09	1.88	19.9	6.2	0.30	9.4	19.0
17	27.46	47.62	24.91	0.62	41.7	8.2	0.43	17.3	19.5
18	8.10	91.83	0.06	2.18	15.2	1.2	0.20	5.0	18.6
19	4.04	84.32	11.64	1.09	46.6	8.4	0.46	17.0	20.3
20	7.81	92.19	0.01	1.70	31.6	3.2	0.34	4.0	19.0
21	3.19	96.07	0.74	0.51	14.2	4.8	0.25	14.7	19.3
22	10.00	84.13	5.87	1.34	11.0	3.1	0.22	13.5	20.0
23	18.65	66.10	15.25	3.18	2.2	0.5	0.07	4.3	19.8
24	64.69	35.31	0.01	8.58	3.3	0.6	0.08	5.0	19.8
25	37.06	62.07	0.88	3.99	7.2	1.8	0.16	8.7	18.5
26	36.54	58.38	5.08	9.58	3.6	0.4	0.08	4.5	19.0
27	67.47	32.10	0.43	6.78	3.6	0.4	0.08	6.5	18.9
28	14.77	73.29	11.93	2.63	14.1	2.3	0.22	9.0	18.8
29	23.16	76.20	0.64	2.15	18.1	3.8	0.27	8.5	18.8
30	10.52	89.48	0.01	1.97	30.5	1.9	0.31	3.0	19.8
31	0.78	98.42	0.80	0.45	45.2	9.5	0.46	19.5	19.0
32	2.16	97.52	0.31	0.65	11.5	2.0	0.13	4.5	19.2
33	2.70	75.63	21.68	0.86	10.5	0.7	0.17	16.0	20.0
34	6.05	93.22	0.73	1.00	40.3	7.5	0.42	16.9	19.1
35	9.61	90.38	0.01	1.52	35.6	4.0	0.37	5.0	19.0
36	35.68	64.29	0.03	3.00	25.4	2.1	0.29	4.6	18.8
37	11.02	83.01	5.97	2.03	26.2	2.4	0.30	5.5	18.6
38	10.18	84.86	4.96	2.14	15.6	2.9	0.24	12.0	18.5
39	31.29	68.53	0.18	6.34	4.9	1.5	0.14	5.0	18.4
40	56.46	43.32	0.23	7.43	9.2	3.0	0.21	11.5	18.3
41	63.63	36.19	0.18	7.67	8.2	1.4	0.19	4.5	18.3
42	26.48	72.93	0.58	2.85	16.4	3.6	0.26	14.5	18.2
43	8.16	91.81	0.03	2.35	33.8	1.6	0.32	2.7	18.8
44	20.40	79.59	0.02	2.18	24.4	1.6	0.28	5.0	20.5
45	26.13	69.71	4.16	2.88	47.0	7.9	0.45	15.8	20.4
46	3.32	94.70	1.98	0.60	12.8	0.3	0.12	5.0	19.0
47	1.84	96.50	1.66	0.61	49.1	3.3	0.41	4.5	19.2
48	1.32	96.50	2.18	0.49	52.5	11.6	0.50	21.0	18.5
49	1.89	95.55	2.55	0.46	60.6	8.4	0.51	12.0	18.0
50	19.12	80.86	0.02	2.38	42.7	1.0	0.33	3.4	19.0
51	56.02	43.65	0.34	7.63	9.6	1.0	0.17	5.5	18.1
52	52.04	47.31	0.66	4.84	16.3	0.9	0.21	3.5	18.0
53	41.37	57.93	0.70	5.38	13.7	1.5	0.21	3.3	19.0
54	29.27	68.77	1.97	4.80	15.0	3.4	0.24	11.5	18.1
55	37.64	61.75	0.61	4.07	16.7	3.2	0.25	7.5	19.2
56	26.64	73.21	0.15	5.22	12.2	0.7	0.21	4.0	18.7
57	83.91	16.09	0.01	8.31	4.9	0.4	0.14	4.0	19.1
58	93.93	6.02	0.05	10.55	8.2	1.6	0.19	6.5	19.5
59	45.65	54.16	0.19	4.74	20.4	2.5	0.27	6.6	18.0
60	41.64	58.34	0.02	4.93	22.0	1.7	0.27	2.0	18.5
61	87.92	12.04	0.04	7.69	4.7	0.7	0.12	5.0	18.7
62	89.15	10.85	0.01	12.06	7.5	1.0	0.16	4.5	19.5
63	80.89	19.03	0.08	10.25	24.6	2.4	0.28	7.7	19.5
64	40.39	59.51	0.11	4.76	18.0	1.4	0.24	4.5	19.5
65	78.95	20.53	0.51	6.93	12.6	2.1	0.21	7.9	19.6
66	43.47	56.41	0.12	3.43	21.2	1.6	0.26	6.2	18.9

Table IV.4. Sado estuary. Environmental data. Fines, sand, gravel and total organic matter (TOM), are percentages of the dry-weight of the total sediment, Shear stress in N.m^{-2}, flow in m^{2}.s^{-1}, velocity in m.s^{-1}, depth in meters and temperature in °C.

Stations	Fines	Sand	Gravel	TOM	Shear s.	Flow	Veloc.	Depth	Temp
67	3.14	93.50	3.35	0.64	49.7	3.9	0.42	3.2	19.9
68	0.60	99.39	0.01	0.53	43.4	8.5	0.44	16.0	20.5
69	24.68	75.08	0.24	1.93	13.2	3.8	0.23	5.5	19.0
70	31.43	68.47	0.11	2.87	13.7	3.7	0.23	4.5	19.0
71	11.53	86.56	1.91	1.57	37.4	2.0	0.34	4.0	19.0
72	63.43	36.52	0.05	7.07	21.7	2.7	0.28	10.5	19.2
73	75.23	24.77	0.01	12.16	3.8	0.4	0.07	3.4	19.7
74	29.32	66.52	4.16	2.50	4.8	0.4	0.06	4.5	19.7
75	9.84	85.07	5.08	1.33	28.3	1.6	0.31	5.5	20.0
76	62.35	37.57	0.08	4.25	28.3	2.9	0.32	9.5	19.5
77	49.5	49.85	0.65	5.24	28.7	2.3	0.31	3.0	19.3
78	72.47	27.41	0.13	10.31	14.5	1.3	0.23	4.7	19.5
79	16.22	83.21	0.57	1.48	28.4	1.8	0.31	3.4	19.5
80	52.7	46.37	0.93	3.75	16.2	2.5	0.24	8.3	19.7
81	6.29	92.94	0.77	1.34	28.6	1.0	0.28	2.8	20.5
82	35.78	63.72	0.50	3.48	49.3	5.2	0.44	10.5	20.1
83	7.56	92.20	0.24	1.97	31.9	5.1	0.36	10.8	19.9
84	12.42	87.34	0.24	1.32	9.2	1.1	0.17	2.5	20.0
85	37.33	61.04	1.62	2.87	11.6	0.5	0.17	3.1	20.5
86	12.91	87.06	0.03	1.33	45.4	3.8	0.40	7.3	19.2
87	28.92	68.27	2.81	3.42	38.6	4.6	0.39	9.8	19.8
88	17.55	79.25	3.20	2.21	19.6	0.6	0.22	5.0	20.4
89	12.96	83.68	3.37	1.51	13.2	0.1	0.04	8.2	20.0
90	73.58	26.20	0.22	4.35	23.5	2.5	0.29	6.9	20.4
91	17.45	81.94	0.61	1.91	20.5	0.5	0.20	2.0	20.0
92	96.28	3.72	0.01	12.39	0.1	0.0	0.10	4.5	21.0
93	95.00	5.00	0.01	6.82	0.1	0.0	0.10	3.4	21.0
94	42.75	56.51	0.75	1.72	9.6	1.7	0.20	6.9	21.0
96	3.62	94.95	1.43	0.94	11.5	1.2	0.19	2.1	20.0
97	22.63	75.98	1.40	3.58	36.7	1.6	0.33	9.9	19.5
98	13.67	78.23	8.10	1.95	34.7	1.1	0.31	3.5	21.5
99	7.57	89.79	2.64	1.54	35.3	3.0	0.35	7.5	19.5
100	28.72	69.54	1.75	4.89	38.8	3.2	0.37	6.5	19.5
101	30.40	69.59	0.01	3.33	24.9	2.5	0.29	7.8	19.8
102	93.75	6.25	0.01	11.37	13.3	1.8	0.22	3.8	20.0
103	22.33	77.56	0.11	2.52	13.6	1.2	0.21	4.0	20.0
104	2.77	96.72	0.51	0.77	37.6	3.3	0.36	8.5	19.5
105	19.92	74.39	5.69	0.80	30.0	0.6	0.25	3.4	18.7
106	95.99	4.01	0.01	14.1	0.0	0.1	0.15	2.0	19.8
107	89.93	10.07	0.01	9.67	27.2	1.9	0.29	6.0	20.0
108	6.83	92.69	0.47	0.87	38.1	3.3	0.37	7.5	21.0
109	27.72	72.18	0.11	2.82	34.2	3.9	0.36	8.5	20.5
110	26.28	73.35	0.37	3.52	30.4	3.1	0.33	7.7	20.5
111	27.54	72.40	0.06	2.12	27.3	2.4	0.31	1.9	20.0
112	22.23	77.65	0.11	1.87	25.3	2.0	0.29	1.5	20.9
113	29.09	70.58	0.33	1.86	26.0	2.8	0.30	5.7	20.9
114	22.60	76.65	0.75	1.62	32.7	3.1	0.34	8.5	20.5
115	1.70	97.56	0.74	0.60	21.9	4.3	0.30	10.1	20.0
116	12.01	83.34	4.66	1.39	0.4	0.1	0.13	11.9	20.0
117	62.75	36.81	0.43	8.76	2.3	0.0	0.10	7.5	19.5
118	8.20	85.84	5.95	1.44	4.3	0.9	0.08	12.0	20.0
119	1.59	93.71	4.70	0.71	27.6	4.3	0.33	10.6	21.5
121	13.12	75.43	11.45	0.61	24.7	3.8	0.31	11.6	20.2
122	32.90	65.81	1.29	2.63	30.5	1.3	0.30	6.5	20.0
123	2.41	97.59	0.01	1.04	29.9	1.7	0.31	2.5	20.5
124	26.22	71.73	2.05	2.76	33.8	2.4	0.34	4.7	20.5
125	9.60	89.49	0.91	2.24	30.6	3.1	0.33	12.5	19.5
126	16.36	80.57	3.07	1.95	13.6	2.2	0.22	9.5	19.5
127	1.93	98.02	0.05	0.52	25.1	0.4	0.24	1.1	20.5
128	7.86	91.71	0.43	0.98	52.5	1.8	0.40	6.5	20.1
129	24.01	75.91	0.07	2.53	37.4	2.6	0.35	3.0	21.0
130	47.07	52.64	0.29	5.49	22.4	1.3	0.26	3.1	21.1
131	5.38	89.15	5.48	1.18	24.4	2.7	0.29	7.5	20.2
132	48.07	51.44	0.49	3.34	23.2	2.1	0.28	6.0	21.2
133	84.02	15.98	0.01	6.04	23.2	0.9	0.25	1.4	22.0

Table IV.4. (continued)

CHAPTER 5

MACROFAUNA CHARACTERIZATION

5.1 - INTRODUCTION

Studies on Sado macrozoobenthos were first made as part of an pluridisciplinary work designed to assess the effects on the estuary of a thermal power plant (Peneda, 1980, 1981, Pinto, 1982, Monteiro Marques, 1982, Peneda *et al.*, 1982a, 1982b, Rodrigues, 1982, Marques & Bellan, 1985, Cancela da Fonseca *et al.*, 1987, Marques, 1989). Some aspects of the intertidal communities have also been studied (Gamito 1983, Costa *et al.*, 1984, 1990, Costa, 1988, Dexter, *pers. comm.*, Rodrigues *et al.*, *in press*).

These previous investigations however were concerned with small scale spatial or temporal variability (Rodrigues, 1982), or with intertidal communities (Costa, 1988, Rodrigues *et al.*, *in press*) or, although general, were less comprehensively designed for assessment of the complexity of the gradients and the spatial heterogeneity of the estuary (Pinto, 1982, Cancela da Fonseca *et al.*, 1987). These latter authors sampled after a major flood and stormy winter which occured during 1978/79 and which may have well have caused the collection of impoverished and heterogeneous samples.

The previous chapters have presented the most relevant and presently available environmental data influencing the benthic communities from the Sado estuary, either obtained during this work or by other workers. This chapter presents the data of the subtidal benthic macrofauna survey. The data consists of faunal lists from each sampling station, in which each species is identified and represented by its quantitative abundance and biomass. To assess the spatial variability, the data per sampling station will be presented almost exclusively in the form of distribution maps of the study area. The analysis will focus on the primary biological variables of species richness (S), abundance (A) and biomass (B), together with various diversity indices, e. g. species diversity (H') and eveness (J), and also the abundance ratio (A/S) and the size ratio (B/A). In every case the data from the total macrofauna will be considered. Where relevant each of the variability in the most important estuarine taxonomic groups, Annelids, Arthropods and Molluscs will be examined and appropriate individual species distribution will be charted.

In order to assess the amount of food potentially available to predatory populations from the macrofauna in the estuary, the secondary production was estimated.

An assessment of the presence of simple gradients of community disturbance, the spatial variability of the values obtained for the different variables in each station were compared to what is known from the SAB model and the variation of A/S and B/A through a gradient of increasing/decreasing organic input (Pearson *et al.*, 1982, Pearson & Rosenberg, 1978).

Finally, the analysis of benthic data will also consider the classification of species into trophic groups in order to assess the trophic structure of the estuary (Pearson, 1971a). The simultaneous analysis of environmental and biological data is the subject of the next chapter.

5.2 - PRIMARY AND DERIVED BIOLOGICAL VARIABLES

5.2.1. - Species richness (S), Abundance (A) and Biomass (B)

5.2.1.1. - Total Macrofauna

The benthic survey conducted in the Sado estuary identified the presence of 362 species, represented by 80218 specimens with the total biomass of 2852.35 g (blotted wet-weight). The raw data is presented in a separate appendix, lodged at the Library of the University of Stirling and LNETI.

The fauna at each of the sampling stations is mainly made up of Annelids, Arthropods and Molluscs. Together, these groups comprise approximately 93% of total species richness and total biomass, and 98% of total abundance. Annelids were the most abundant and species rich group and also the only one present in all the sampling stations with macrofauna. Molluscs contributed the highest total biomass.

In addition to these major taxonomic groups, total macrofauna also included less well represented groups, namely echinoderms, anthozoans, nemerteans, sipunculids, ascidians, phoronids, and others. Table V.1 summarizes the distribution of species richness, abundance and biomass among the different taxonomic groups. The full species list with taxonomic authorities and the respective number of presences in the estuary, total abundance and biomass, is presented in Annex II. Annex III presents the species codes used in the data treatment developed in Chapter 6.

Table V.2 gives for each of the sampling stations, the total species richness, the total abundance and the total biomass expressed as wet-weight, and ash-free dry weight.

	S	**A**	**B**
ANNELIDA	**134**	**53643**	**501.39**
Polychaeta	131	52347	491.27
Oligochaeta	3	1296	0.82
fragments	-	-	9.30
MOLLUSCA	**81**	**4934**	**2054.62**
Polyplacophora	4	99	187.53
Scaphopoda	1	1	0.32
Nudibranchia	1	6	0.03
Gasteropoda	21	625	157.21
Bivalvia	54	4203	1709.53
ARTHROPODA	**123**	**20121**	**104.48**
Pycnogonida	1	2	0.001
Insecta	1	5	0.01
Ostracoda	3	313	1.10
Malacostraca	118	19801	103.37
ECHINODERMATA	**7**	**115**	**6.24**
Holothurioidea	2	18	3.36
Ophiuroidea	3	91	0.94
Echinoidea	2	6	1.94
VARIA*	**17**	**1405**	**185.62**
TOTAL	**362**	**80218**	**2852.35**

* includs phoronids, sipunculids, anthozoans, nemerteans, ascidians, cephalochordata, platyhelminthes and fishes.

Table V.1 - Total number of species (S), individuals (A) and biomass (B) - g, wet-weight - of the different taxonomic groups identified in the Sado estuary.

St.	S	A	B 1	B 2	St.	S	A	B 1	B 2
1	72	585	60.28	4.530	67	18	68	1.37	0.163
2	52	317	2.51	0.232	68	7	7	0.44	0.043
3	17	119	1.09	0.143	69	36	186	10.45	1.307
4	43	725	1.68	0.231	70	64	858	49.49	5.379
5	70	1123	38.62	3.915	71	46	319	5.50	1.096
6	46	990	15.82	1.758	72	46	702	20.00	1.959
7	16	76	0.36	0.038	73	13	31	0.56	0.065
8	20	94	0.61	0.055	74	33	499	14.63	1.901
9	42	198	1.04	0.118	75	46	281	19.36	2.103
10	22	88	3.19	0.277	76	39	618	7.96	0.941
11	38	206	0.53	0.076	77	60	1269	56.70	4.091
12	62	1994	3.87	0.427	78	15	44	0.22	0.027
13	91	807	71.87	6.931	79	62	939	79.28	7.312
14	72	1084	85.97	10.277	80	39	513	49.95	3.098
15	49	1230	6.41	0.846	81	58	1130	29,08	4.171
16	89	1218	46.89	5.221	82	38	920	11.13	1.118
17	60	589	9.42	2.570	83	61	617	16.71	3.580
18	62	739	42.62	5.652	84	50	965	71.63	4.180
19	84	989	39.40	4.127	85	49	537	86.96	5.796
20	68	699	11.50	2.034	86	24	123	11.13	0.765
21	73	1279	6.68	0.776	87	28	556	11.53	1.595
22	67	1079	134.51	10.870	88	29	323	6.96	0.854
23	59	710	13.87	1.775	89	38	403	8.97	1.099
24	24	155	3.51	0.320	90	18	113	3.66	0.436
25	71	966	14.25	3.720	91	48	665	17.40	1.469
26	17	14731	73.75	6.458	92	14	27	0.22	0.033
27	52	758	33.13	7.803	93	7	1204	4.12	0.494
28	83	986	39.22	4.454	94	30	86	11.18	0.827
29	73	668	14.03	1.686	96	40	413	3.47	0.431
30	59	643	14.09	1.668	97	53	1548	24.70	3.430
31	6	13	0.56	0.052	98	47	501	35.13	3.696
32	15	22	8.60	1.008	99	29	376	5.25	0.660
33	38	126	177.21	13.899	100	50	1163	39.44	3.800
34	31	282	9.28	1.203	101	58	796	7.40	2.948
35	45	468	8.93	1.324	102	16	80	5.31	0.389
36	63	868	90.51	9.107	103	34	356	5.78	0.629
37	67	670	8.83	1.220	104	11	85	3.80	0.341
38	55	543	13.66	2.022	105	51	477	34.36	3.144
39	63	1108	60.56	8.206	106	19	333	3.41	0.422
40	63	1638	75.23	7.114	107	21	63	2.89	0.400
41	46	764	89.07	5.793	108	24	254	6.78	0.770
42	35	527	10.23	1.039	109	29	280	14.73	1.554
43	76	623	5.60	1.014	110	33	296	6.14	1.010
44	61	607	14.67	1.501	111	50	517	46.12	3.384
45	60	765	10.18	1.996	112	29	406	40.33	2.947
46	42	370	10.17	1.131	113	34	963	13.87	1.685
47	73	954	37.18	3.288	114	21	138	8.91	1.046
48	35	93	0.68	0.167	115	14	56	1.00	0.126
49	29	253	0.50	0.192	116	28	141	20.86	2.861
50	43	408	15.00	1.068	117	10	22	0.37	0.051
51	45	287	43.65	3.668	118	11	118	1.83	0.220
52	52	343	44.96	4.350	119	24	55	4.50	0.360
53	49	499	23.12	2.252	121	6	15	0.24	0.032
54	50	873	16.32	3.352	122	33	396	17.68	1.421
55	52	982	73.86	4.644	123	15	70	3.74	0.435
56	33	228	12.68	1.033	124	38	479	11.78	1.492
57	22	258	18.58	1.026	125	4	60	3.24	0.417
58	28	201	9.56	1.121	126	5	14	1.32	0.126
59	44	678	38.89	3.071	127	15	77	0.67	0.094
60	56	1321	41.67	3.333	128	13	61	0.82	0.114
61	17	266	6.13	0.479	129	44	362	19.46	1.991
62	8	10	2.98	0.346	130	34	267	9.94	0.975
63	37	487	48.38	3.630	131	20	115	6.25	0.446
64	47	587	26.48	1.874	132	19	92	1.31	0.167
65	15	55	1.27	0.158	133	25	93	21.54	1.629
66	51	655	15.36	0.967					

Table V.2 - Total number of species (S - sp/0.1m^2), abundance (A - ind/0.1m^2), wet - weight (B1) and ash-free dry weight biomass (B2 - g/0.1m^2), in each sampling station.

Of the 362 species identified 87 were taken once and 36 twice, and 229 species were present in 10 or less stations (sampling frequency of 13%). These low frequency species represent 63% of the total number of species sampled.

On the other hand 15 species were present in 67 or more stations (sampling frequency higher than 50%). Nine of these belonged to the polychaete Annelids, 4 to the Arthropods, 1 to the bivalve Molluscs, the other being a nemertean. Figure 5.1 illustrates the partitioning of species as a function of their occurence in the sampling stations. It is clear that the majority of species (209 out of 362) show a sampling frequency below 5% (present at up to 7 sampling stations).

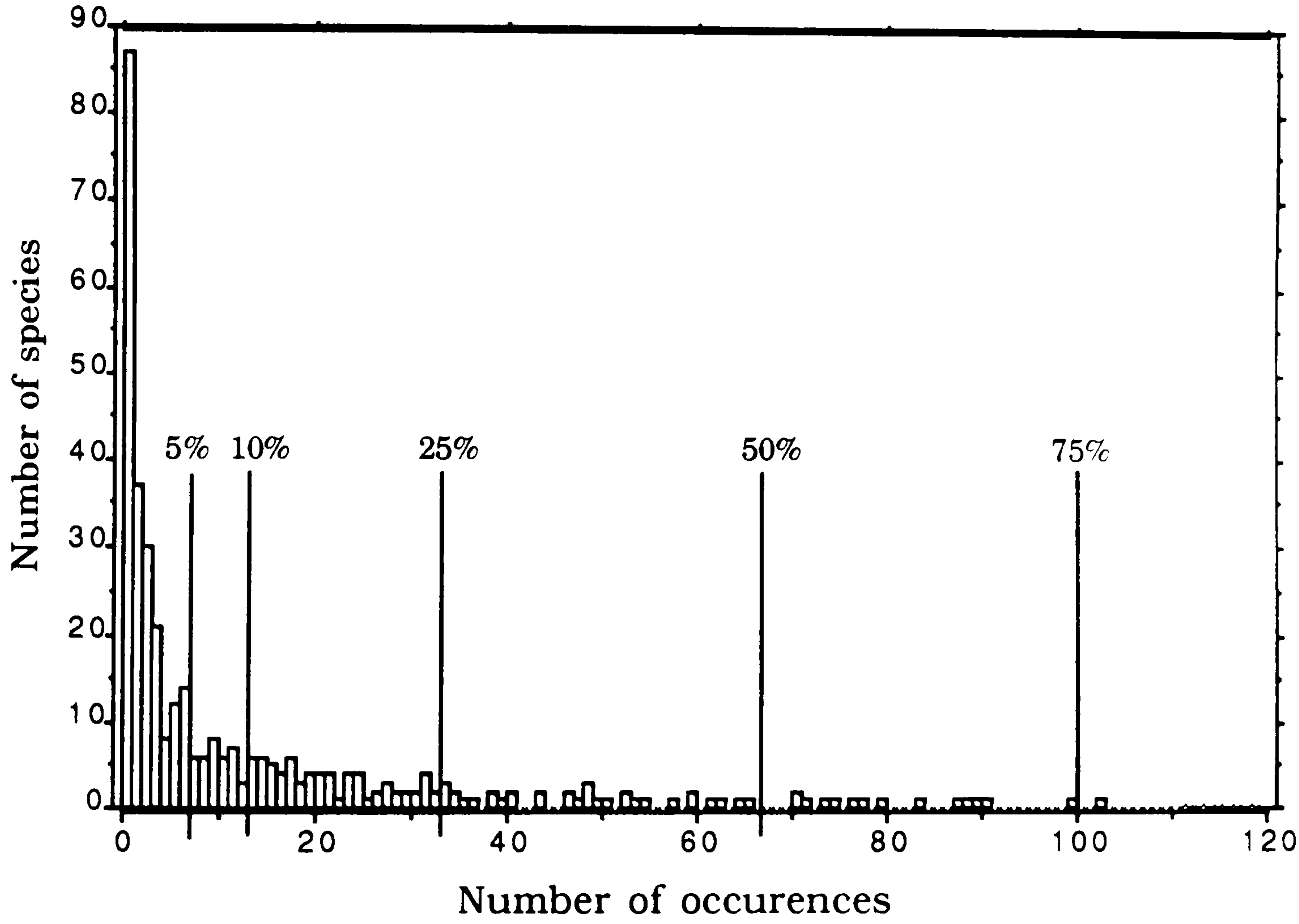


Figure 5.1 - Histogram showing the frequency of occurence of species in the sampling stations. Vertical lines and percentages represent sampling frequencies.

The most common species (sampling frequency higher than 60%) were the polychaetes, *Caulleriella* sp, *Cirriformia* sp, *Aonides oxycephala*, *Tharyx* sp and *Spiochaetopterus costarum* with respectively 103, 100, 91, 90 and 89 occurences, and the crustaceans *Corophium annulatum* and *Iphinöe tenella* which appeared in 88 and 84 stations.

The spatial pattern shown by the distribution of the total species richness is presented in figure 5.2. Only two out of the 133 sampling stations were afaunal. These stations, 95 and 120, are located in the northern channel, near the margin of the estuary.

An analysis of figure 5.2 shows clearly that the group which comprises the highest number of sampling stations (66 - 50% of the total), includes those stations having between 33 and 64 species. Sampling stations with fewer species are mainly located in the vicinity of the urban effluent outfall (stations 24 and 26), in the northern channel along the margin from Propam to Eurominas and also in the upper region of the estuary, in front of Boliden, Setenave and Eurominas. On the other hand the richest stations, with more than 64 species, are located closer to the estuarine entrance, in a region between the mouth of the estuary and the beginning of the intertidal sandbanks.

In general, the spatial variability of species richness follows the longitudinal axis of the estuary. The total number of species increased from the entrance inwards, up to the beginning of the intertidal sandbanks and then decreased in the direction of the upper and inner regions. In the northern channel this gradient showed some local modifications as a result of the impoverishment close to the margin (*cf.* figure 5.2).

As with the total species number, total abundance also showed very heterogeneous values, with a majority of species represented by few individuals. Only 79 species (22%) were represented by more than a total of 100 individuals. Of the remaining 283 species, 179 were in fact represented by a maximum of 10 specimens. These species, which represent almost 50% of the total number identified in the estuary, comprise only 686 specimens, e. g. less than 1% of the total abundance.

The 79 species represented by more than 100 individuals correspond to 37 Annelids, 27 Arthropods, 11 Molluscs and 4 species from other groups (nemerteans, phoronids and anthozoans). Of these, a total of 17 species were present with more than 1000

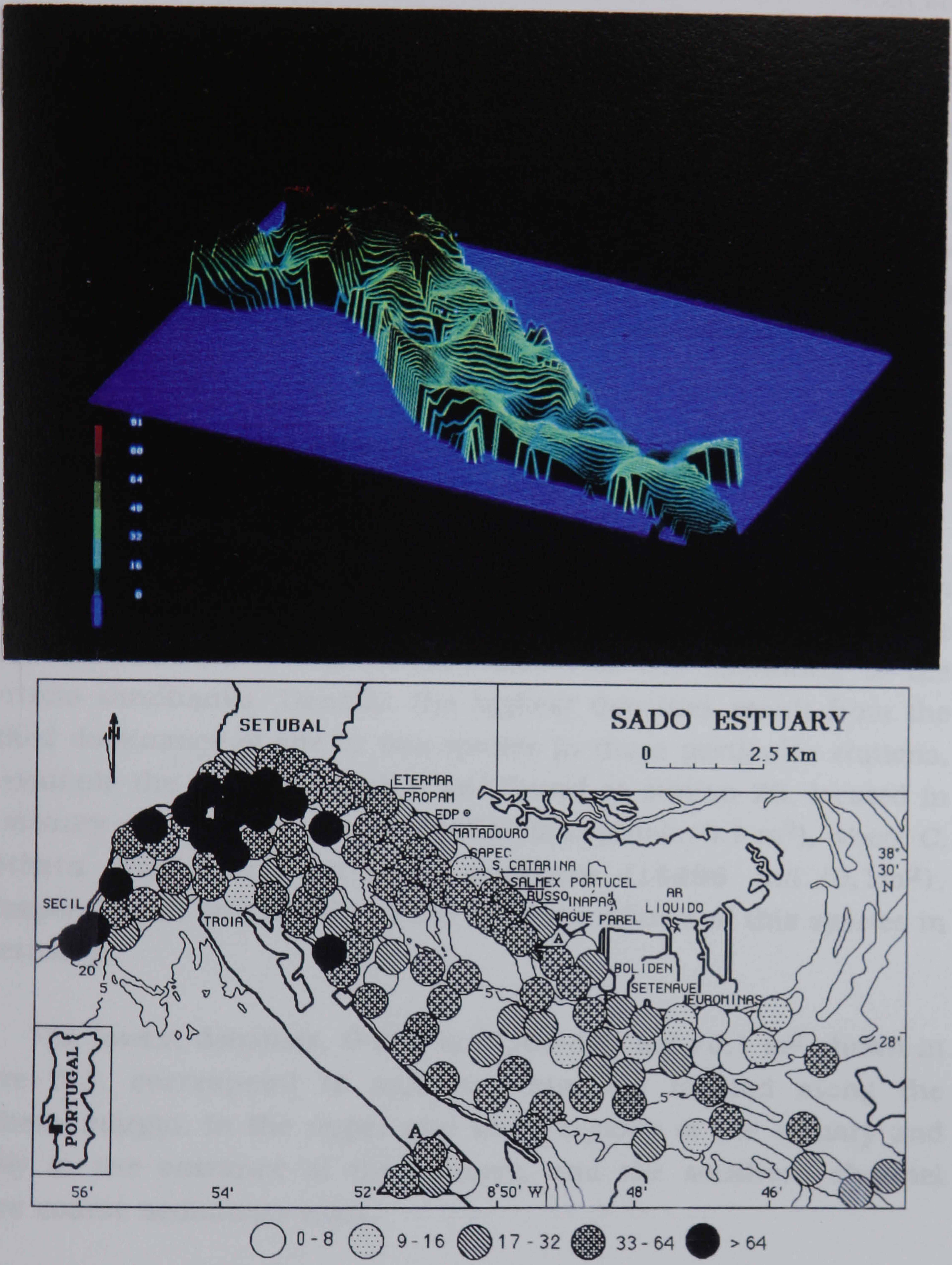


Figure 5.2 - Sado Estuary. Spatial distribution of total species richness (sp./0.1m^2). General (upper graph) and detailed view (lower graph).

specimens. They included 10 Annelids, 6 Arthropods and 1 Mollusc. Together, they comprise almost 70% of the total abundance.

The polychaetes *Capitella capitata, Spiochaetopterus costarum, Tharyx sp, Cirriformia sp* and *Caulleriella sp* were the 5 most abundant species, comprising 34159 individuals representing almost 43% of the total abundance. The amphipods *Corophium annulatum* and *Photis longipes* were the most abundant crustaceans with 2611 and 2417 individuals and *Abra alba* the most abundant Mollusc with 1652 individuals.

The spatial distribution of abundance classes in the estuary is presented in figure 5.3.

This suggests that a major group of sampling stations with higher densities (401-800 and > 800 ind./0.1 m^2) occupies the region between the estuarine entrance and the beginning of the intertidal sandbanks. Usually, the highest densities result from the marked dominance of one or two species in those particular stations, for example the maximum value was found at station 26, located in the vicinity of the urban sewage (14731 individuals/0.1 m^2), where *C. capitata* was found in high numbers (14496 ind./0.1m^2), corresponding in fact to 92% of the total abundance of this species in the estuary.

The lowest densities, 0-200 and 201-400 ind./0.1 m^2 shown in figure 5.3, correspond to sampling stations located along the northern margin, in the upper and inner regions of the estuary and finally in the entrance of the estuary, and the southern channel where coarse sediments exist.

Changes in relative dominance are shown in figure 5.4, which plots the abundance of the first ranked species at each of the sampling stations. The highest values of relative abundance (>50%) correspond to stations located along the northern margin and in the upper region of the estuary. At 66 sampling stations (≈ 50%) the first rank species comprises 25% or less of the total abundance.

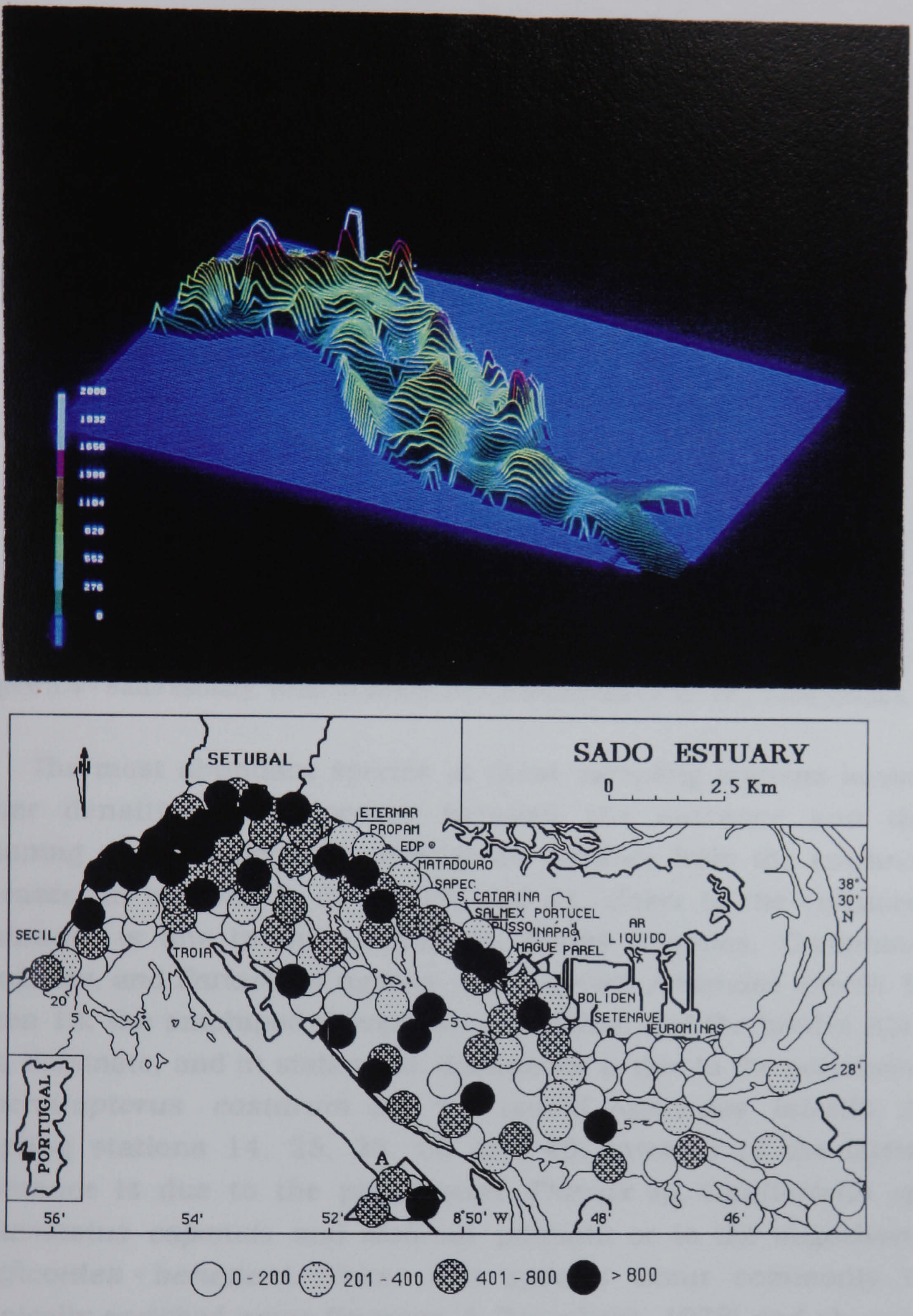


Figure 5.3 - Sado Estuary. Spatial distribution of total faunal abundances (ind./0.1m^2). General (upper graph) and detailed view (lower graph).

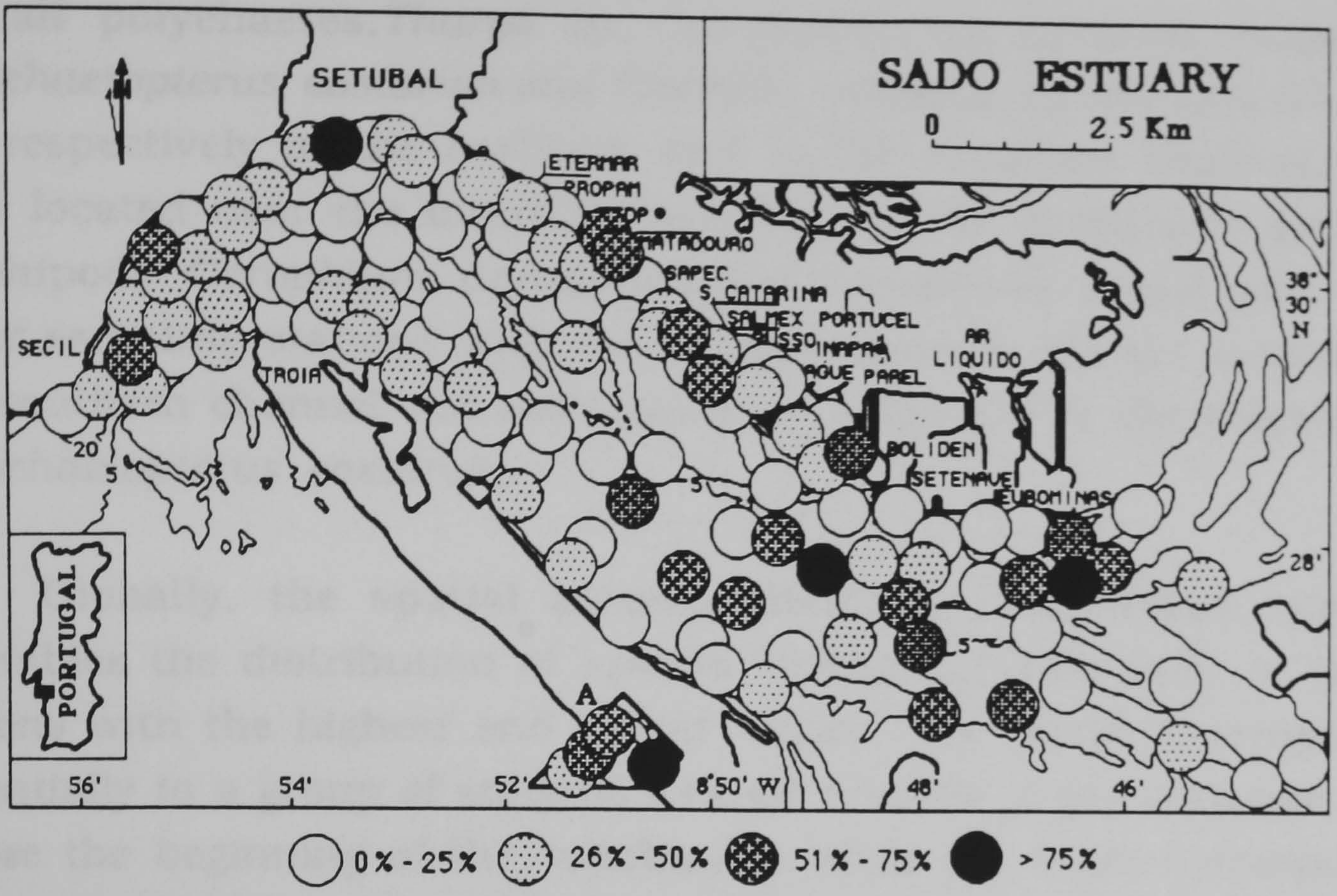


Figure 5.4 - Sado estuary. Relative abundance represented by the first rank species.

The most abundant species at those sampling stations having higher densities, and located between the entrance and the beginning of the sandbanks, change as distance from the entrance increases. In stations 5, 6, 12, 15, and 21, closer to the entrance, dominance is due to the amphipods, *Photis longipes*, *Corophium annulatum*, and *Pariambus typicus* and a tanaid, *Apseudes latreilli*. In station 13, the amphipod *Corophium annulatum* and the bivalve *Abra alba*, dominate, and in station 16, dominance is due to the polychaete *Spiochatopterus costarum* and the tanaid *Apseudes latreilli*. At sampling stations 14, 25, 28, 39 and 40, inwards of the latter, dominance is due to the polychaetes *Tharyx* sp, *Caulleriella* sp, *Mediomastus capensis* and *Melinna palmata* or to the oligochaete *Tubificoides benedeni*. These last species occur commonly in organically enriched areas (Pearson & Rosenberg, 1978) and changes in the dominant species at these stations, located in the vicinity of the urban sewage, could be related to the influence of this input. This is also indicated by the fact that station 26, the closest to the outfall, is strongly dominated by the opportunist *Capitella capitata*

At the stations with highest densities along the northern channel (stations 54, 55, 60, 77, 79 and 93) the dominant species are all polychaetes,*Tharyx* sp, *Cirriformia* sp, *Melinna palmata*, *Spiochaetopterus costarum* and *Capitella capitata*. At stations 97 and 81, respectively in the northern and in the southern channel, but both located near the intertidal sandbanks, the dominants are the amphipods *Corophium annulatum* and *Corophium runcicorne*. The other sampling stations with the highest abundances are located in the southern channel and dominance is mostly due to the polychaete *Spiochaetopterus costarum*.

Globally, the spatial pattern shown by abundance classes resembles the distribution of species richness, particularly in those regions with the highest and lowest values. The former corresponds essentially to a group of stations located inwards of the entrance and before the beginning of the sandbanks, while the latter corresponds to locations with coarser and unstable sands in the vicinity of the mouth and along the southern channel and the sampling stations closer to the northern margin of the estuary, extending inwards of Etermar up to Eurominas. This latter region is influenced by the industrial complex in the Sado estuary.

Biomass was measured as a wet-weight, dry weight and ash-free dry weight. A full description of the methods used to obtain and convert the various measures of biomass is presented in chapter 3. The conversion factors calculated for each species are presented in Annex IV.

As expected, total biomass per species is very unevenly distributed. The total biomass for each major taxonomic group also shows strong differences, with Arthropods clearly comprising the greater part of total biomass. Expressed as blotted wet-weight, Molluscs, Annelids and Arthropods comprise 93% of total biomass, whilst Molluscs alone represent 72% (*cf.* table V.1).

Individual biomass also shows a clear dominance by Molluscs species. Considering wet-weight biomass, 38 species (10.5%) are represented by more than 10.0g, comprising 91.3% of total biomass. Of these species, 19 are Molluscs (50%), 14 Annelids, 1 is an Arthropod and 4 belong to other groups. The six dominant species, which all contribute more than 100.0 g and comprise 55.4% of total wet-weight biomass, are also Molluscs, *Cardium paucicostatum, Venerupis pullastra, Chaetopleura angulata, Solen marginatus, Nassarius reticulatus* and *Abra alba.*

If expressed as undecalcified dry weight, Molluscs biomass dominance becomes even more explicit. In fact, 29 species (8.0%) are represented globally by more than 5.0 g and comprise 93.3% of total dry weight biomass. Of these, 21 are Molluscs (72%), 4 Annelids, 1 is an Arthropod and 3 species belong to other groups. Three species are represented by more than 100.0 g and comprise 55.2% of total biomass, the Molluscs *Cardium paucicostatum, Venerupis pullastra* and *Chaetopleura angulata.*

Considering ash-free dry weight measurements, which eliminates the contribution of shells and other non-soft parts, 34 species (9.4%) are represented by a total biomass higher than 1.0 g, of which 15 are Molluscs (44.1%), 15 Annelids, 1 an Arthropod and 3 belong to minor groups. These 34 species comprise 90.1% of total ash-free dry weight biomass. Seven species weighed more than 10.0 g and comprise 54.9% of total biomass. Five of these species are Molluscs, *Nucula nucleus, Venerupis pullastra, Cardium paucicostatum, Chaetopleura angulata* and *Solen marginatus*, one is a polychaete, *Notomastus latericeus* and the other an undetermined anthozoan species.

The spatial distribution of total wet-weight biomass per sampling station, shown in figure 5.5, presents a clear pattern. The highest biomass, 177.21 $g/0.1m^2$, was found in station 33, dominated by the bivalve *Venerupis pullastra.* Other high values ($\geq$32.01$g/0.1m^2$) were found mainly along the estuarine margins, in the northern, from the mouth of the estuary until Etermar, and in the southern inwards of Instalações Navais. Other areas of high values are located closer to the margins of the intertidal sandbanks and comprise two to four sampling stations. With the exception of sampling stations 16 and 79, where the biomass dominance is due to an anthozoan and a polychaete species, all the others correspond to Mollusc species.

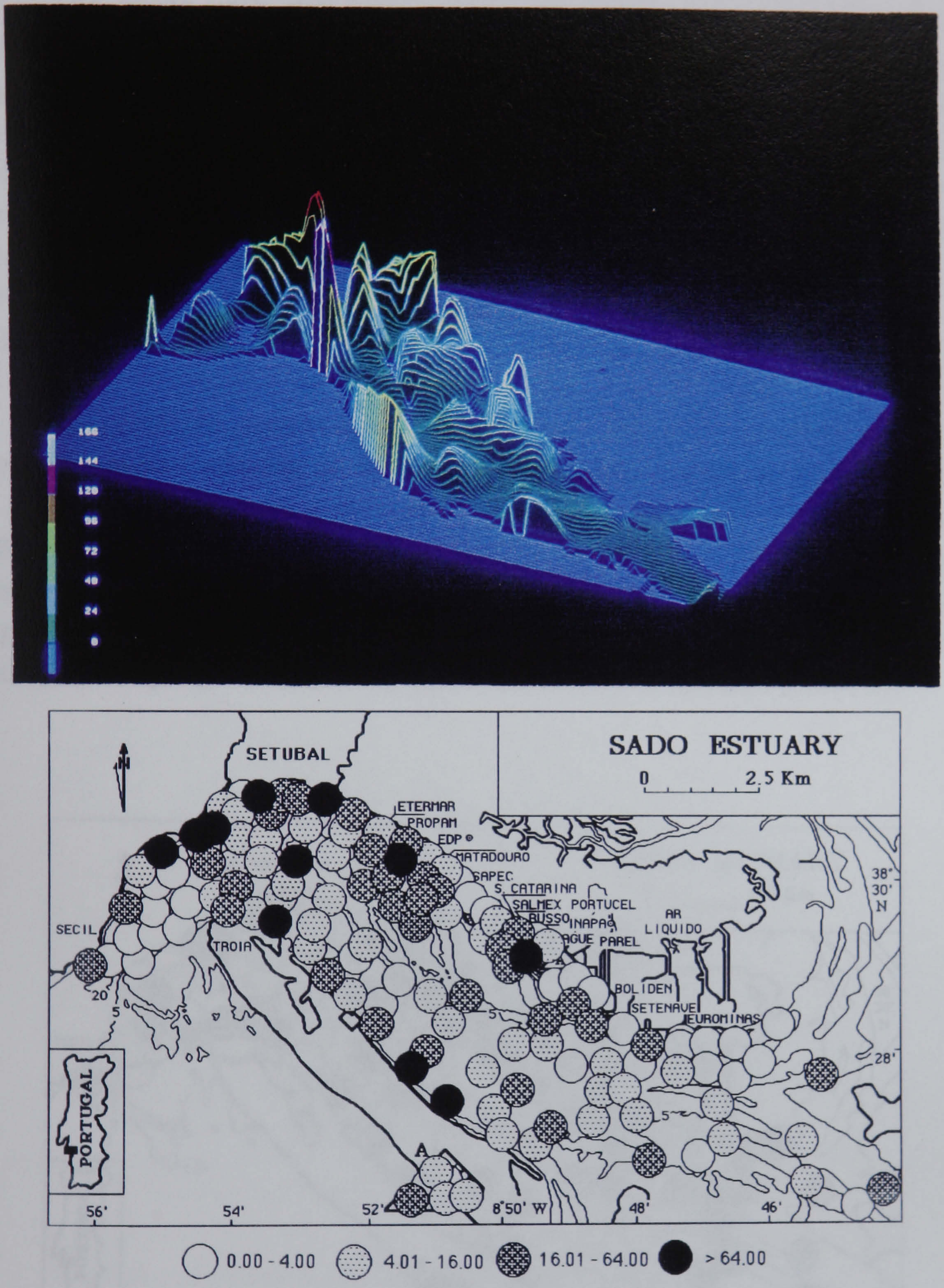


Figure 5.5 - Sado Estuary. Spatial distribution of total wet-weight biomass (g/0.1m^2). General (upper graph) and detailed view (lower graph).

The areas with the lowest biomass are also clearly delineated spatial regions in the estuary, namely the entrance (excluding the region nearest to the northern margin), the northern margin inwards from the EDP outfall and extending up to an area located in front of Boliden, Setenave and Eurominas, in the upper region, and a patch in the southern channel which comprises sampling stations 48, 49, 67 and 68. In general, all these low biomass areas also showed low abundances and some of them low species richness (*cf.* figures 5.2, 5.3, 5.5).

The relative proportion of wet-weight biomass contributed by the first ranked species at each of the sampling stations is presented in figure 5.6. The class encompassing the highest number of stations (65, ≈ 49%) consists of those in which the relative biomass of the first ranked species lies between 25 and 50% of total biomass, suggesting that biomass is more enevenly distributed than is species abundance (*cf.* figure 5.5). Also the distribution of sampling stations

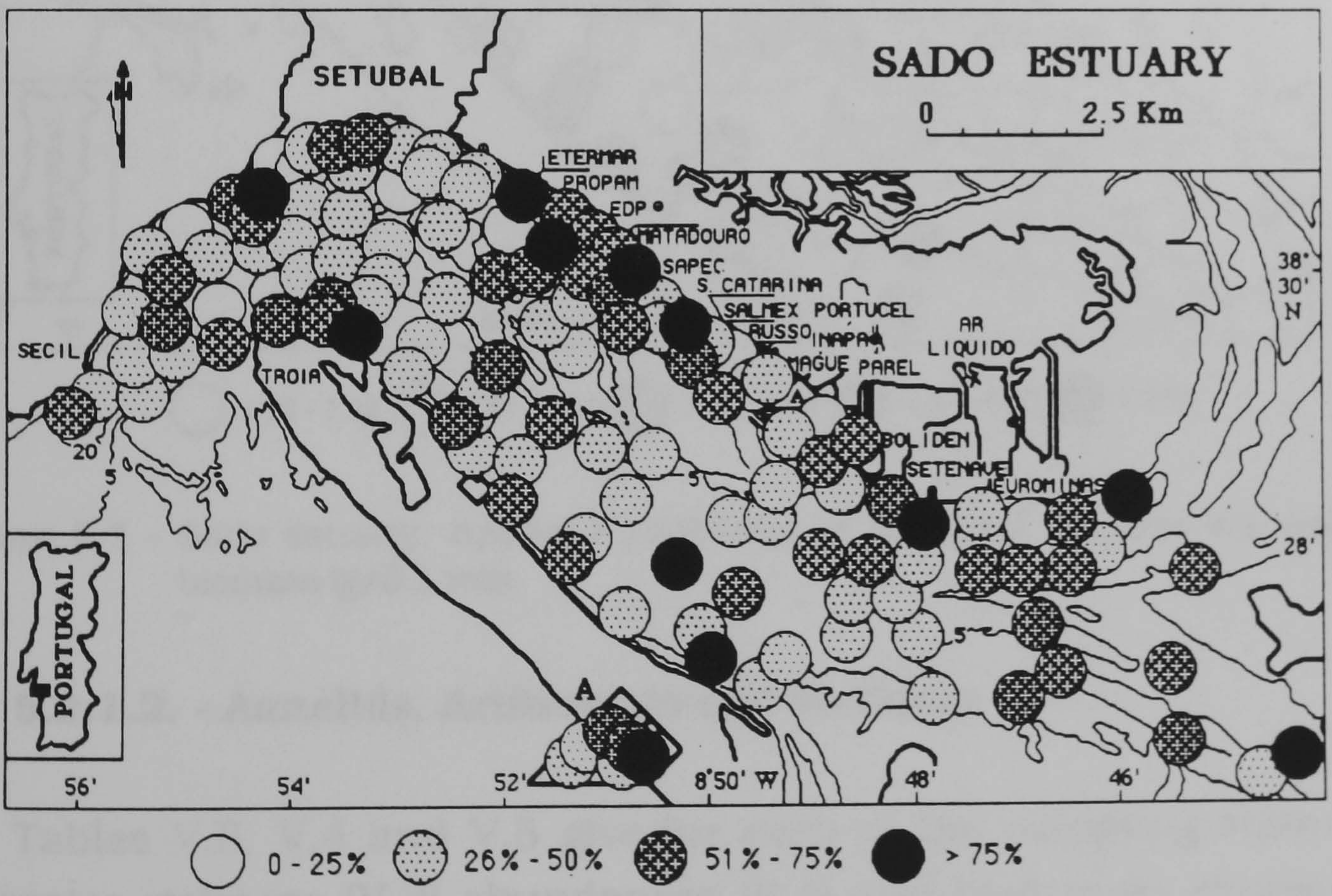


Figure 5.6 - Sado estuary. Relative wet-weight biomass represented by the first rank species.

belonging to the classes with higher hierarchical partition of biomass, is not so clearly localised as in the case of abundances, as there are more stations in the entrance region and in the south channel where the first ranked species biomass value lies in the higher percentage classes.

Figure 5.7 presents the spatial distribution of total ash-free dry weight biomass per sampling station. This map shows, in general, the same low and high value areas as the wet-weight biomass, but the grouping of stations is clearer and appears less scattered than in figure 5.5.

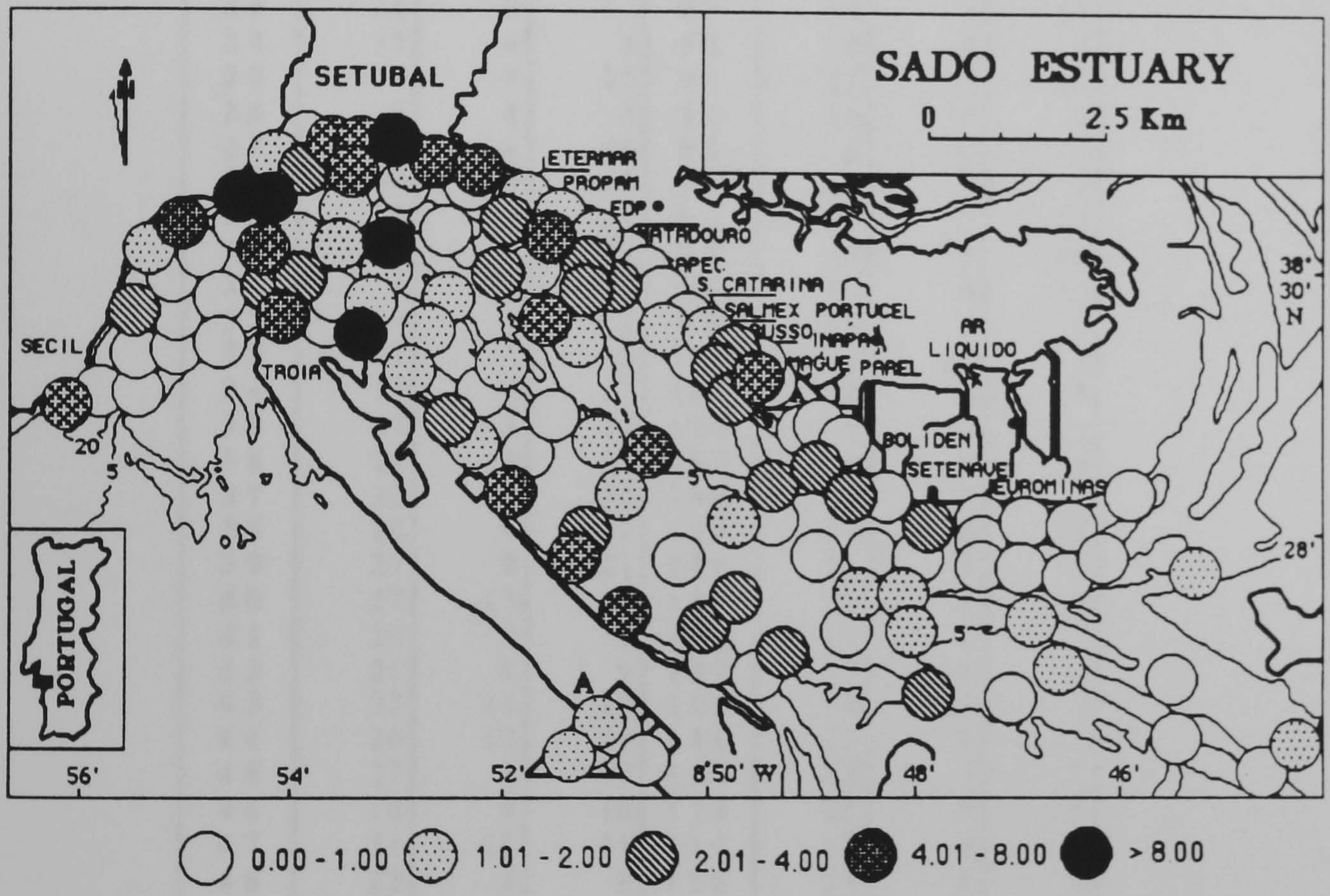


Figure 5.7 - Sado estuary. Spatial distribution of the total ash-free dry weight biomass (g/0.1 m2).

5.2.1.2. - Annelids, Arthropods and Molluscs

Tables V.3, V.4 and V.5 give for each of the sampling stations, the species richness (V.3) abundances (V.4) and biomasses expressed as wet-weight and ash-free dry weight (V. 5), of the most important taxonomic groups identified in the estuary, Annelids, Arthropods and Molluscs.

St.	Ann.	Moll.	Arth.	St.	Ann.	Moll.	Arth.
1	25	16	26	**67**	13	0	4
2	27	8	16	**68**	3	2	2
3	8	1	7	**69**	18	6	11
4	19	2	17	**70**	30	14	18
5	25	18	21	**71**	24	4	14
6	16	10	20	**72**	20	10	15
7	8	2	6	**73**	4	1	8
8	13	1	5	**74**	18	3	9
9	23	5	11	**75**	21	9	12
10	10	3	8	**76**	17	6	14
11	20	1	17	**77**	26	9	22
12	31	10	15	**78**	11	0	4
13	32	21	29	**79**	29	9	20
14	34	12	20	**80**	17	7	13
15	22	4	21	**81**	28	5	21
16	40	20	24	**82**	19	7	10
17	28	9	18	**83**	33	11	14
18	32	13	14	**84**	20	10	17
19	42	14	22	**85**	22	12	11
20	30	10	22	**86**	15	4	4
21	32	7	25	**87**	18	4	5
22	26	7	28	**88**	15	5	7
23	34	9	11	**89**	18	4	14
24	15	4	4	**90**	10	4	4
25	30	8	25	**91**	25	5	14
26	9	4	4	**92**	10	0	4
27	26	8	16	**93**	6	0	1
28	40	9	27	**94**	15	5	8
29	36	11	21	**96**	20	3	13
30	26	7	22	**97**	26	5	18
31	3	0	3	**98**	19	8	18
32	9	3	3	**99**	18	3	7
33	21	7	8	**100**	22	13	13
34	19	4	7	**101**	29	9	17
35	27	3	13	**102**	5	4	6
36	28	8	24	**103**	16	4	13
37	32	10	20	**104**	9	1	1
38	26	6	21	**105**	25	8	13
39	27	9	21	**106**	11	3	5
40	27	13	17	**107**	11	3	6
41	20	9	14	**108**	14	2	7
42	21	4	9	**109**	15	4	7
43	32	11	29	**110**	19	5	8
44	26	12	21	**111**	23	9	15
45	27	7	19	**112**	13	7	7
46	18	6	16	**113**	18	5	9
47	31	18	21	**114**	13	4	3
48	23	2	9	**115**	11	1	2
49	20	1	7	**116**	12	4	10
50	18	6	16	**117**	4	0	5
51	16	9	17	**118**	3	3	4
52	22	10	18	**119**	13	3	8
53	21	11	15	**121**	5	1	0
54	24	8	18	**122**	17	6	10
55	22	9	18	**123**	7	4	3
56	17	6	8	**124**	20	6	10
57	12	2	7	**125**	2	0	2
58	12	1	15	**126**	2	2	0
59	20	6	15	**127**	13	2	0
60	28	7	18	**128**	8	1	4
61	9	2	5	**129**	19	6	15
62	5	1	2	**130**	17	3	12
63	19	7	10	**131**	9	6	2
64	23	9	12	**132**	9	3	6
65	9	0	5	**133**	10	2	12
66	22	7	19				

Table V.3 - Species richness (species/0.1m^2) for each of the sampling stations of the most important taxonomic groups: Ann. - Annelids, Moll.- Molluscs and Arth. - Arthropods.

St.	Ann.	Moll.	Arth.	St.	Ann.	Moll.	Arth.
1	164	154	247	67	60	0	7
2	155	17	140	68	3	2	2
3	75	6	36	69	115	40	27
4	87	6	618	70	695	86	68
5	249	127	688	71	226	6	66
6	102	28	860	72	499	58	138
7	37	3	36	73	21	1	9
8	61	1	29	74	405	26	62
9	127	38	27	75	206	10	52
10	20	10	57	76	471	72	69
11	156	3	47	77	1049	54	153
12	209	53	1603	78	40	0	4
13	300	154	314	79	719	28	165
14	671	77	316	80	309	37	165
15	140	18	1055	81	590	14	477
16	744	112	331	82	765	130	23
17	427	25	106	83	460	39	94
18	397	214	117	84	468	32	432
19	837	35	78	85	347	35	135
20	438	61	189	86	110	5	6
21	391	100	739	87	465	79	11
22	547	93	420	88	251	35	24
23	488	105	85	89	361	5	35
24	110	37	7	90	99	8	6
25	665	48	220	91	403	6	246
26	14680	43	8	92	21	0	6
27	363	119	273	93	1199	0	5
28	576	64	275	94	63	6	9
29	475	18	153	96	303	20	86
30	463	47	120	97	363	17	1136
31	6	0	7	98	315	38	141
32	12	5	5	99	351	4	12
33	65	51	8	100	1048	45	65
34	246	22	9	101	430	67	287
35	365	32	50	102	23	20	27
36	333	91	434	103	281	5	67
37	402	44	182	104	83	1	1
38	223	22	282	105	334	21	113
39	812	136	138	106	310	16	7
40	1061	124	435	107	43	3	16
41	489	132	124	108	225	6	22
42	431	34	57	109	182	70	17
43	302	25	263	110	241	34	19
44	356	23	212	111	306	41	155
45	280	20	410	112	345	19	14
46	172	15	181	113	911	29	18
47	339	112	491	114	126	5	4
48	74	2	16	115	53	1	2
49	241	1	10	116	80	35	18
50	253	19	131	117	8	0	13
51	62	70	150	118	58	51	6
52	212	30	89	119	40	4	11
53	206	19	264	121	14	1	0
54	470	119	284	122	298	67	31
55	773	32	173	123	55	8	5
56	107	11	104	124	321	80	73
57	134	38	85	125	57	0	3
58	131	2	68	126	3	9	0
59	459	18	190	127	71	6	0
60	892	28	388	128	56	1	4
61	88	3	170	129	192	10	151
62	6	1	3	130	173	27	63
63	359	56	71	131	85	15	7
64	428	27	124	132	45	11	33
65	27	0	27	133	20	18	54
66	404	135	113				

Table V.4 - Abundances (ind/0.1m^2) of the most important taxonomic groups in each sampling station. Ann. - Annelids, Moll. - Molluscs, Arth. - Arthropods.

St.	Ann.		Moll		Arth.		St.	Ann.		Moll.		Arth.	
	B 1	B 2	B 1	B 2	B 1	B 2		B 1	B 2	B 1	B 2	B 1	B 2
1	0.55	0.069	58.97	4.321	0.66	0.066	67	0.32	0.044	0.00	0.000	1.03	0.118
2	0.54	0.061	1.69	0.112	0.27	0.026	68	0.02	0.003	0.05	0.005	0.37	0.035
3	0.52	0.076	0.51	0.061	0.06	0.005	69	2.44	0.254	6.19	0.421	1.12	0.126
4	0.73	0.091	0.10	0.006	0.69	0.065	70	6.52	0.690	40.20	2.139	2.73	0.331
5	2.31	0.220	28.92	2.146	1.76	0.187	71	2.38	0.280	0.94	0.042	0.19	0.027
6	1.57	0.161	13.39	1.059	0.87	0.111	72	3.67	0.462	14.05	0.811	2.18	0.269
7	0.14	0.020	0.05	0.003	0.16	0.015	73	0.45	0.053	0.001	0.0003	0.10	0.012
8	0.03	0.003	0.001	0.000	0.57	0.047	74	7.99	0.982	0.40	0.027	0.16	0.023
9	0.27	0.029	0.60	0.038	0.15	0.013	75	4.13	0.509	7.47	0.516	1.88	0.332
10	0.51	0.074	2.28	0.156	0.40	0.041	76	6.20	0.778	1.13	0.074	0.60	0.077
11	0.35	0.046	0.02	0.001	0.16	0.017	77	13.81	1.437	38.93	1.911	2.52	0.314
12	1.55	0.215	0.97	0.060	1.07	0.112	78	0.19	0.025	0.00	0.000	0.03	0.004
13	2.92	0.366	66.18	4.339	0.66	0.074	79	24.54	2.798	39.88	2.354	2.50	0.315
14	4.26	0.516	79.92	6.251	1.03	0.113	80	3.83	0.508	45.83	2.472	0.27	0.036
15	1.51	0.201	0.31	0.024	0.97	0.095	81	15.04	1.660	8.32	0.646	0.40	0.037
16	5.63	0.603	22.80	1.686	0.75	0.070	82	6.53	0.611	2.42	0.139	2.14	0.258
17	4.02	0.316	4.79	0.343	0.46	0.040	83	5.46	0.550	10.97	0.744	0.23	0.028
18	2.15	0.232	31.02	1.928	0.18	0.019	84	3.78	0.369	65.73	3.425	0.34	0.037
19	3.79	0.396	23.03	1.667	1.34	0.094	85	3.02	0.311	81.19	4.747	0.12	0.013
20	6.42	0.674	1.17	0.071	0.30	0.031	86	0.74	0.097	10.36	0.652	0.03	0.002
21	2.45	0.274	3.29	0.272	0.55	0.062	87	3.16	0.370	3.42	0.210	4.95	0.599
22	2.48	0.310	130.91	10.252	1.06	0.085	88	2.63	0.330	0.70	0.042	2.21	0.270
23	8.50	0.971	3.65	0.234	0.24	0.032	89	7.08	0.850	0.21	0.013	0.06	0.007
24	0.99	0.133	1.73	0.092	0.005	0.001	90	3.36	0.411	0.14	0.007	0.16	0.019
25	3.68	0.475	6.28	0.513	0.41	0.044	91	5.50	0.575	10.56	0.515	0.52	0.073
26	21.98	2.618	51.59	3.599	0.18	0.021	92	0.20	0.026	0.00	0.000	0.02	0.002
27	3.35	0.379	29.27	2.095	0.51	0.062	93	4.10	0.492	0.00	0.000	0.01	0.002
28	5.97	0.062	28.72	2.212	1.43	0.154	94	1.42	0.178	8.44	0.473	0.26	0.030
29	5.14	0.622	7.87	0.578	0.36	0.044	96	2.81	0.360	0.23	0.020	0.10	0.010
30	3.13	0.320	9.01	0.611	0.15	0.017	97	20.75	2.498	1.74	0.121	1.12	0.135
31	0.11	0.016	0.00	0.000	0.44	0.036	98	15.82	1.838	14.15	0.954	4.11	0.508
32	4.88	0.721	3.70	0.267	0.02	0.002	99	3.33	0.342	0.16	0.009	0.18	0.020
33	0.73	0.097	176.13	13.680	0.11	0.010	100	10.20	1.058	27.96	1.787	1.27	0.154
34	2.76	0.336	3.63	0.262	0.02	0.001	101	3.02	0.347	3.15	0.266	0.85	0.111
35	3.04	0.326	2.47	0.143	0.10	0.010	102	0.26	0.037	5.02	0.349	0.02	0.002
36	3.66	0.426	83.26	5.013	0.47	0.051	103	3.02	0.401	2.61	0.146	0.13	0.016
37	4.67	0.521	2.76	0.208	0.24	0.026	104	1.58	0.209	2.03	0.107	0.18	0.020
38	2.21	0.234	4.83	0.304	0.60	0.071	105	6.68	0.800	27.13	1.425	0.28	0.038
39	4.98	0.622	44.96	2.552	4.32	0.502	106	2.22	0.296	1.17	0.124	0.02	0.002
40	18.19	2.000	46.11	2.488	0.66	0.079	107	2.82	0.387	0.05	0.002	0.02	0.002
41	6.42	0.828	31.84	1.931	0.28	0.036	108	1.92	0.199	4.58	0.241	0.11	0.010
42	5.08	0.628	5.03	0.296	0.10	0.014	109	1.93	0.219	7.19	0.380	3.92	0.472
43	2.25	0.223	2.76	0.189	0.34	0.034	110	4.03	0.501	2.01	0.146	0.10	0.011
44	8.78	0.919	5.37	0.340	0.26	0.031	111	2.82	0.273	40.14	2.186	1.22	0.143
45	3.57	0.030	4.38	0.304	0.81	0.081	112	4.61	0.505	32.53	1.933	0.03	0.004
46	2.30	0.235	7.51	0.555	0.21	0.026	113	7.85	0.788	3.04	0.216	2.28	0.276
47	6.91	0.790	29.55	2.045	0.44	0.046	114	2.59	0.266	0.95	0.051	2.82	0.346
48	0.35	0.035	0.09	0.011	0.24	0.027	115	0.60	0.081	0.03	0.004	0.37	0.042
49	0.45	0.042	0.002	0.0001	0.03	0.003	116	1.27	0.177	0.50	0.023	0.26	0.031
50	2.56	0.299	12.13	0.608	0.27	0.030	117	0.18	0.026	0.00	0.000	0.01	0.001
51	1.23	0.154	41.72	2.145	0.17	0.017	118	0.40	0.058	0.27	0.015	0.64	0.076
52	2.40	0.301	41.86	2.552	0.15	0.019	119	0.35	0.045	3.04	0.168	1.13	0.126
53	5.22	0.609	16.33	1.184	0.50	0.061	121	0.24	0.032	0.003	0.001	0.00	0.000
54	5.22	0.694	10.35	0.714	0.74	0.092	122	1.69	0.171	11.33	1.563	4.65	0.562
55	11.07	1.219	61.85	2.936	0.52	0.073	123	1.62	0.214	1.75	0.171	0.01	0.001
56	1.20	0.149	11.03	0.529	0.28	0.042	124	2.05	0.267	0.58	0.036	8.62	1.042
57	1.69	0.233	16.79	0.798	0.09	0.009	125	1.25	0.185	0.00	0.000	1.99	0.241
58	5.41	0.646	0.02	0.001	4.13	0.475	126	0.27	0.040	0.70	0.037	0.00	0.000
59	6.32	0.878	31.78	1.766	0.39	0.049	127	0.64	0.092	0.03	0.002	0.00	0.000
60	7.90	0.835	31.18	1.762	0.56	0.067	128	0.76	0.105	0.06	0.007	0.01	0.001
61	2.46	0.306	3.44	0.157	0.20	0.019	129	4.11	0.475	12.06	0.748	0.48	0.054
62	2.91	0.342	0.07	0.004	0.003	0.0003	130	0.95	0.129	5.15	0.325	3.47	0.415
63	3.53	0.476	44.48	2.278	0.19	0.025	131	0.74	0.095	5.13	0.286	0.02	0.002
64	3.70	0.422	22.03	1.273	0.23	0.029	132	0.25	0.027	0.48	0.030	0.57	0.062
65	0.86	0.112	0.00	0.000	0.41	0.045	133	2.18	0.246	19.30	1.223	0.05	0.006
66	2.61	0.291	12.31	0.573	0.34	0.046							

Table V.5 - Wet-weight (B1) and ash-free dry weight (B2) biomass (g/0.1m^2) for each of the sampling stations of the most important taxonomic groups: Ann. - Annelids, Moll. -Molluscs and Arth. - Arthropods.

Annelids

Annelids were the only taxonomic group present in all the sampling stations (excepting stations 95 and 120 with no macrofauna).

A total of 53643 Annelids were collected, 52347 polychaetes from 131 species and 1296 oligochaetes from 3 species.

The most abundant species were the capitellid *Capitella capitata*, the chaetopterid *Spiochaetopterus costarum*, the cirratullids *Tharyx* sp., *Cirriformia* sp. and *Caulleriella* sp., and the ampharetid *Melinna palmata*. These 6 species comprised 36380 individuals, corresponding to 67.8% and 69.5% of, respectively, the total number of Annelids and of polychaetes. 60 species (48%) were represented by a total of 10 or less individuals.

The highest densities of *Capitella capitata*, 15720 specimens, occurred at station 26, near of the Setúbal sewage outfall, and at station 93 located near the pulp mill effluent outfall. These stations showed, respectively, densities of 14680 and 1199 Annelids per 0.1m^2, of which 14496 (92%) and 1104 (92%) were contributed by *C. capitata*.

The most frequent by occurring species were the cirratulids *Caulleriella* sp, *Cirriformia* sp and *Tharyx* sp, the spionid *Aonides oxycephala* the chaetopterid *Spiochaetopterus costarum*, and the glycerid *Glycera tridactyla*. Eighty one species (60%) were sampled in 13 or less stations (sampling frequency ≤ 10%).

Total wet-weight biomass indicates 14 species contributed more than 10.0 g, of which 78% were Annelids. The polychaets *Lygdamis murata*, *Spiochaetopterus costarum*, *Melinna palmata*, *Cirriformia sp* and *Capitella capitata*, all had values higher than 25.0g.

Figures 5.8 to 5.18 show the spatial distribution and local density of several annelid species, chosen either because the species are very frequent and/or abundant or because they tend to show particular distribution areas. These distribution maps also introduce some general features useful to the interpretation of data treatment which will be presented in the next chapter.

Cirratulids are one of the most widespread families in the estuary. The three species identified, *Tharyx* sp, *Cirriformia* sp and *Caulleriella* sp tend to occupy almost every area in the estuary, with the exception of the entrance region. This is particularly clear with *Tharyx* sp. Local density strongly varies for the three species, which clearly tend to show the highest abundances in the northern channel (figure 5.8).

Capitella capitata and *Malacoceros fuliginosus* are particularly abundant in the vicinity of the urban sewage and the pulp mill outfall and *Tubificoides benedeni* is present almost exclusively along the northern margin (Fig. 5.9).

The spionid *Aonides oxycephala*, is distributed throughout the estuary, but tends to show higher densities in the northern channel. This is also the case with *Melinna palmata*, which is nearly absent from the sampling locations near the entrance, the southern channel and the upper estuary, where the species tends to settle only in the vicinity of the margin (figure 5.10).

Other species with a wide distribution are *Spiochaetopterus costarum*, *Glycera tridactyla* and *Polydora caeca* (figure 5.11), which have higher densities in both the northern and southern channels. *Spiochaetopterus costarum* also has higher densities at some sampling stations in the upper estuary.

The phyllodocids *Anaitides mucosa* and *Anaitides lineata* also tend to occupy both channels and the entrance region but are almost absent from the upper estuary (figure 5.12), while *Scalibregma inflatum* clearly shows higher abundances in the inner part of the southern channel and the upper region of the estuary. This species is totally absent from the entrance region and the sampling stations near the industrial belt along the northern margin (figure 5.12), where some of the carnivores seem to find favourable conditions (e. g. *Diopatra neapolitana* and *Marphysa sanguinea* , figure 5.12).

The Capitellid species occupy different distributions in the estuary. *Capitella capitata*, is almost entirely confined to the vicinity of the Setúbal sewage and pulp mill outfalls, *Mediomastus capensis*, *Notomastus latericeus* and *Heteromastus filiformis* (figure 5.13) tend to settle successively from the outer to the inner regions. *Mediomastus capensis* appears near the entrance and in the northern and southern channels, with higher densities mainly between the mouth of the estuary and the intertidal sandbanks, but is totally absent in the upper region. The distribution of *Notomastus latericeus* ranges from the mouth of the estuary up to the inner estuary, while it occurs in higher densities along the southern channel and is absent through most of the northern channel. *Heteromastus filiformis* is totally absent near the estuarine entrance and in most of the southern channel and occurs at its highest densities in the northern channel, though extending throughout the upper and inner estuary (figure 5.13).

Terebellids also occupy more or less specific regions, namely close to the margin of the estuary and on the intertidal sandbanks (figure 5.14). This is clearly the case of *Lanice conchilega* and *Lygdamis murata*, whilst *Pista cristata* appears to be more widely distributed in the northern channel. All three species are absent from the entrance region and the majority of the middle stations along the southern channel and the upper estuary. *Polycirrus* sp, on the contrary, is mainly settled near the entrance at the beginning of the northern and southern channels, in which the species shows higher abundances but extends up to some locations in the upper estuary (figure 5.14).

Syllids, namely *Syllis hyalina* and *Parapionosyllis elegans* also have discrete distributions (fig. 5.15). Both species are present near the entrance but while *Syllis hyalina* extends through the northern channel and part of the southern channel, *Parapionosyllis elegans* occurs throughout the southern channel, especially along the southern margin of the intertidal sandbanks, and extends into the upper region in the region of median to coarse sand.

Similar distributions to *Parapionosyllis elegans* are shown by *Goniadella galaica*, *Scoloplos armiger* and *Nepthys cirrosa*, which all occupy principally the southern channel. Another nepthyid, *Nepthys hombergii* tends to be more frequent along the northern channel, though also settles in the southern channel margin (figure 5.16).

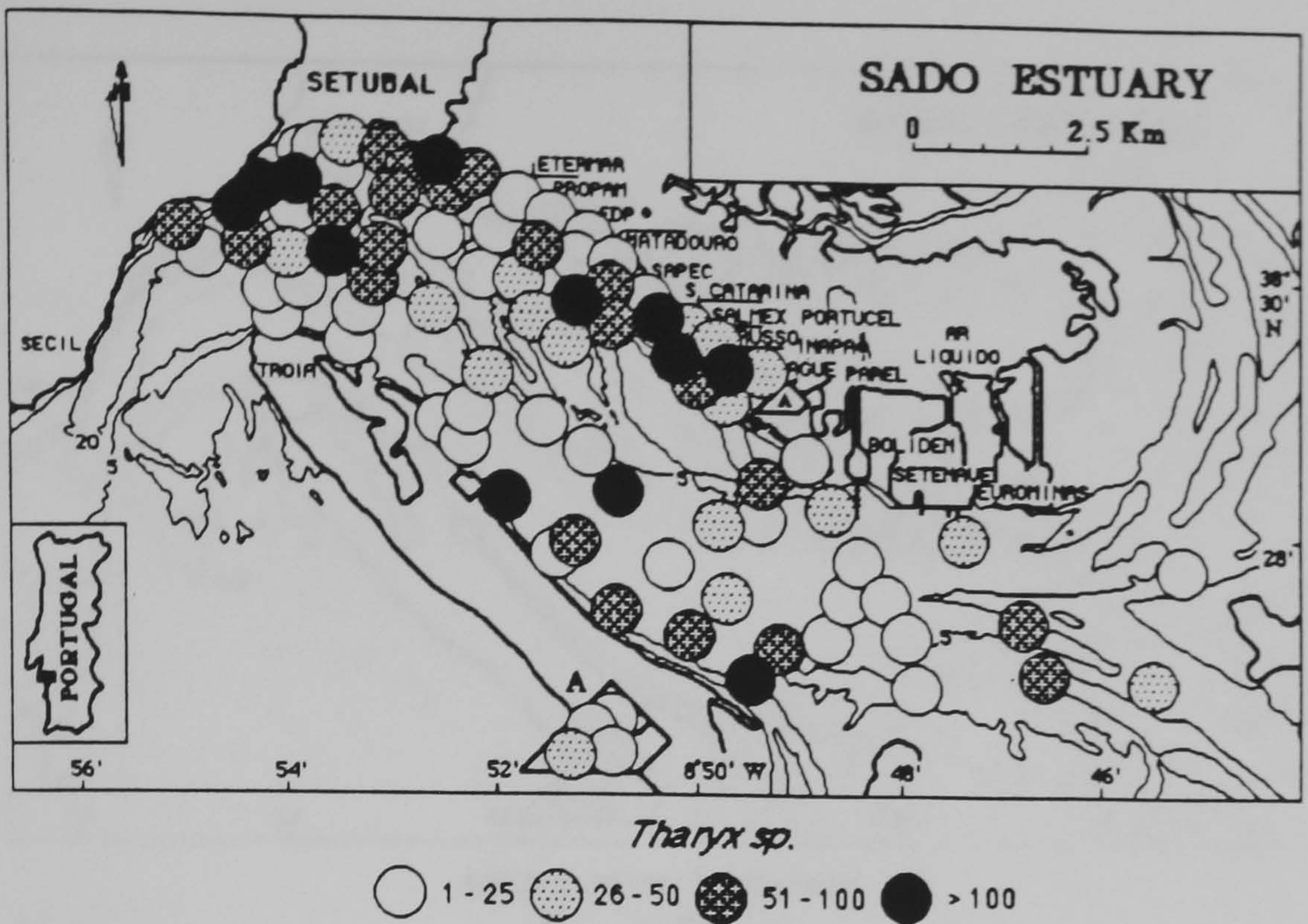
The dorvilleids *Schistomeringos rudolphi*, *Schistomeringos neglecta* and *Protodorvillea kefersteini*, are all absent from the upper region and inner estuary and only occasionally occur in the northern channel. They are mainly settled in the entrance region on the southern margin of the intertidal sandbanks (*Protodorvillea kefersteini* and *Schistomeringos neglecta*) or close to sources of organic enrichment, namely the pulp mill and sewage outfalls (mainly *Schistomeringos rudolphi*) (figure 5.17).

Finally, a few other Annelids are mainly distributed near the estuarine mouth or in a few sampling stations with coarser sediments along the southern channel and the upper region of the estuary. This is the case with *Pisione remota*, *Saccocirus papillocercus*, *Glycera capitata*, *Polygordius appendiculatus* and undetermined serpulids (figure 5.18).

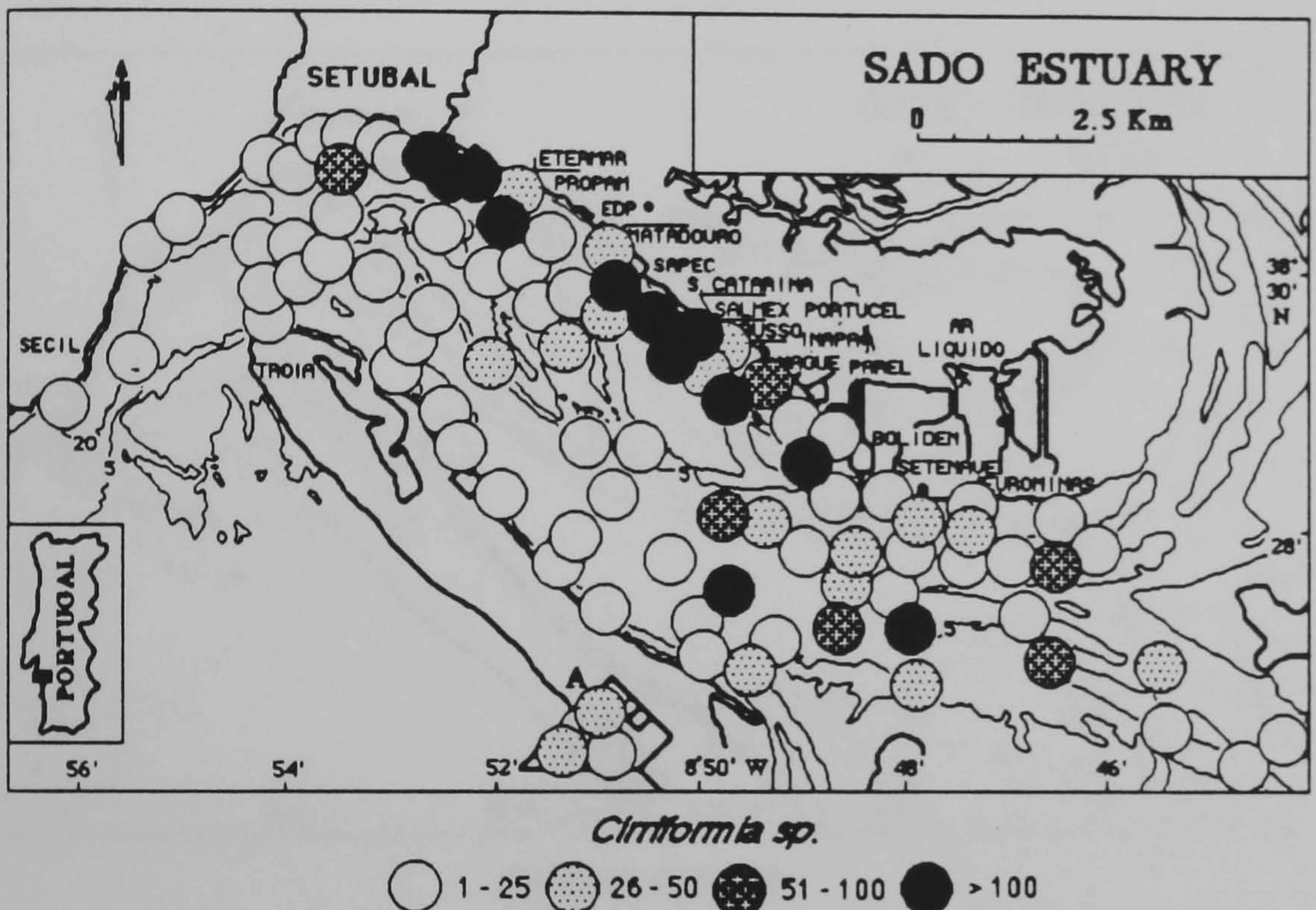
Biomass distribution maps from the different species are not shown. However, abundance and biomass per species tend to be highly significantly correlated, as shown by the results presented in table V.6. Both descriptions should thus present similar spatial patterns for each of the species.

Species	Df.	r	level signif.
Cirrifomia sp	98	0.880	***
Caulleriella sp	101	0.744	***
Tharyx sp	88	0.744	***
Diopatra neapolitana	19	0.553	***
Marphysa sanguinea	8	0.678	*
Scalibregma inflatum	49	0.985	***
Anaitides lineata	45	0.524	***
A. mucosa	69	0.740	***
Polydora caeca	73	0.963	***
Spiochaetopterus costarum	87	0.963	***
Glycera tridactyla	78	0.668	***
Melinna palmata	64	0.979	***
Aonides oxycephala	89	0.978	***
Nephtys hombergii	47	0.309	*
N. cirrosa	38	0.390	**
Scoloplos armiger	60	0.928	***
Goniadella galaica	30	0.987	***
Parapionosyllis elegans	27	0.881	***
Sphaerosyllis bulbosa	16	0.768	***
Syllis hyalina	47	0.999	***
Lygdamis murata	28	0.988	***
Lanice conchilega	48	0.586	***
Pista cristata	53	0.759	***
Polycirrus sp	32	0.393	**
Notomastus latericeus	76	0.679	***
Mediomastus capensis	70	0.504	***
Heteromastus filiformis	56	0.511	***
Serpulids	17	0.891	***
Polygordius appendiculatus	6	0.980	***
Glycera capitata	17	0.830	***
Pisione remota	15	0.905	***
Saccocirrus papillocercus	9	0.645	*
Protodorvillea kefersteini	29	0.720	***
Schistomeringos neglecta	1	1.000	***
S. rudolphi	9	1.000	***

Table V.6 - Abundance and wet-weight biomass correlation coefficients for annelid species represented in figures 5.8 to 5.18. df=degrees of freedom; levels of significance = * < 0.05; ** < 0.02; *** << 0.001.



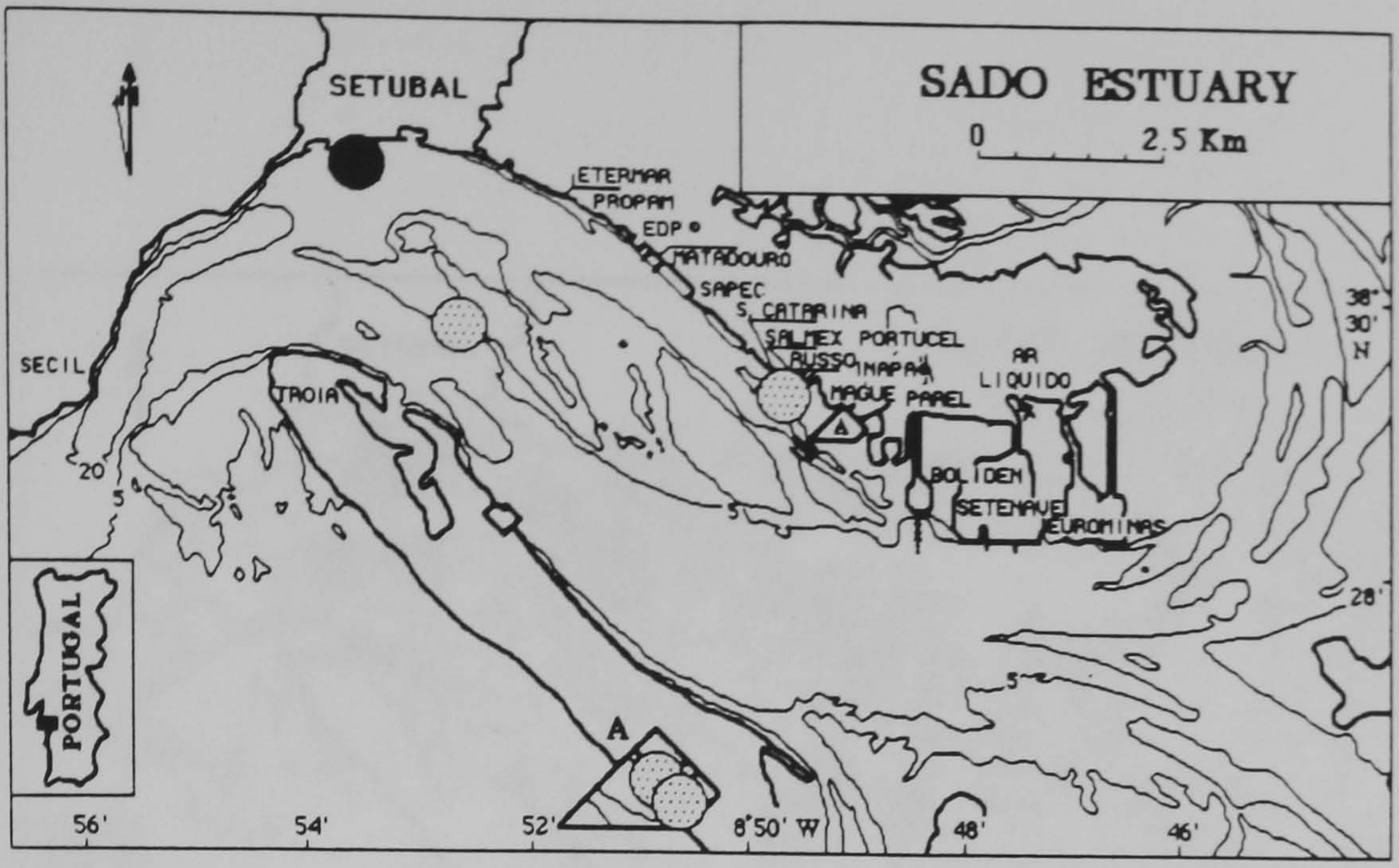
Tharyx sp.



Cirriformia sp.

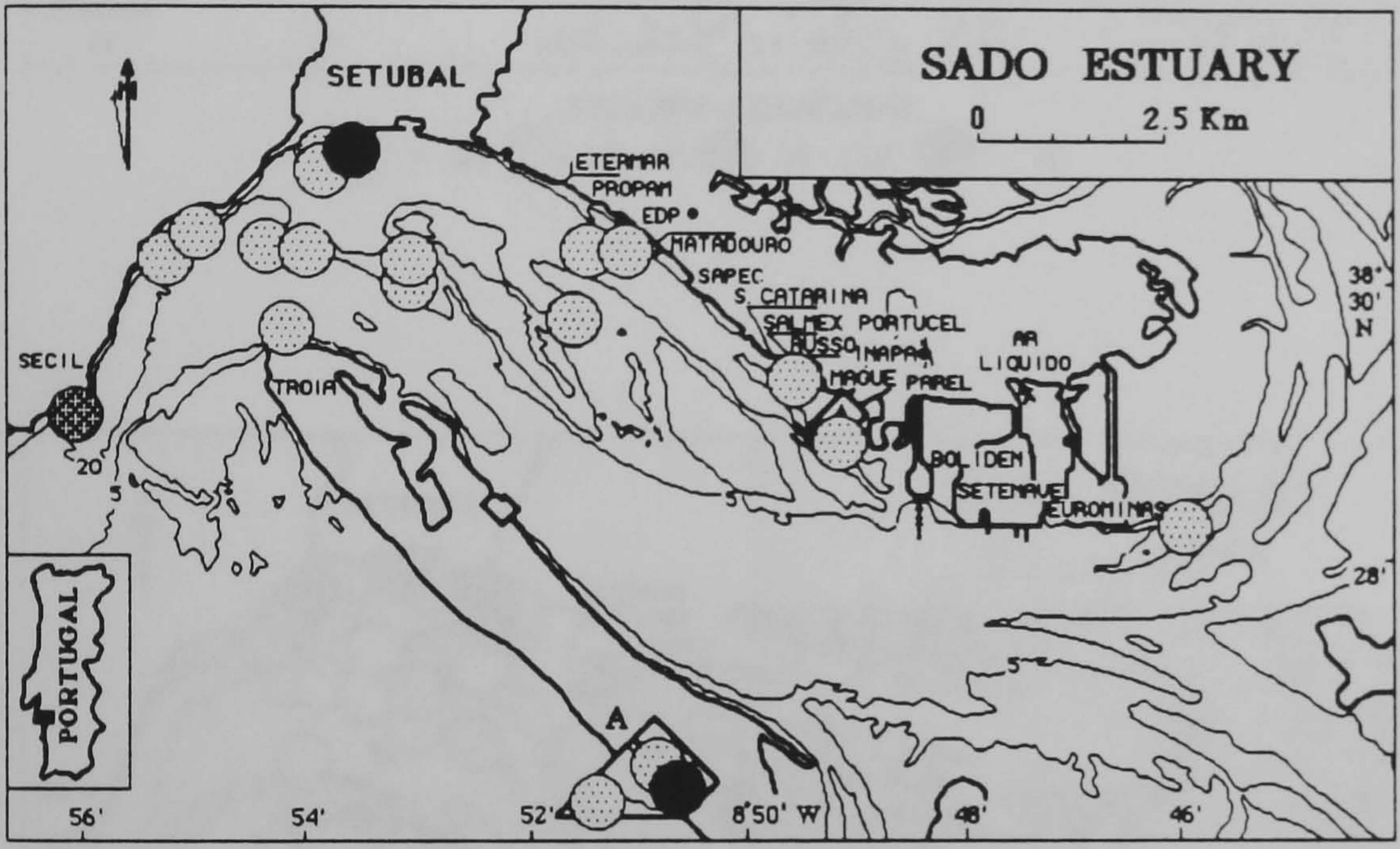
Caulleriella sp.

Figure 5.8 - Sado Estuary. Spatial distribution and local density (ind./0.1m^2) of the Cirratulids, *Tharyx* sp, *Caulleriella* sp. and *Cirriformia* sp.



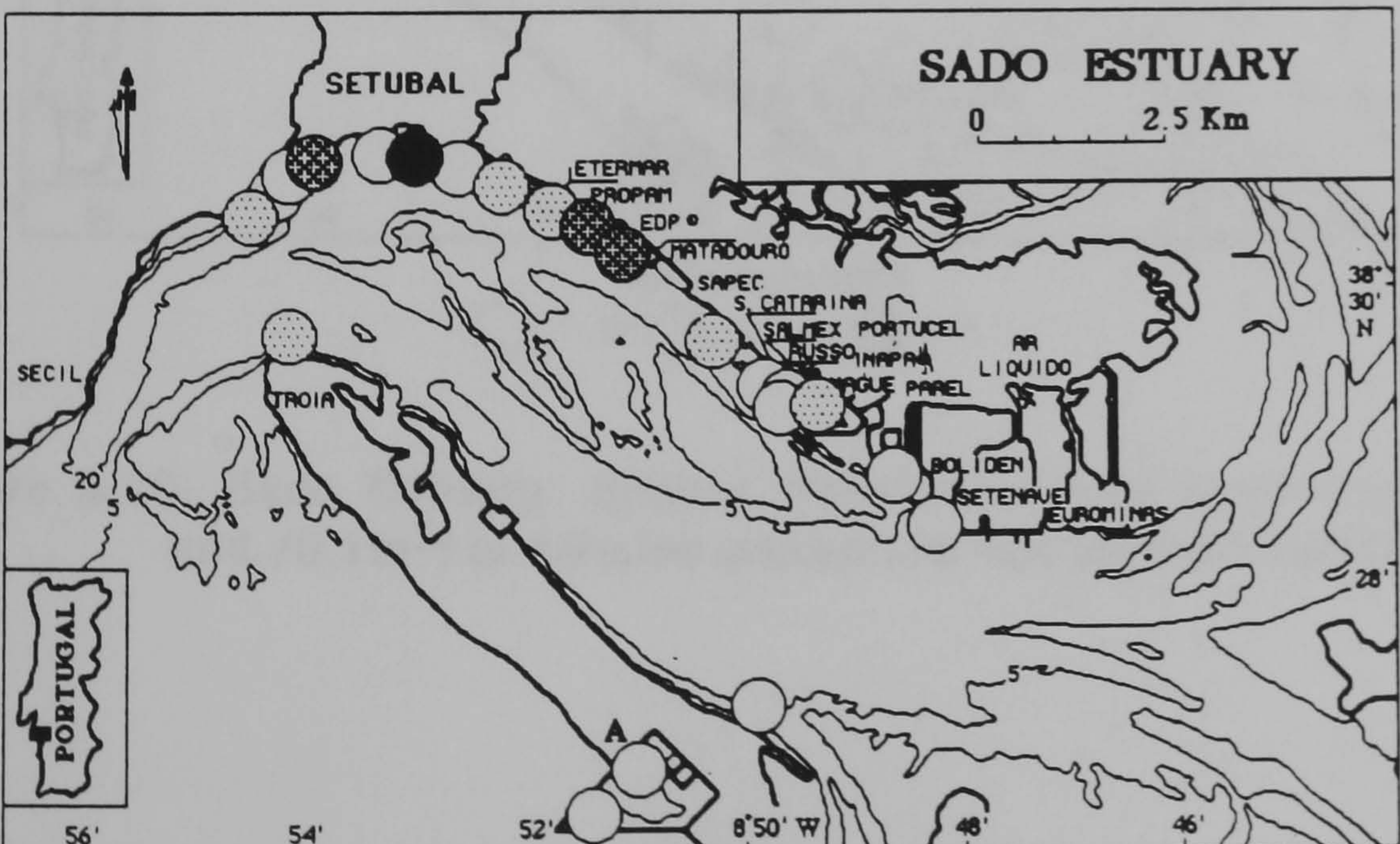
Malacoceros fuliginosus

◌ 1 - 50 ● > 50



Capitella capitata

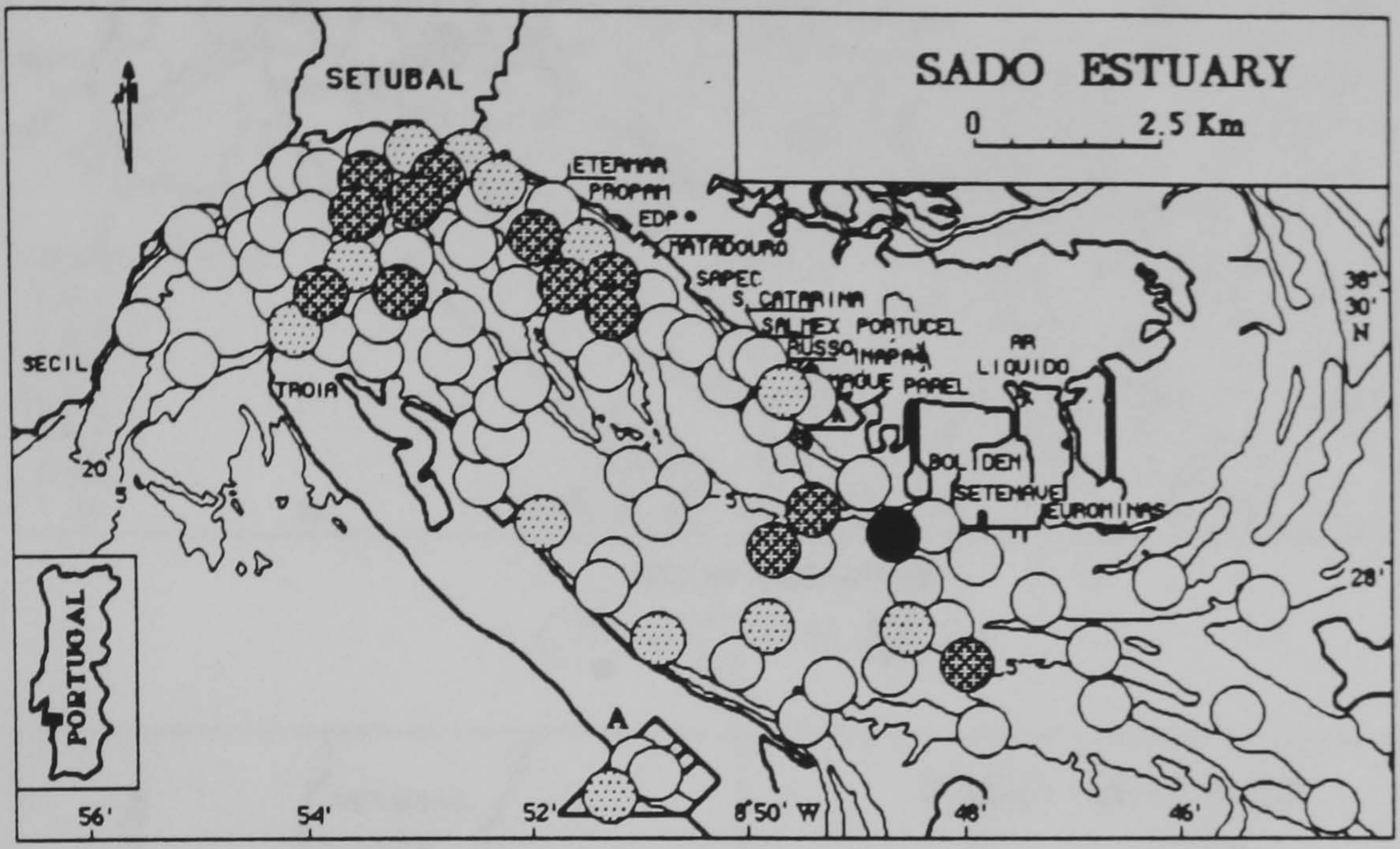
◌ 1 - 50 ▩ 51 - 1000 ● > 1000



Tubificoides benedeni

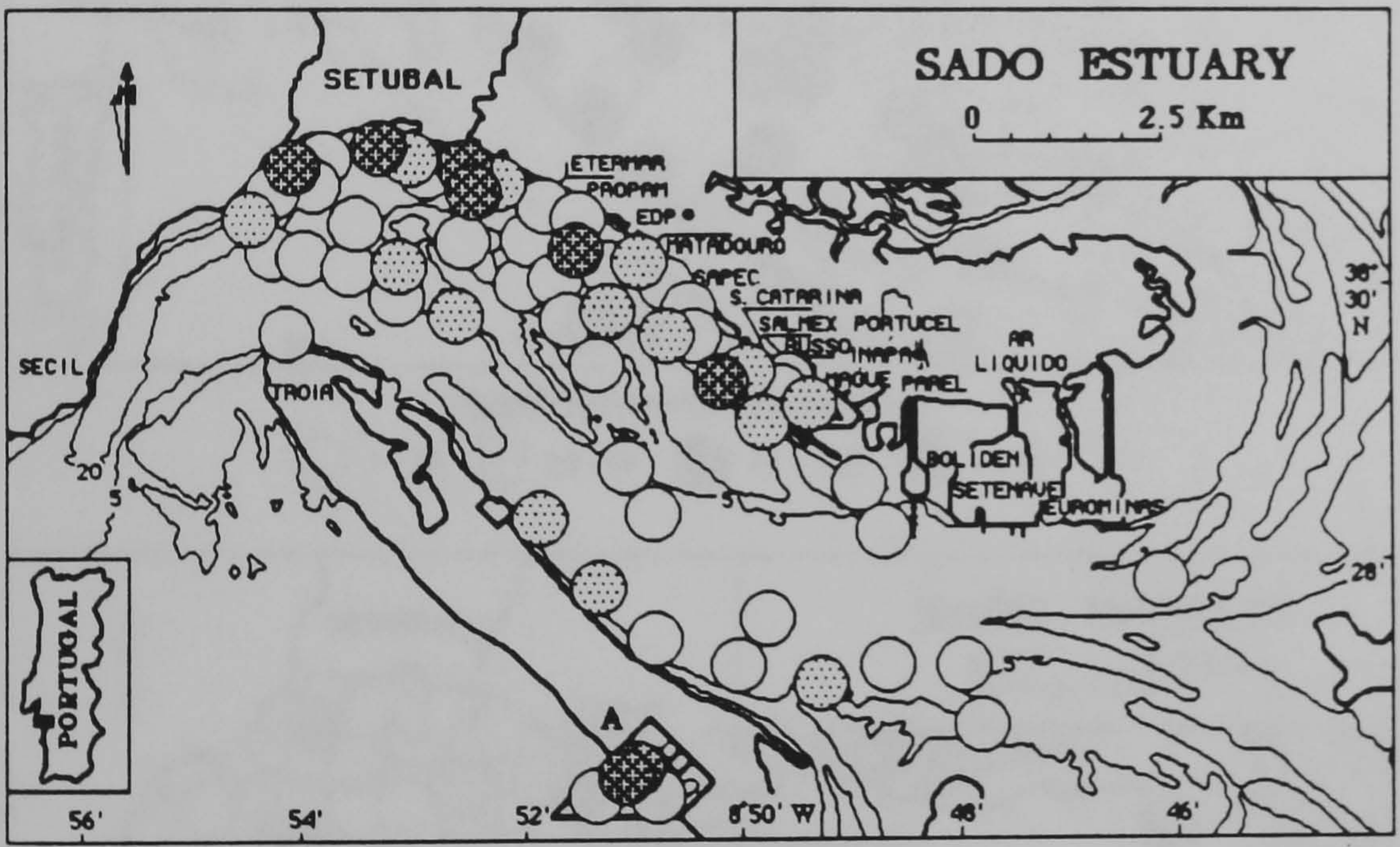
○ 1 - 10 ◌ 11 - 40 ▩ 41 - 160 ● > 160

Figure 5.9 - Sado Estuary. Spatial distribution and local density (ind./0.1m^2) of *Malacocerus fuliginosus*, *Capitella capitata* and *Tubificoides benedeni*.



Aonides oxycephala

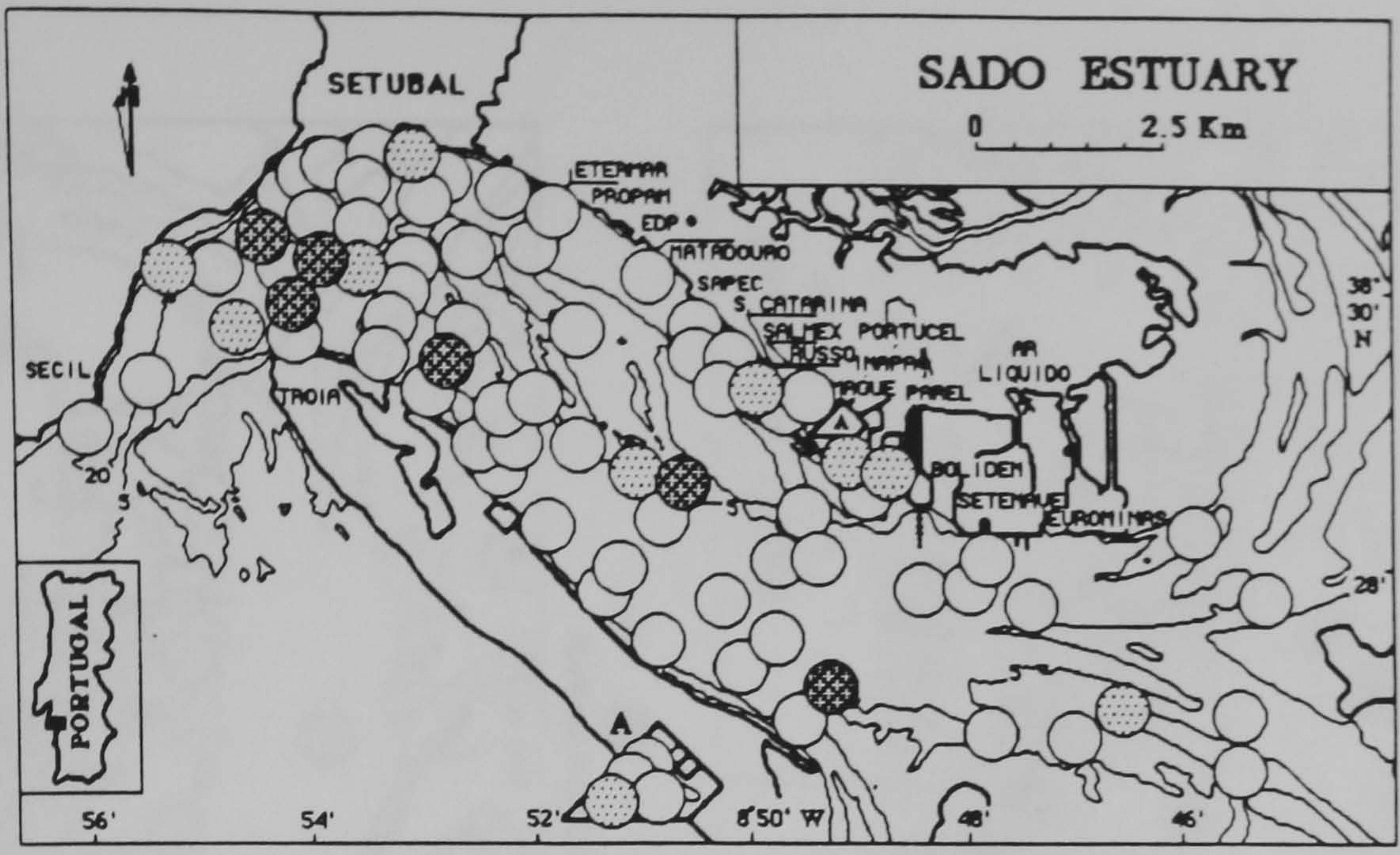
○ 1 - 25 ◌ 26 - 50 ▩ 51 - 100 ● >100



Melinna palmata

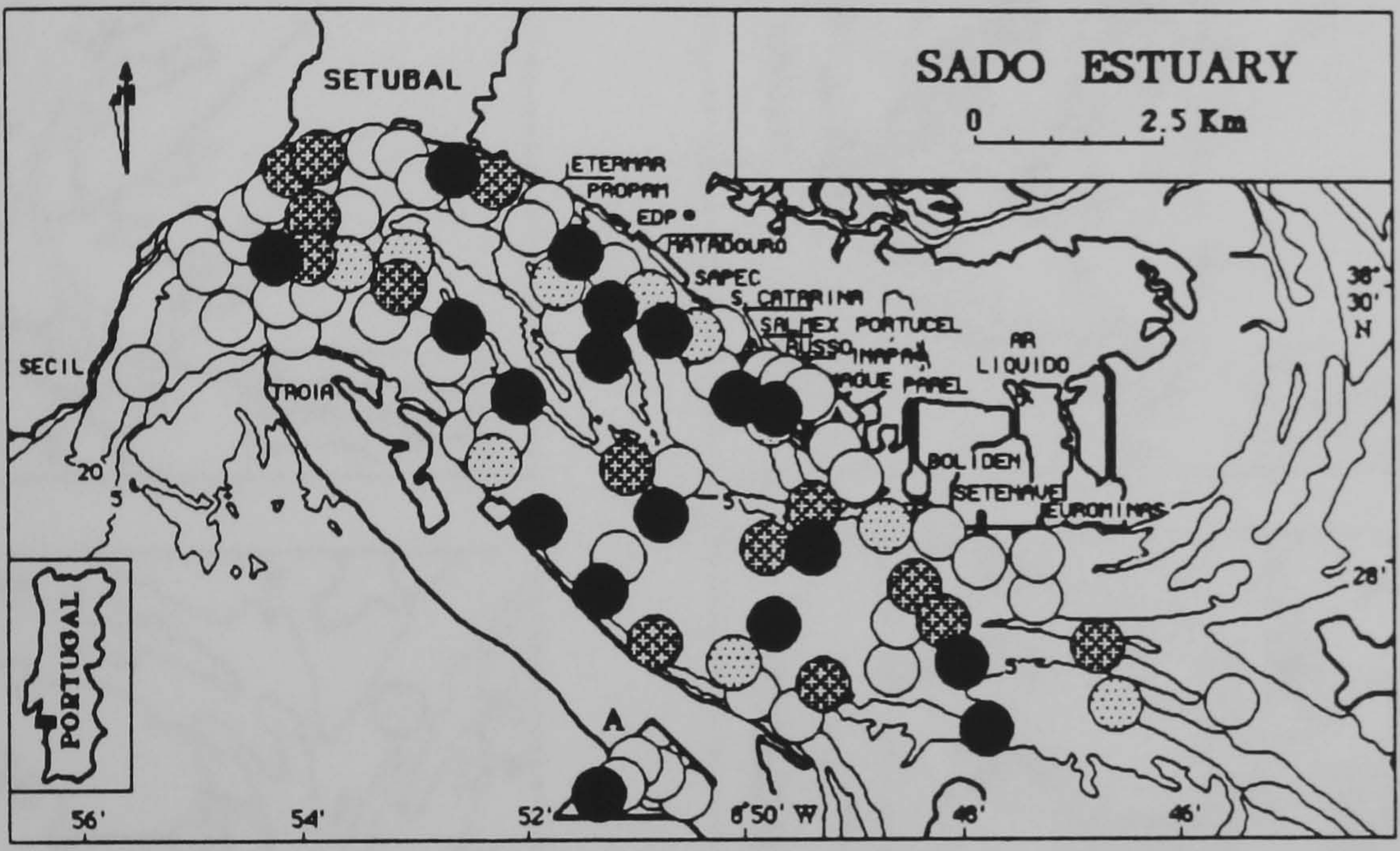
○ 1 - 20 ◌ 21 - 60 ▩ > 60

Figure 5.10- Sado Estuary. Spatial distribution and local density (ind./0.1m^2) of *Aonides oxycephala* and *Melinna palmata.*



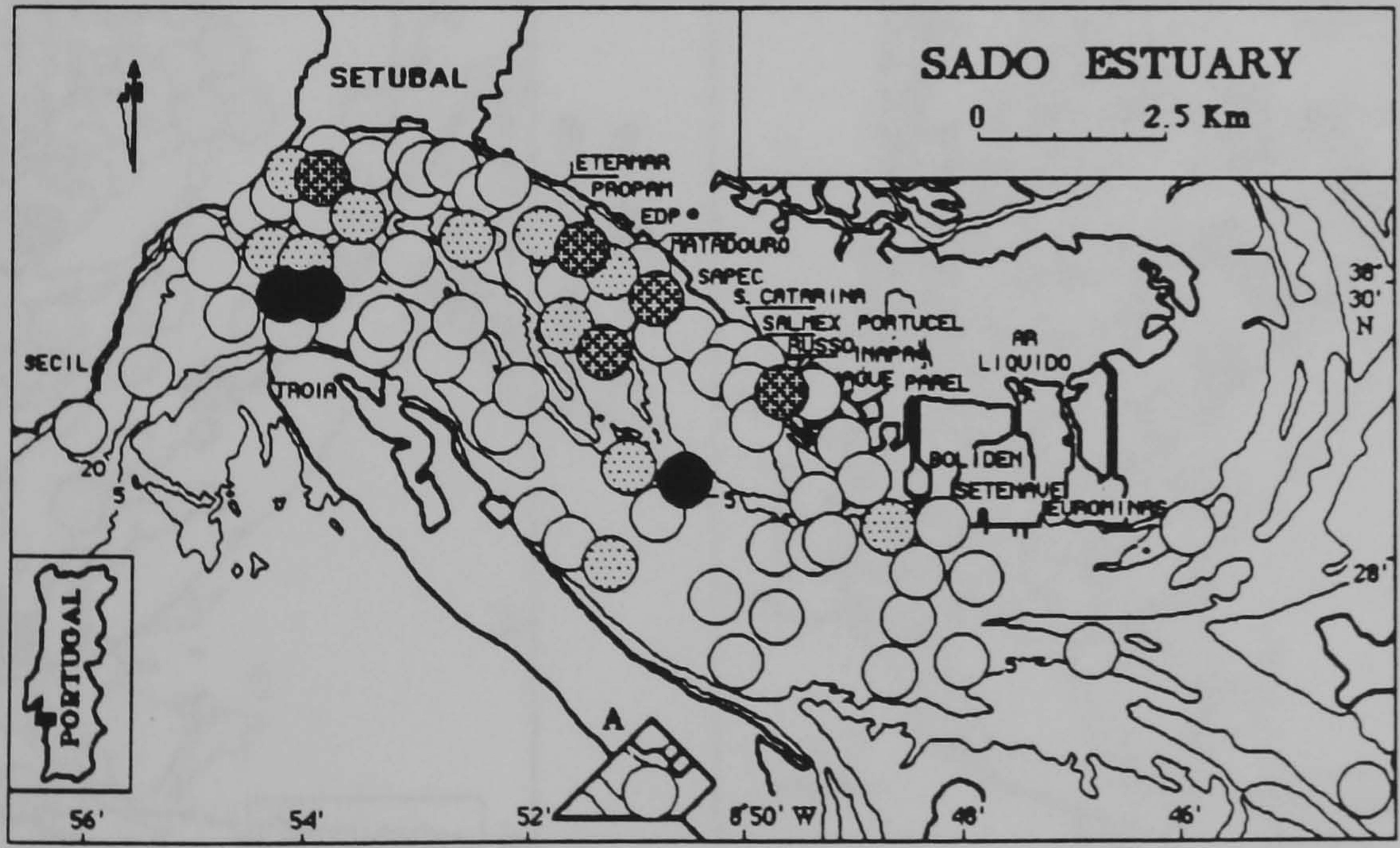
Glycera tridactyla

○ 1 - 5 ▨ 6 - 10 ▩ > 10



Spiochaetopterus costarum

○ 1 - 25 ▨ 26 - 50 ▩ 51 - 100 ● > 100



Polydora caeca

○ 1 - 10 ▨ 11 - 20 ▩ 21 - 60 ● > 60

Figure 5.11 - Sado Estuary. Spatial distribution and local density (ind./0.1m^2) of *Glycera tridactyla*, *Spiochaetopterus costarum* and *Polydora caeca*.

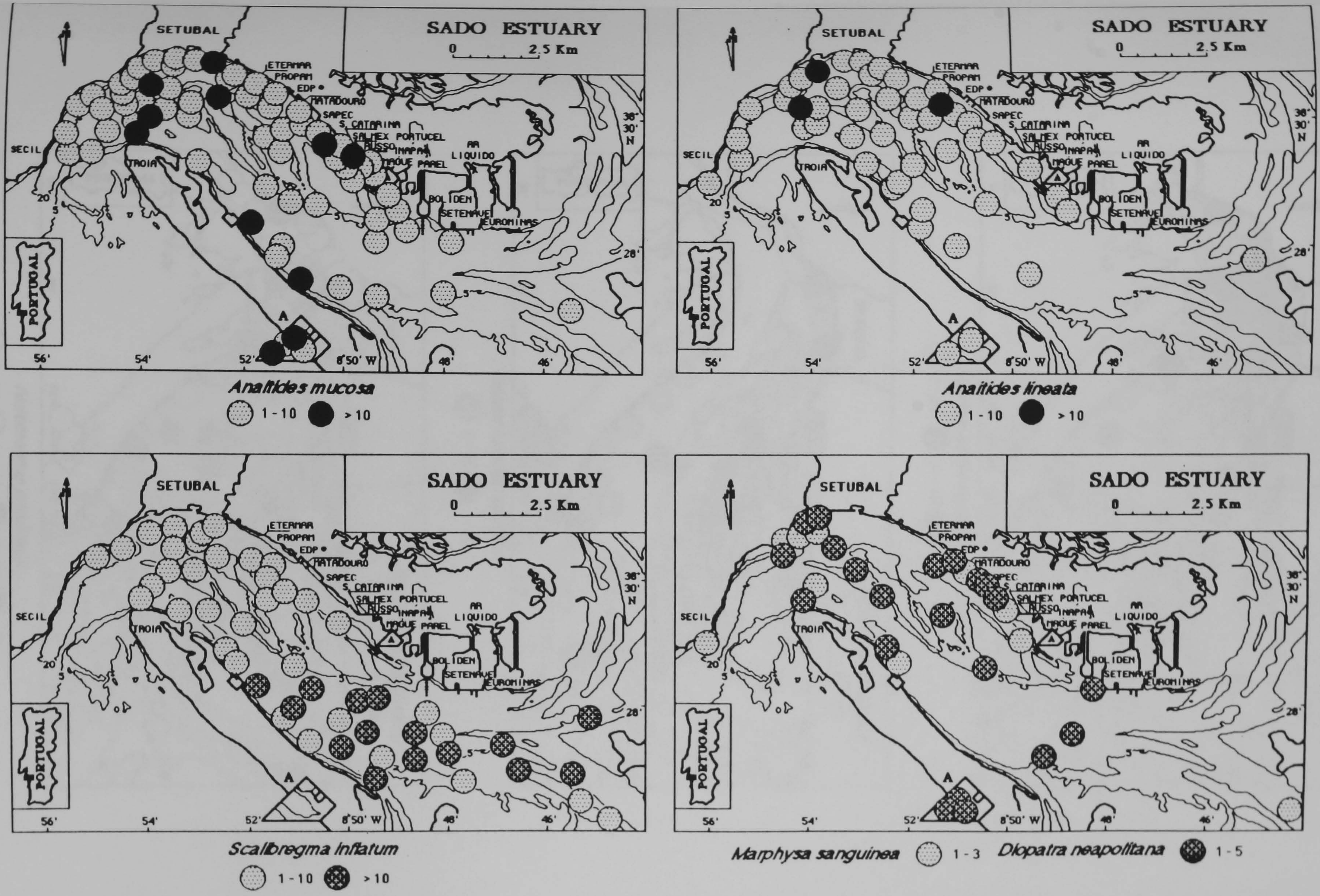
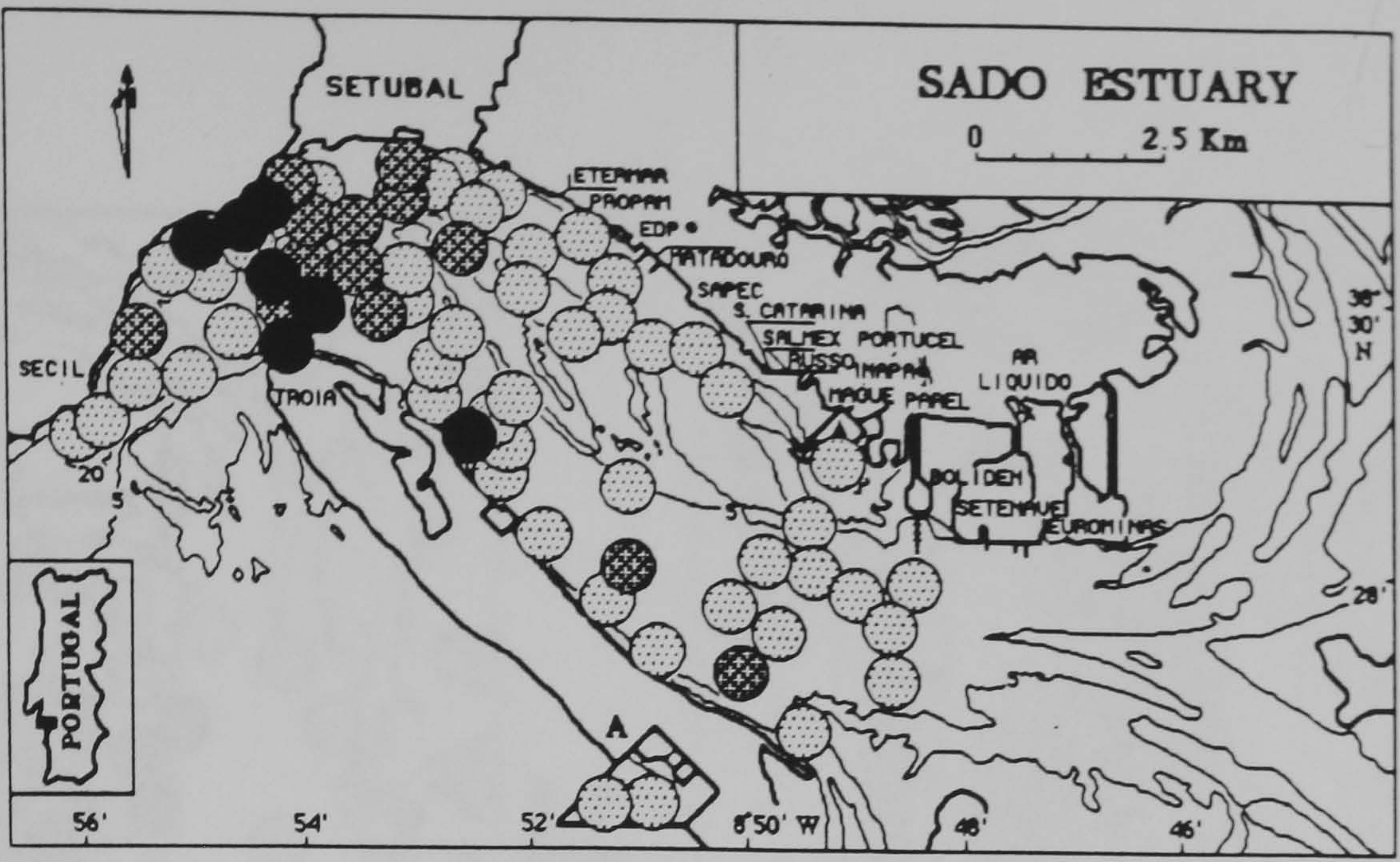
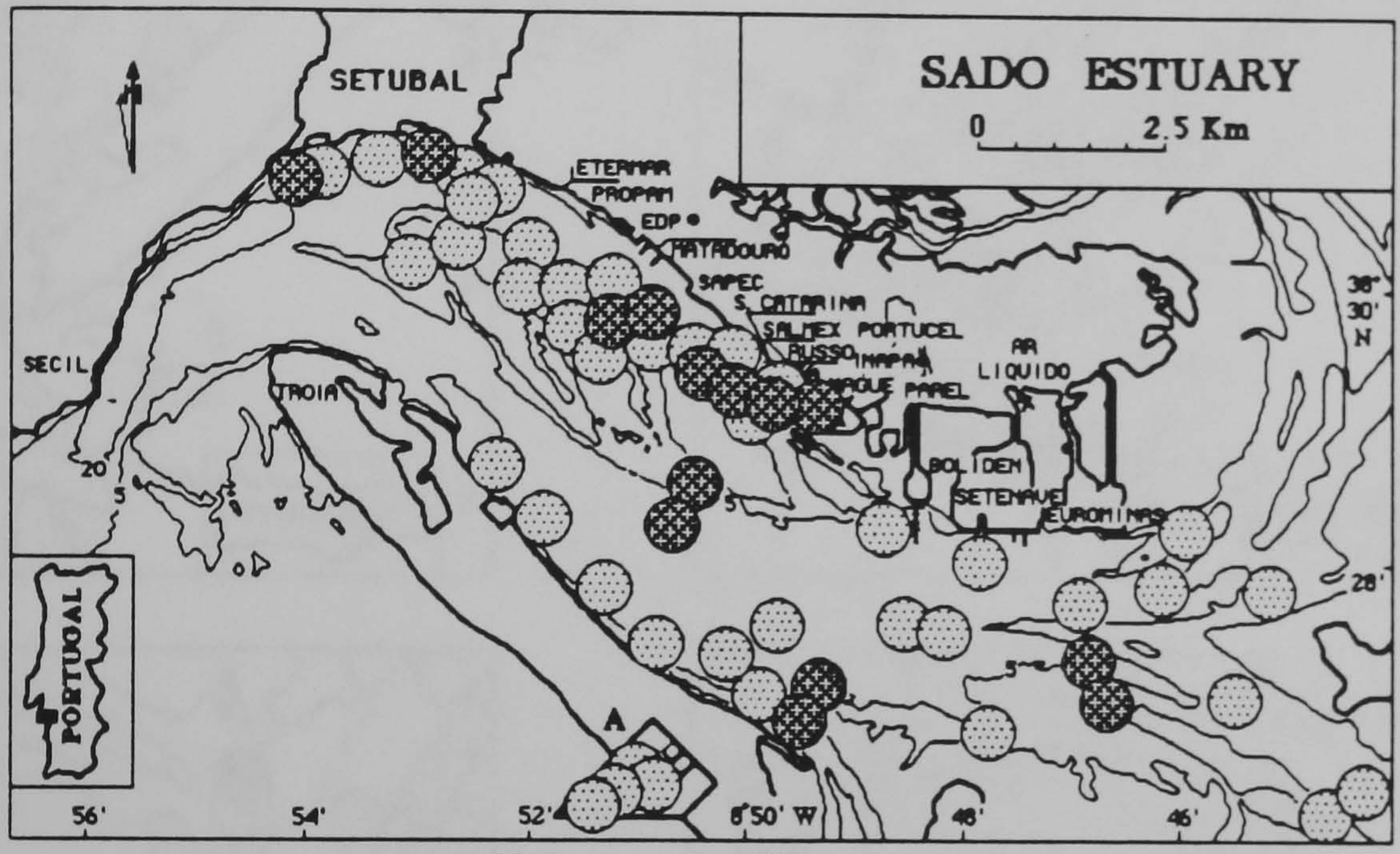


Figure 5.12 - Sado Estuary. Spatial distribution and local density (ind./$0.1m^2$) of *Anaitides mucosa*, *Anaitides lineata*, *Scalibregma inflatum*, *Marphysa sanguinea* and *Diopatra neapolitana*.



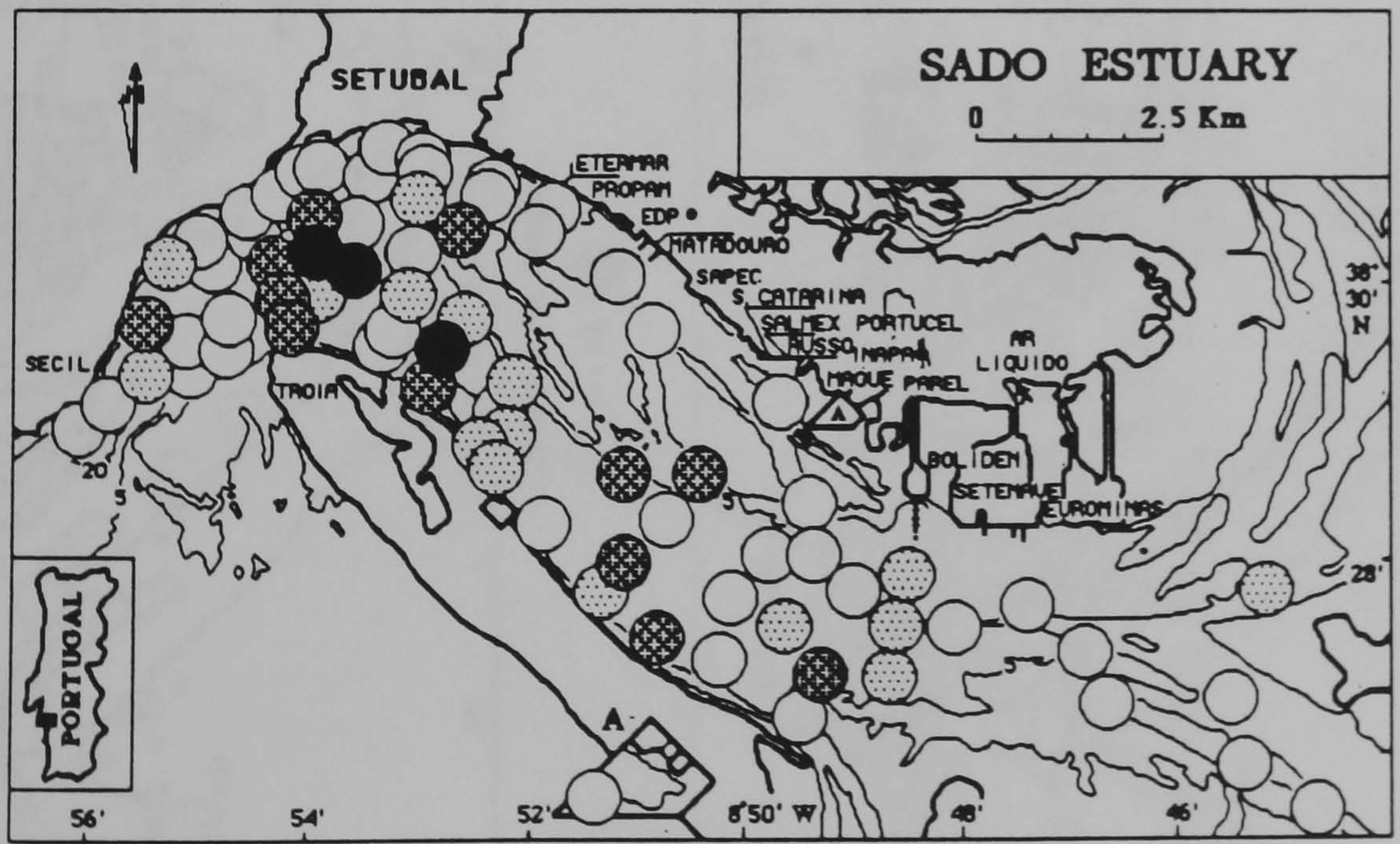
Mediomastus capensis

○ 1 - 20 ▨ 21 - 60 ● > 60



Heteromastus filiformis

○ 1 - 10 ▨ > 10



Notomastus latericeus

○ 1 - 10 ○ 11 - 25 ▨ 26 - 50 ● > 50

Figure 5.13 - Sado Estuary. Spatial distribution and local density (ind./0.1m^2) of the Capitellids, *Mediomastus capensis*, *Heteromastus filiformis* and *Notomastus latericeus*.

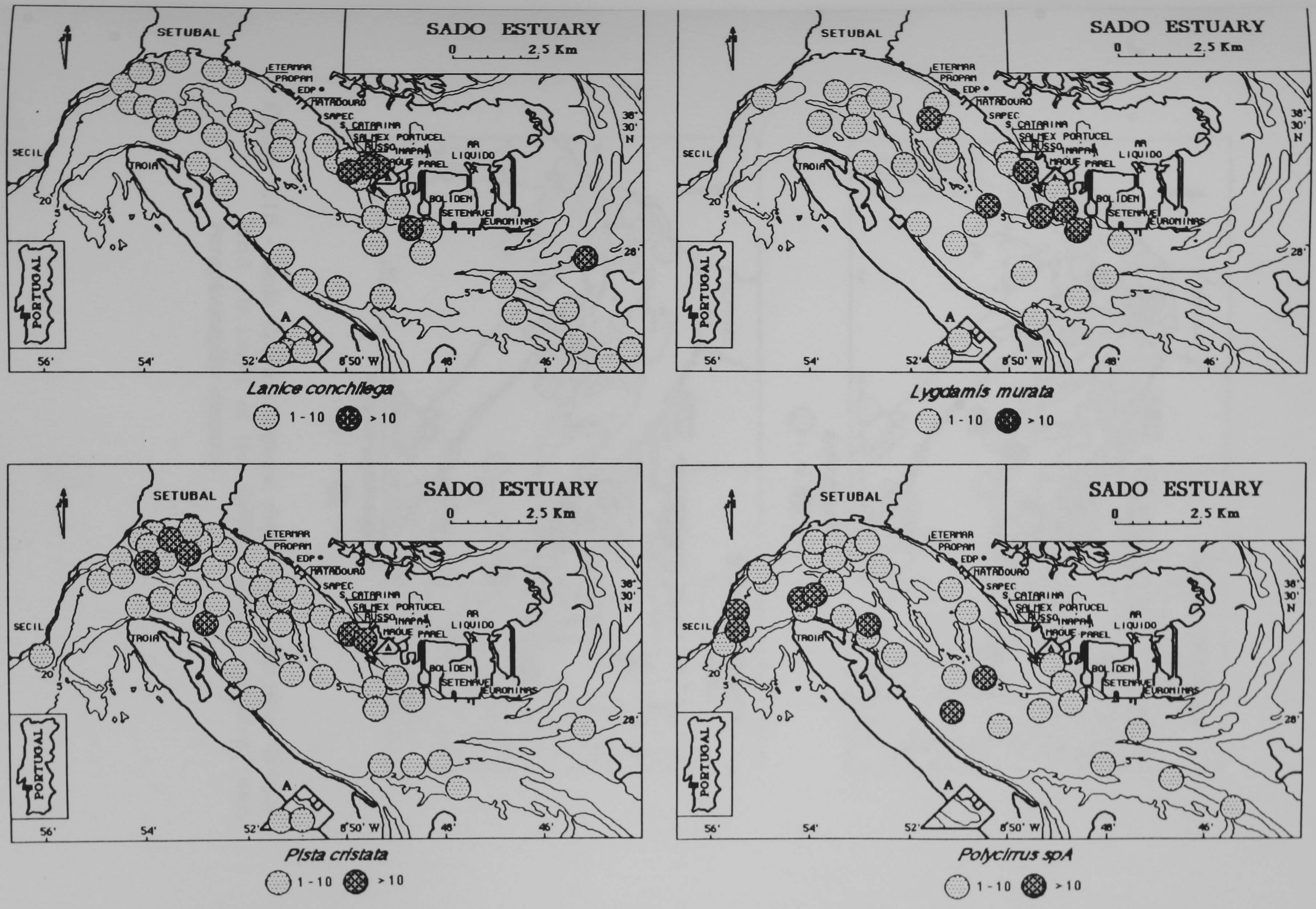
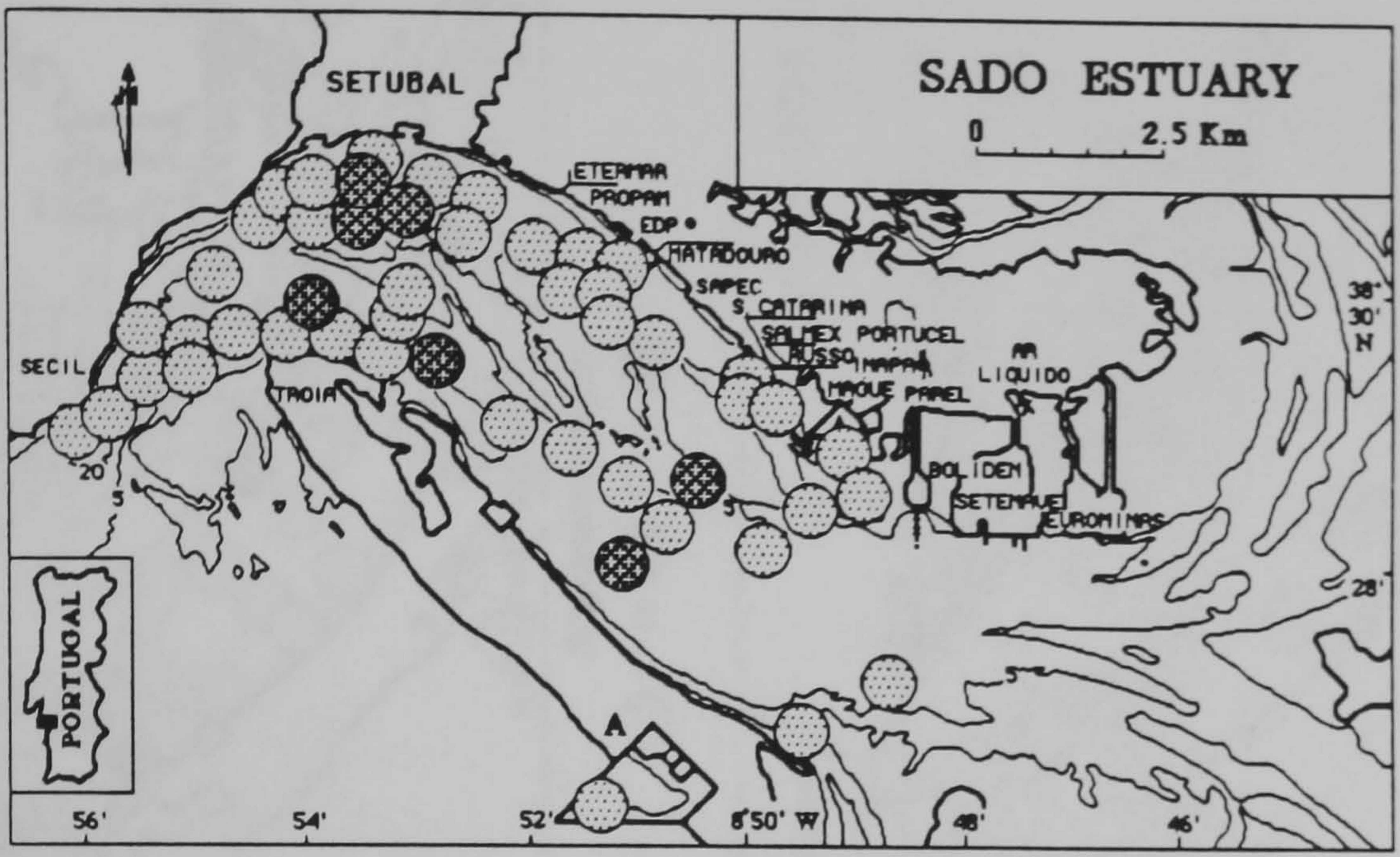
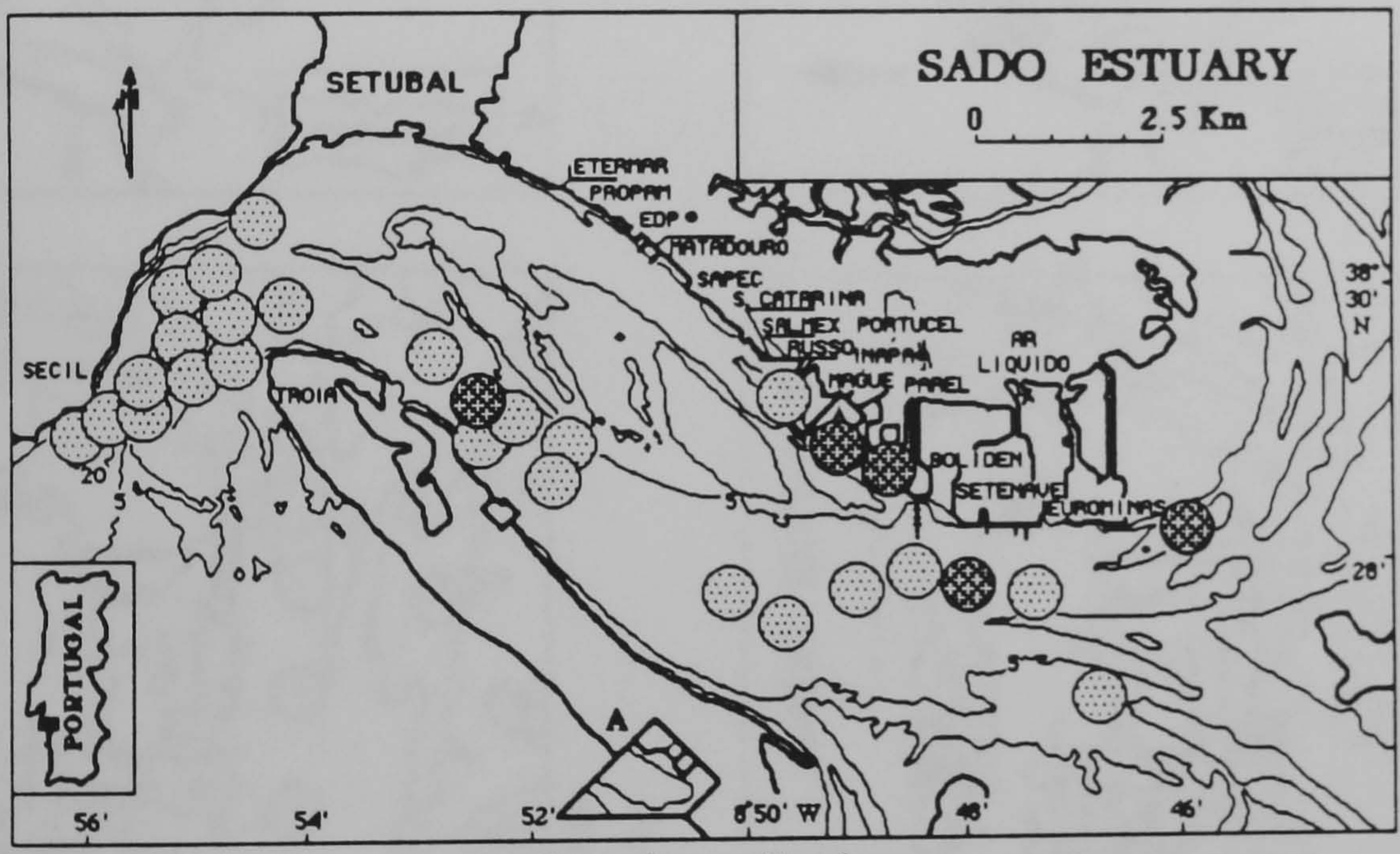


Figure 5.14 - Sado Estuary. Spatial distribution and local density (ind./$0.1m^2$) of *Lanice conchilega*, *Lygdamis murata*, *Pista cristata*, and *Polycirrus* spA.



Syllis hyalina

○ 1 - 10 ● >10



Parapionosyllis elegans

○ 1 - 10 ● >10

Figure 5.15 - Sado Estuary. Spatial distribution and local density (ind./0.1m^2) of the Syllids, *Syllis hyalina*, and *Parapionosyllis elegans*.

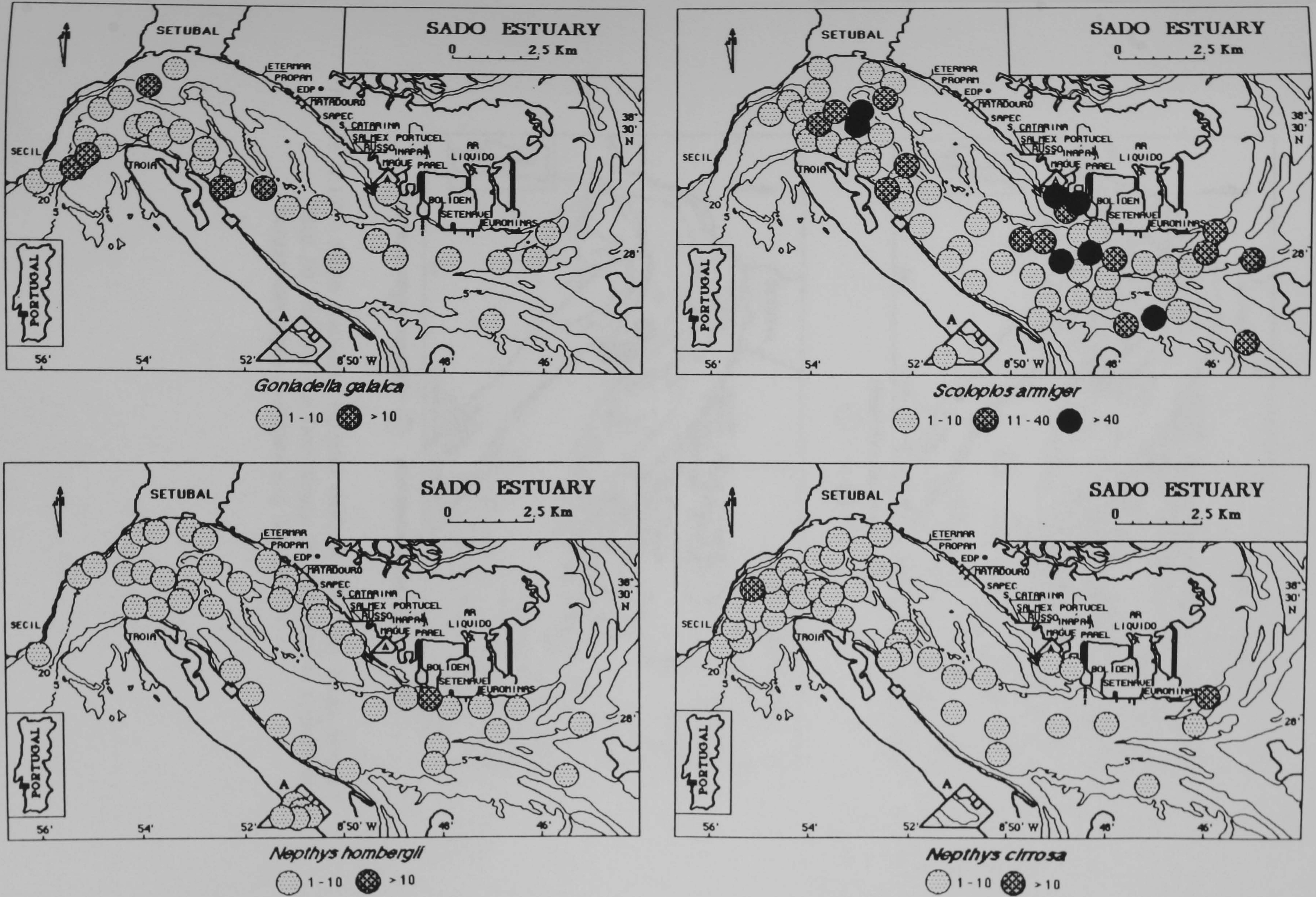
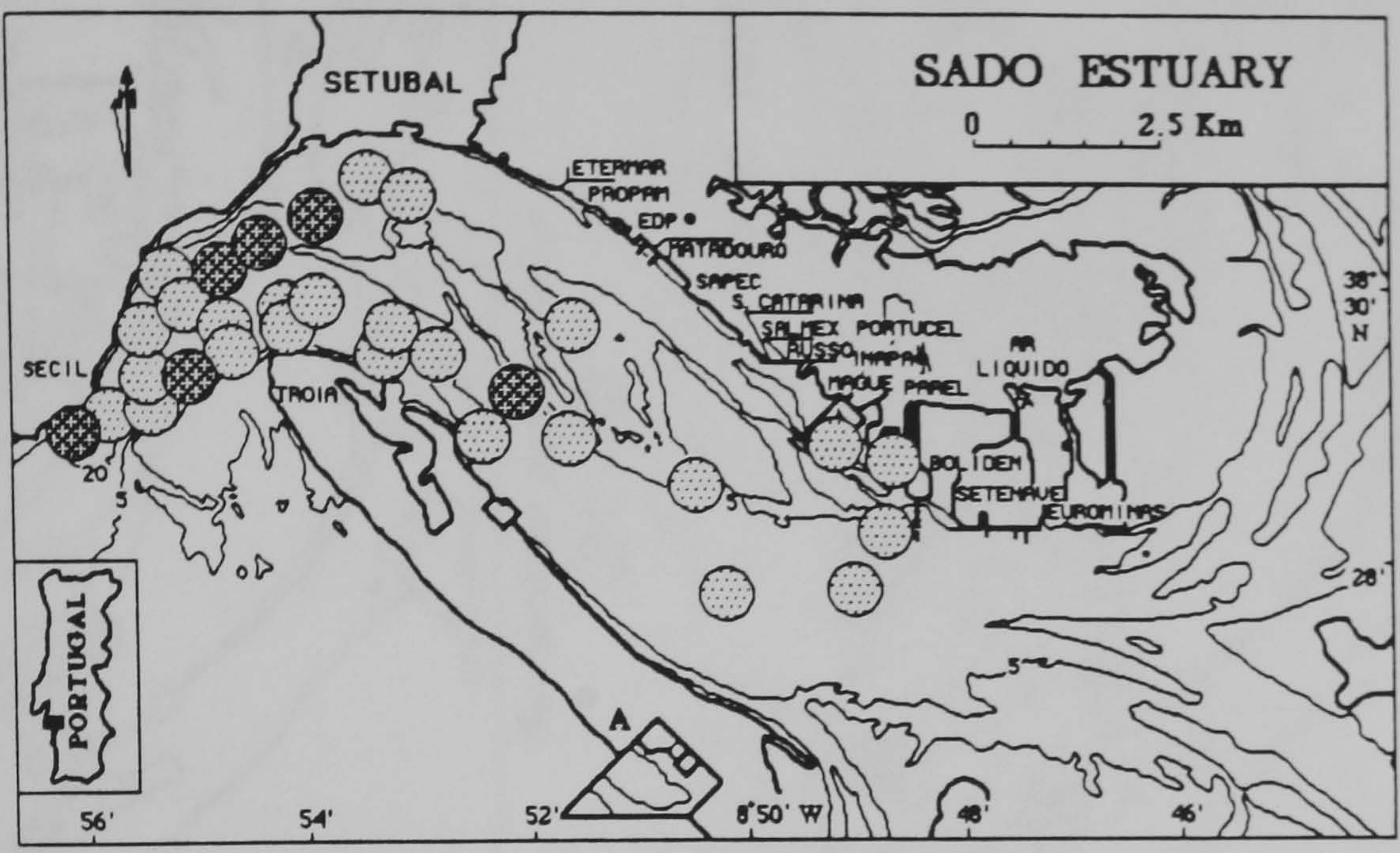
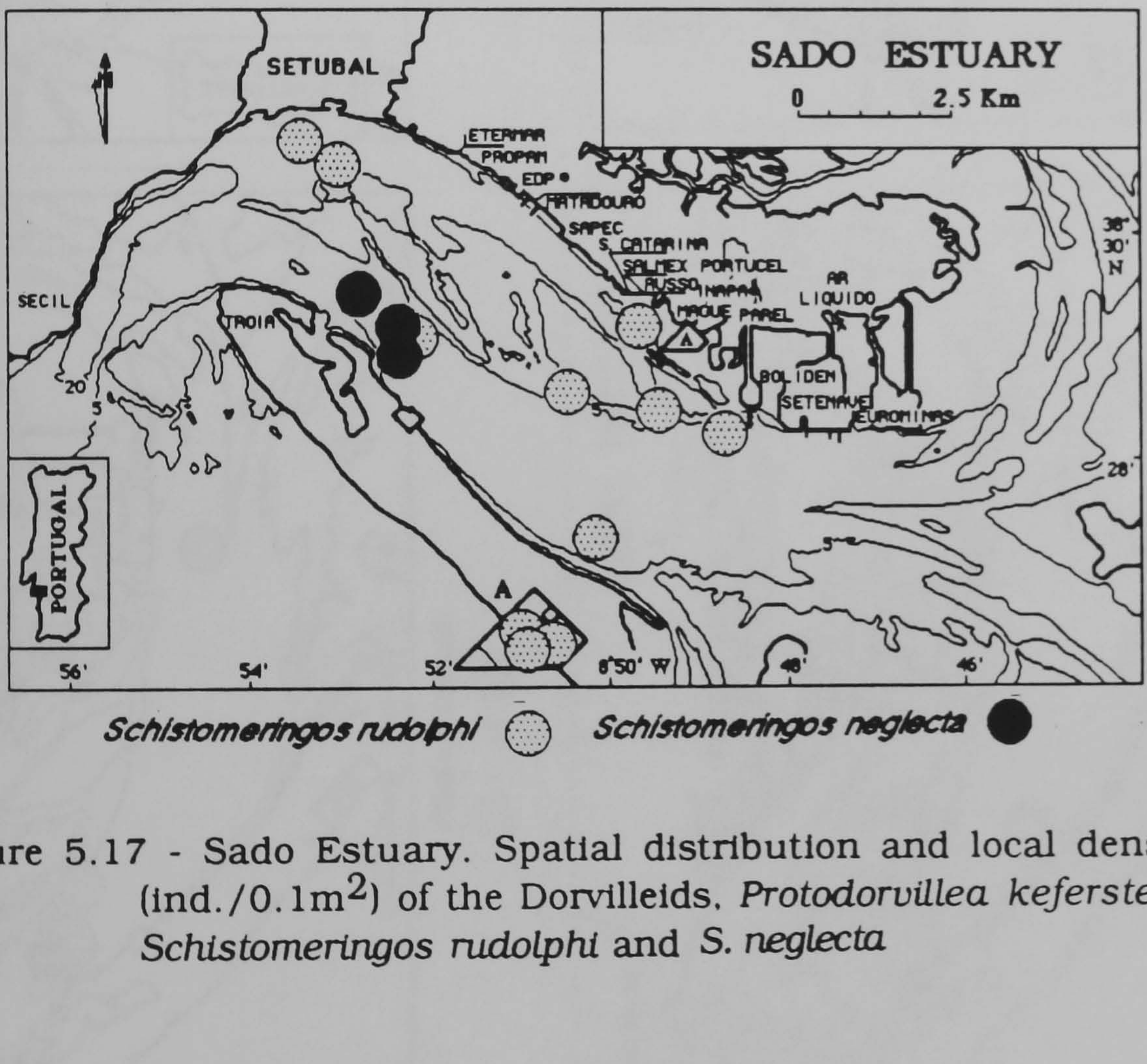


Figure 5.16 - Sado Estuary. Spatial distribution and local density (ind./0.1m^2) of *Goniadella galaica*, *Scoloplos armiger*, *Nephtys hombergii* and *Nephtys cirrosa*.



Protodorvillea kefersteini

○ 1 - 10 ● >10



Schistomeringos rudolphi ○ *Schistomeringos neglecta* ●

Figure 5.17 - Sado Estuary. Spatial distribution and local density (ind./0.1m^2) of the Dorvilleids, *Protodorvillea kefersteini*, *Schistomeringos rudolphi* and *S. neglecta*

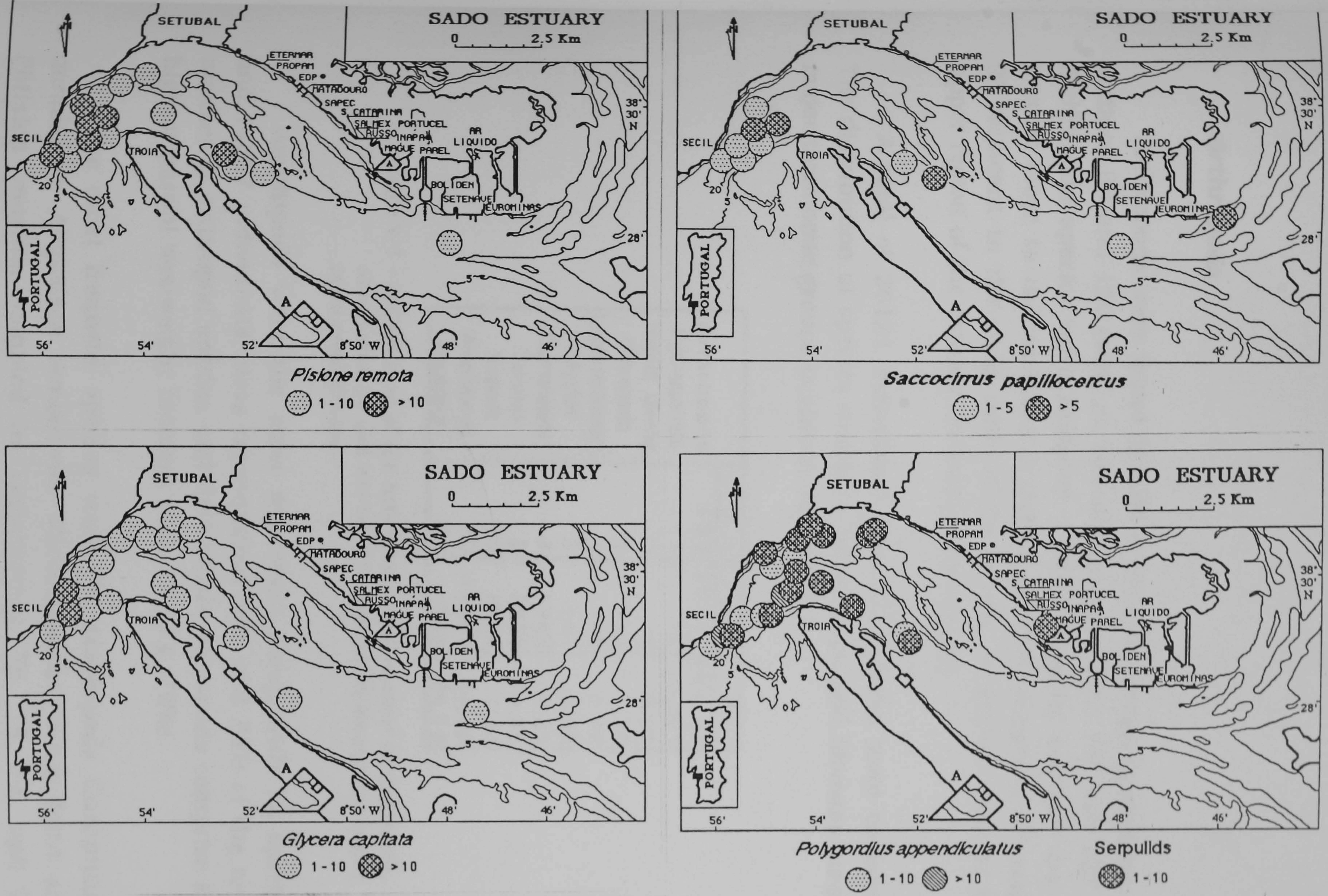


Figure 5.18 - Sado Estuary. Spatial distribution and local density (ind./0.1m^2) of *Pisione remota, Saccocirrus papillocercus, Glycera capitata* and *Polygordius appendiculatus.*

Arthropods

Arthropods were found in 128 of the 133 sampling stations. At stations 95 and 120 (with no macrofauna) and 121, 126 and 127 no Arthropoda species were sampled. These sampling stations are all located close to the northern margin and with exception of station 95 adjacent to the pulp mill, all lie in the innermost part of the upper region of the estuary, in front of Eurominas.

A total of 20121 individuals and 123 species were collected. The distribution of species numbers, abundance and biomass among major taxonomic groups is shown in table V.7.

	S	A	B
Arthropods	**123**	**20121**	**104.48**
Pycnogonids	1	2	0.001
Insect larvae	1	5	0.01
Ostracods	3	313	1.10
Leptostraceans	1	9	0.02
Mysids	2	147	0.83
Cumaceans	4	1365	1.23
Tanaids	3	2174	4.59
Isopods	13	1046	7.49
Amphipods	72	14897	14.02
Decapods	23	163	75.19

Table V.7 - Distribution of the Arthropods total number of species (S), abundance (A) and wet-weight Biomass (B) among the major taxonomic groups.

Amphipods were the most important group with 72 species and 14897 individuals, thus representing 59% and 74% of the total number of arthropod species and individuals. Decapods comprise the highest partial wet-weight biomass with 75.19 g (72%).

The most frequent species were the amphipods *Corophium annulatum*, *Ampelisca tenuicornis*, *Microdeutopus versiculatus* and *Phtisica marina*, sampled in, respectively, 88, 74, 54, and 60 locations. The cumacean *Iphinöe tenella* occured at 84 stations and the isopod *Cyathura carinata* was present in 63 sampling stations. Approximately 67% of the arthropod species identified in the estuary showed a sampling frequency of ≤ 10% (present in no more than 13 stations). Twenty six species were collected only once and 14 twice.

Analysis of total abundances, shows the species *Corophium annulatum, Photis longipes, Pariambus typicus, Iphinöe tenella, Ampelisca tenuicornis* and *Apseudes latreilli*, to have the highest values, with, respectively, 2611, 2417, 2014, 1335, 1323 and 1282 individuals. They comprise 48% of the total arthropod abundance.

A total of 55 species (45%) were represented by 10 or less individuals.

Only one species was collected with a total wet-weight biomass higher than 10.0 g. This species, *Upogebia cf. typica*, contributed 52.8 g, corresponding alone to 50.5% of total arthropod biomass.

Arthropod total species richness, abundance and wet-weight biomass distribution per sampling station generally shows a close relationship to the spatial pattern derived from total macrofauna data. Arthropod total species richness and total abundance, however, tend to distinguish part of the entrance region and the northern channel (with the exception of sampling stations close to the margin), characterized by the highest values. Total wet-weight biomass pattern differs and shows some of the highest values in the southern channel and inner estuary, which is a significant difference in relation to the pattern obtained with total macrofauna data. This particular distribution shown by arthropod biomass results mainly from the preferential spatial distribution of *Upogebia cf. typica*, in the innermost part of the southern channel and upper region (figure 5.19).

The distribution and local density of Arthropods varies from species to species. As with the Annelids, some Arthropods are confined to particular areas and many have higher densities along the northern channel. This is the case with the anthurid *Cyathura carinata*, the cumacean *Iphinöe tenella* (figure 5.20) and the tanaid *Apseudes talpa* (figure 5.21). Nevertheless the two latter species also have high densities in the region between the entrance and the beginning of the intertidal sandbanks. The cumaceans *Bodotria scorpioides* and *Diastylis rugosa* (*cf.* figure 5.20) are mainly confined to the intermediate region, but the former is also found along the northern channel. Neither species was found in the southern channel. The tanaid *Apseudes latreilli* (figure 5.21) tends mainly to settle in the outer region of the estuary and at locations along the southern margin. All these species tend to be rare in the vicinity of the entrance, and in the upper region of the estuary with the exception of *Apseudes latreilli*.

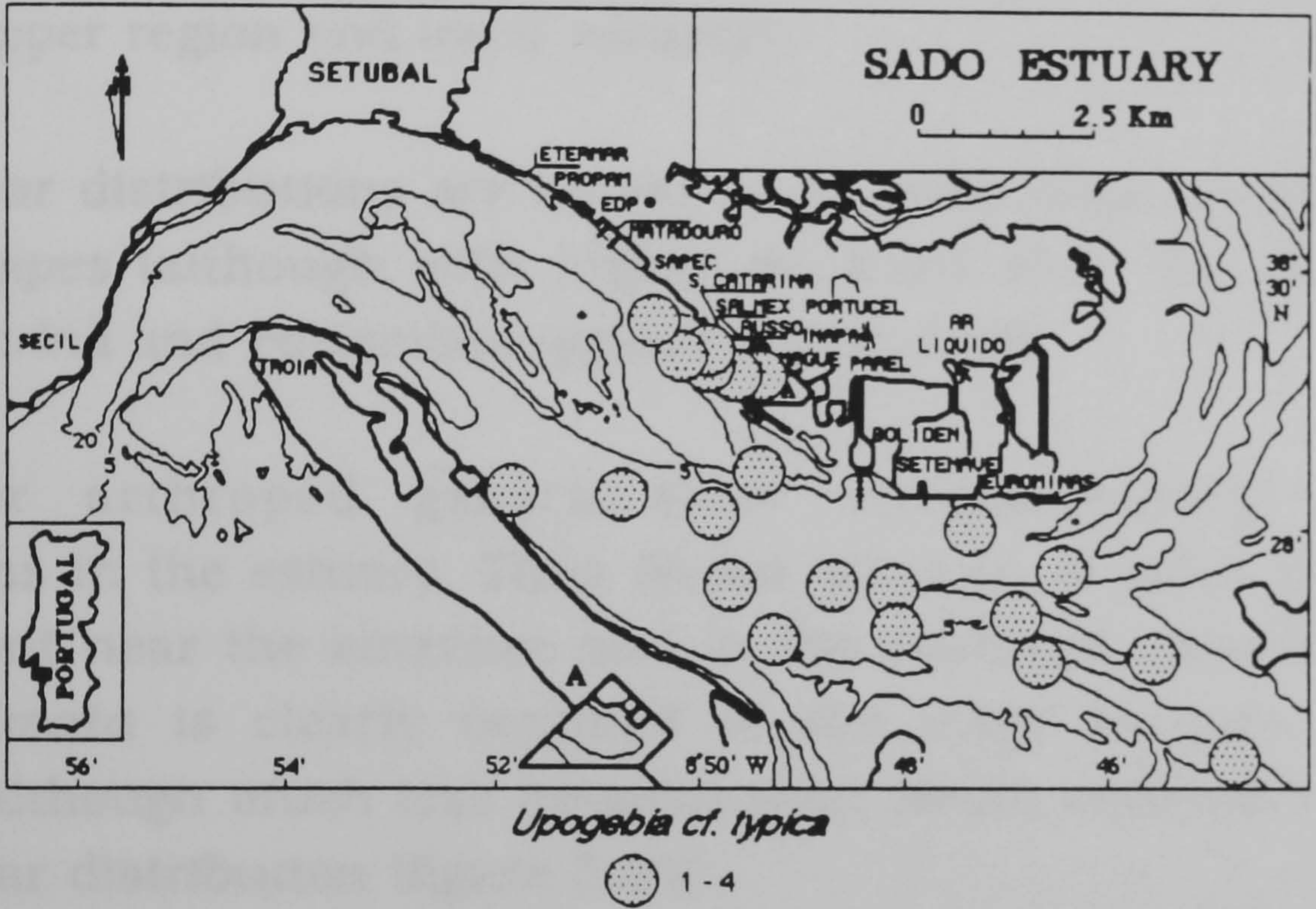


Figure 5.19- Sado Estuary. Spatial distribution and local density (ind./0.1m^2) of *Upogebia cf. typica*.

The amphipod *Corophium annulatum* is generally distributed throughout the estuary but has its highest densities in the intermediate area and on the edges of the sandbanks (figure 5.22). Other *Corophium* species, namely *Corophium runcicorne*, and *Corophium sextonae* are also widely distributed (figure 5.22) but *Corophium runcicorne* is almost absent near the entrance and in the northern channel, while *Corophium sextonae* is more frequent in this channel, though occurring in higher densities at occasional stations near the mouth, in the beginning of the northern channel, in the innermost part of the intertidal sandbanks, and the inner estuary. Another *Corophiidae* species *Corophium* "complex" (Rodrigues & Dauvin, 1987) is confined to the upper region and to the inner estuary (figure 5.22). This isolated distribution was confirmed in a later survey conducted during August 1990 in the Marateca channel (inwards of Eurominas) (Rodrigues & Quintino, 1991).

Ampelisca species also show higher frequency and densities in sampling stations along the northern channel (figure 5.23). This is the case with *Ampelisca tenuicornis Ampelisca remora* (absent near the entrance, upper region and inner estuary and very rare in the southern channel), *Ampelisca diadema, Ampelisca brevicornis* and *Ampelisca spinimana* (all almost absent from the entrance, southern channel, upper region and inner estuary).

Similar distributions are shown by *Microdeutopus versiculatus, Photis longipes* (although with higher densities near the entrance), *Phtisica marina* and *Pariambus typicus* (figure 5.24).

Other arthropod genera show complementary species distributions in the estuary. Thus *Melita obtusata* is more abundant and frequent near the entrance and in the southern channel, while *Melita palmata* is clearly confined to the inner estuary. *Melita gladiosa,* although much less frequent than *Melita obtusata* tends to show similar distribution (figure 5.25).

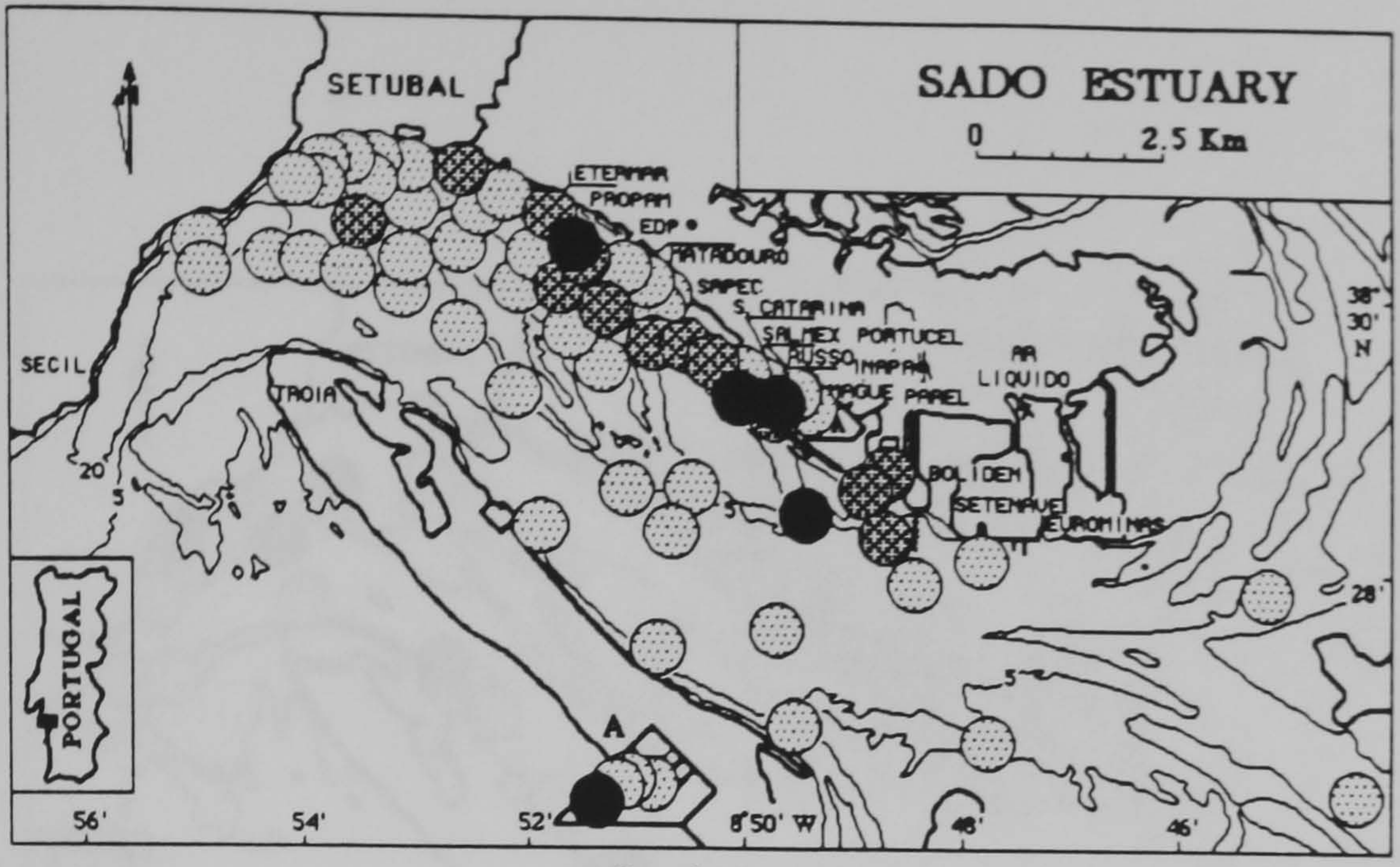
The species *Harpinia antennaria* and *Harpinia laevis,* although relatively rare, tend to settle near the entrance, while *Harpinia pectinata,* which is much more frequent, extends mainly throught the northern channel (figure 5.26). *Atylus vedlomensis* is almost absent inwards of the beginning of the intertidal sandbanks, while *Atylus guttatus* on the contrary is rather rare outwards of these sandbanks (figure 5.27). The mysids *Gastrossaccus spinifer* and *Heteromysis microps* also show these characteristics, with *Gastrossaccus spinifer* more frequent and abundant near the entrance while *Heteromysis microps* occurs at the end of both channels and in the upper region of the estuary (figure 5.27).

A few other species are only very rarely present inwards of the intertidal sandbanks. This is the case of the isopods *Cirolana* sp and *Euridyce pulchra,* of the amphipods *Urothöe brevicornis* and *Maera* *othonis* (figure 5.28). *Urothöe grimaldii, Urothöe elegans* (figure 5.28), *Gammaropsis maculata* and *Gammarela fucicola* (figure 5.29), although being rare in the same regions as the latter species, were also found in some locations in the southern channel (mainly the ones with coarser sediments) and at the entrance to the northern channel (*Gammaropsis maculata* and *Urothöe elegans*).

Finally, the burowing decapod *Upogebia cf. typica*, the largest arthropod collected in the estuary by grab samples, clearly tends to occupy the innermost region of both northern and southern channel, the upper region and the inner estuary (*cf.* figure 5.19).

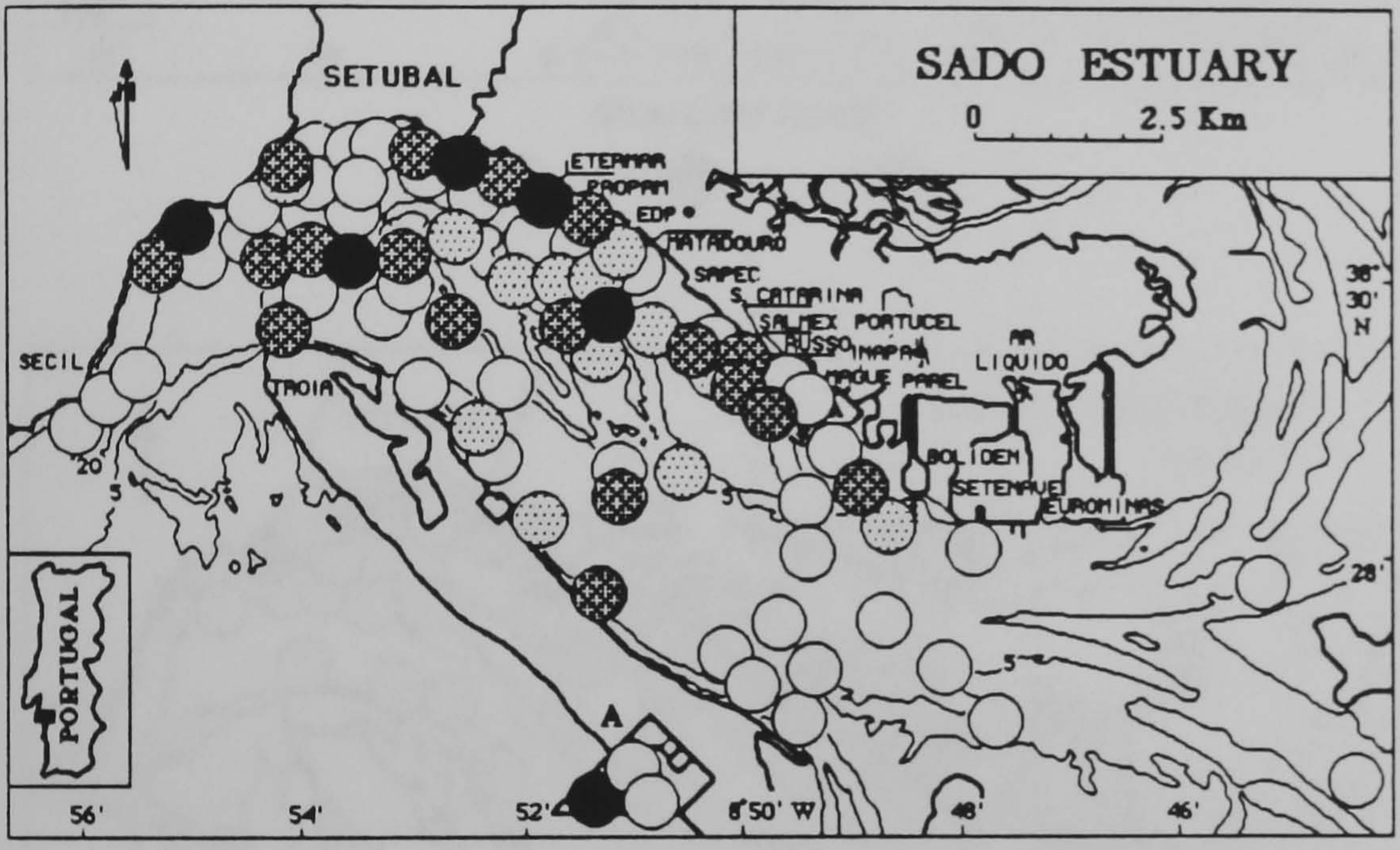
Given the fact that the majority of the arthropod wet-weight biomass was determined through the use of conversion factors, obtained by weighing combined samples of several specimens of a given species from several sampling locations, biomass distribution maps would essentially show the same characteristics as the abundance maps.

For *Upogebia cf. typica* and *Cyathura carinata* specimens, it was possible to measure the separate weight per sampling station, given their individual and/or sample size. Correlation coefficients between abundance and wet-weight biomass for these two species are respectively 0.74 and 0.998, both significantly different from zero at $p<<0.001$, thus suggesting that these species also present very similar abundance and biomass spatial patterns.



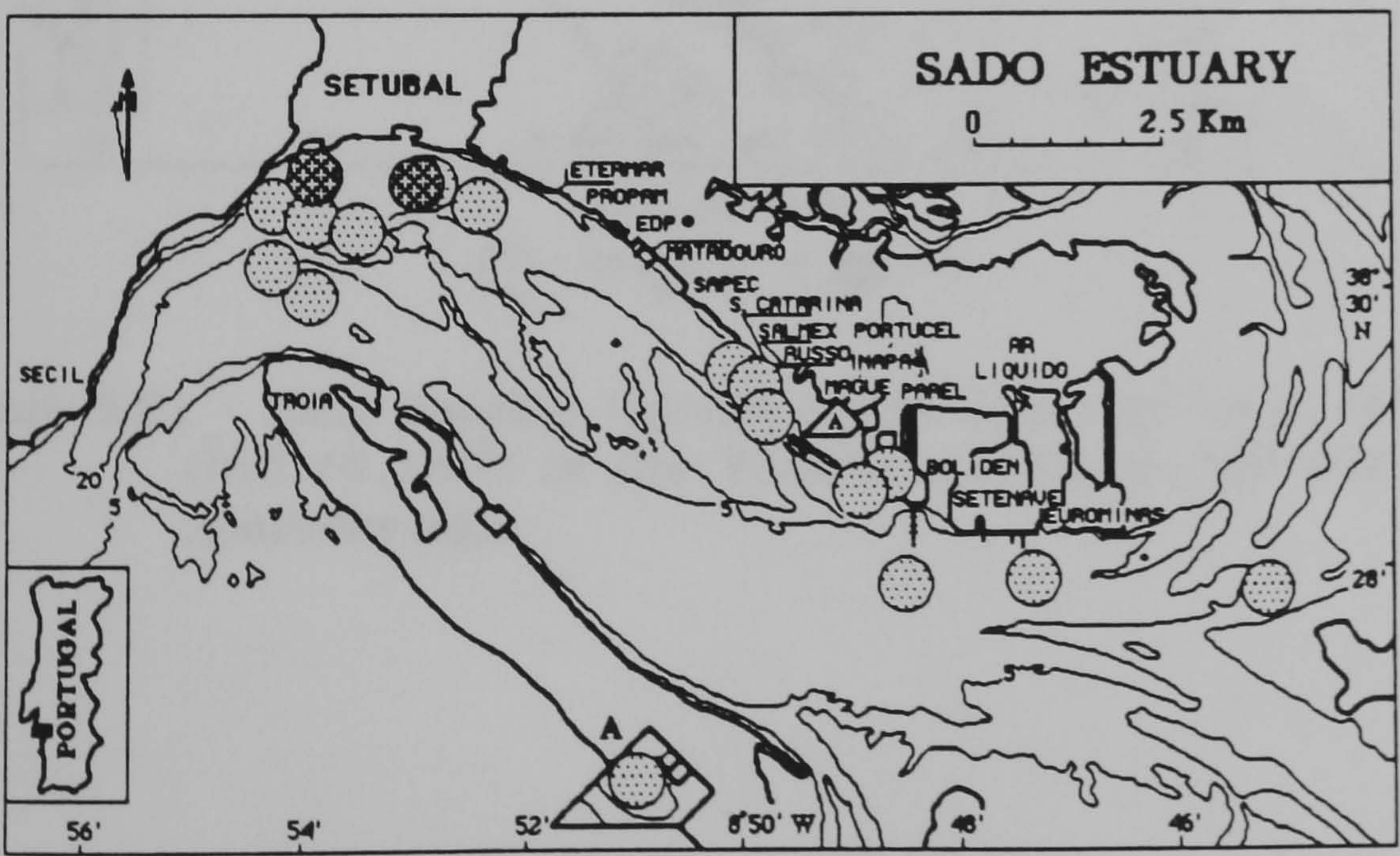
Cyathura carinata

◌ 1 - 20 ▨ 21 - 40 ● > 40



Iphinöe tenella

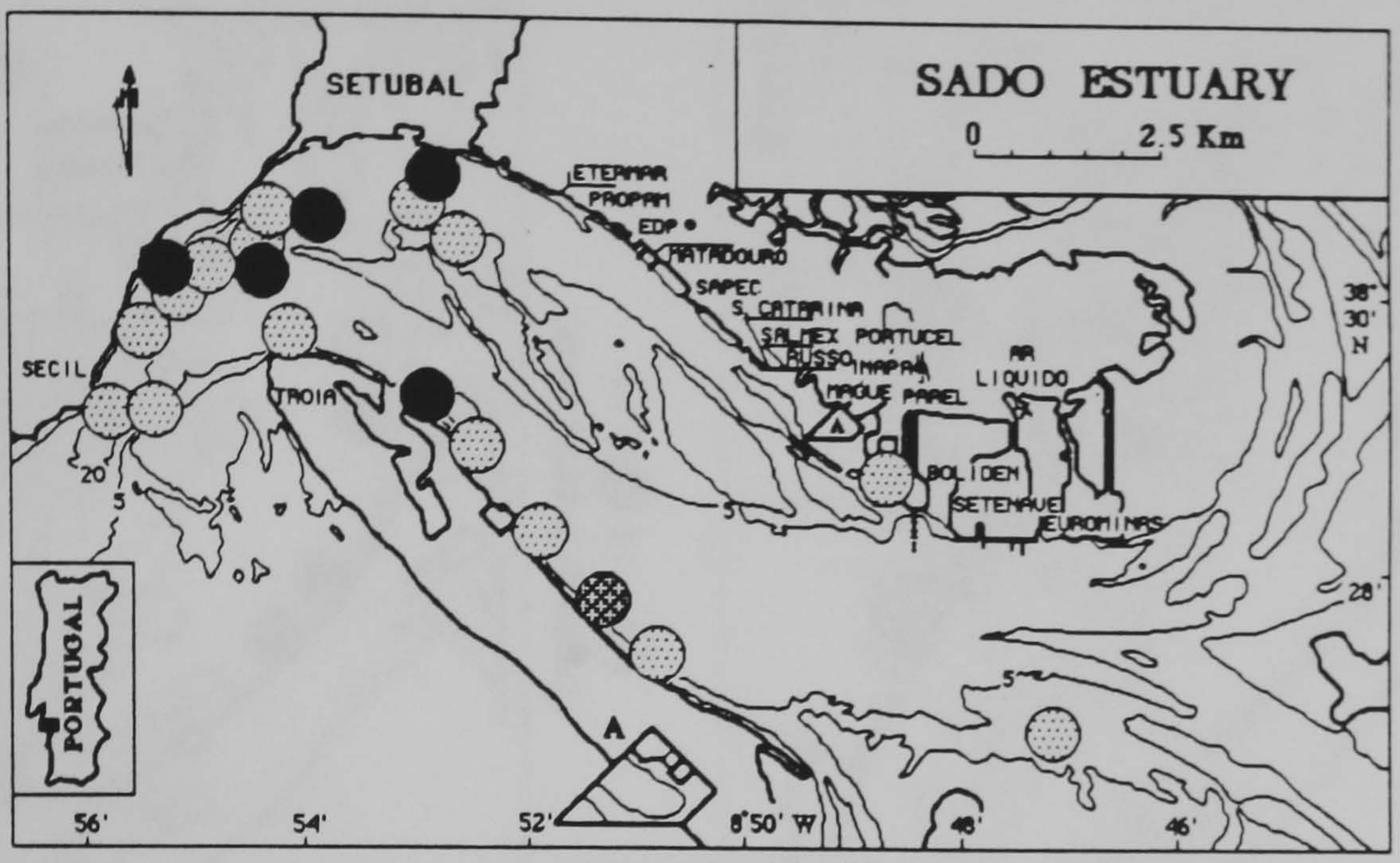
○ 1 - 10 ◌ 11 - 20 ▨ 21 - 40 ● > 40



Diastylis rugosa *Bodotria scorpioides*

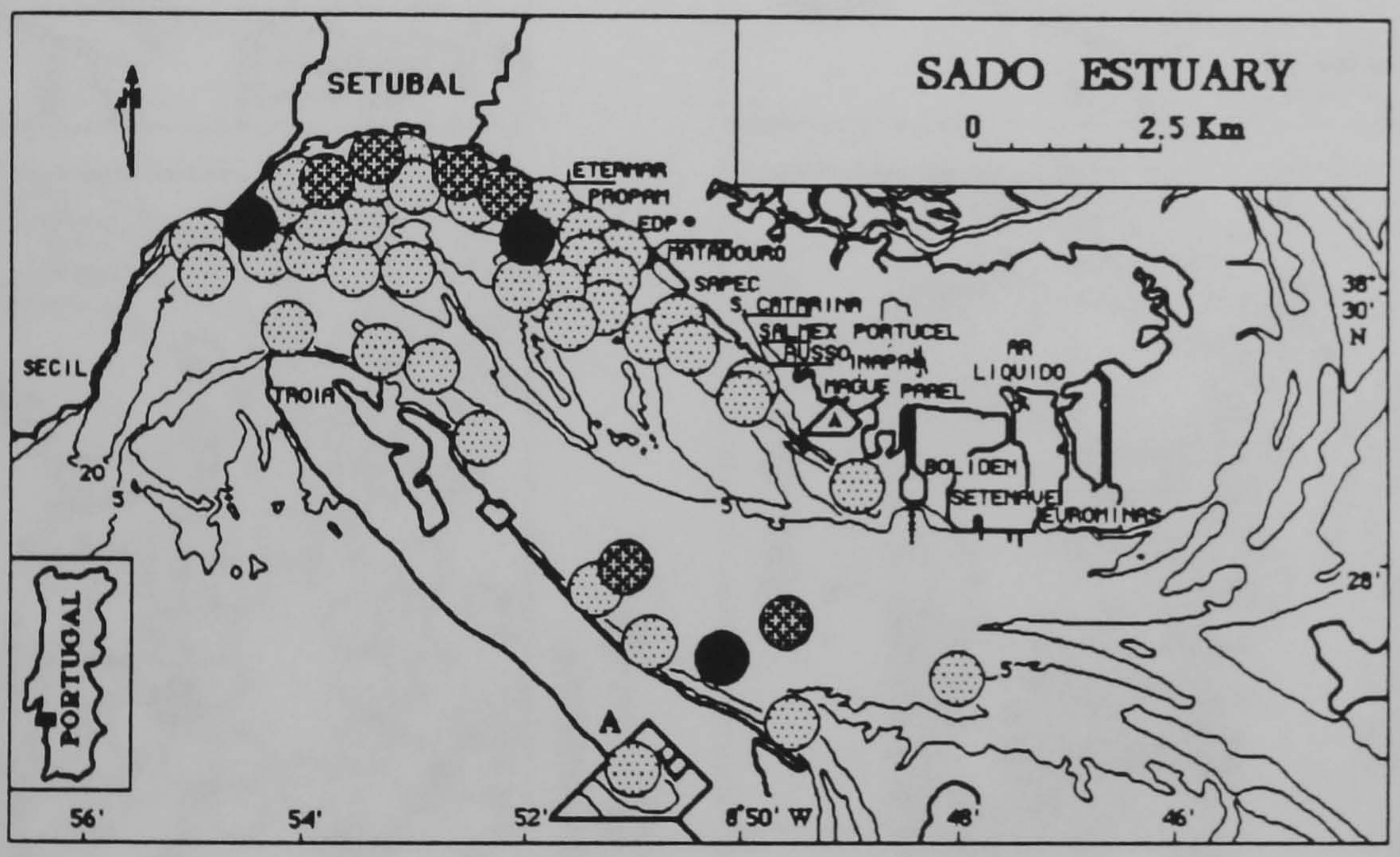
◌ 1 ▨ 1 - 4

Figure 5.20 - Sado Estuary. Spatial distribution and local density (ind./0.1m^2) of *Cyathura carinata*, *Iphinöe tenella*, *Diastylis rugosa* and *Bodotria scorpioides*.



Apseudes latreilli

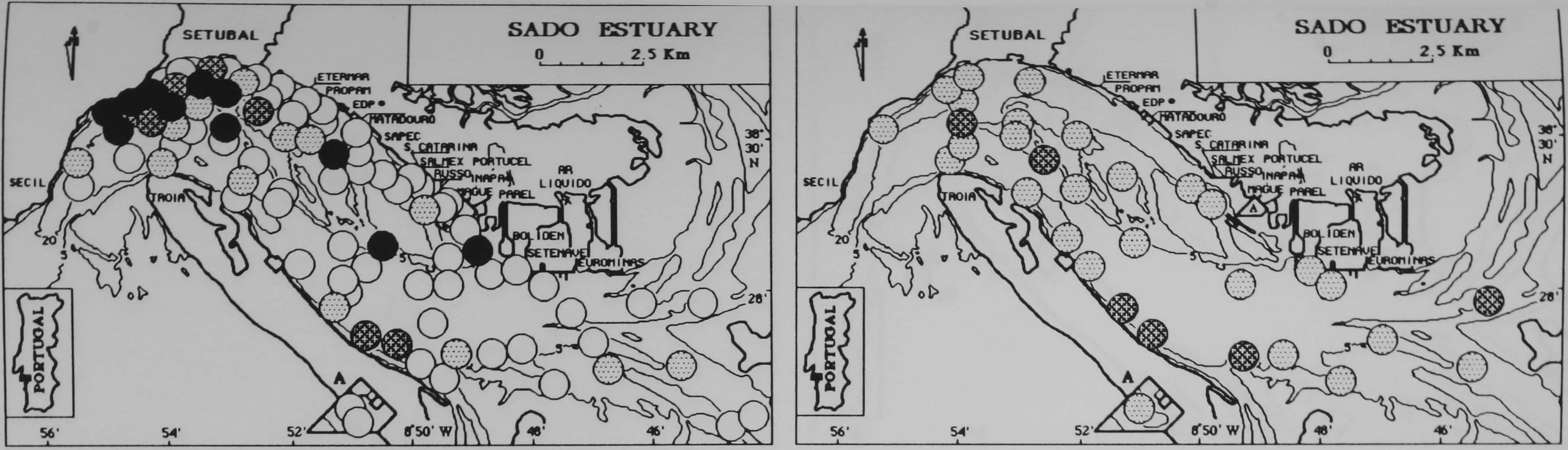
○ 1 - 10 ▩ 11 - 100 ● >100



Apseudes talpa

○ 1 - 20 ▩ 21 - 60 ● > 60

Figure 5.21 - Sado Estuary. Spatial distribution and local density (ind./0.1m^2) of the Tanaids *Apseudes latreilli* and *Apseudes talpa*.

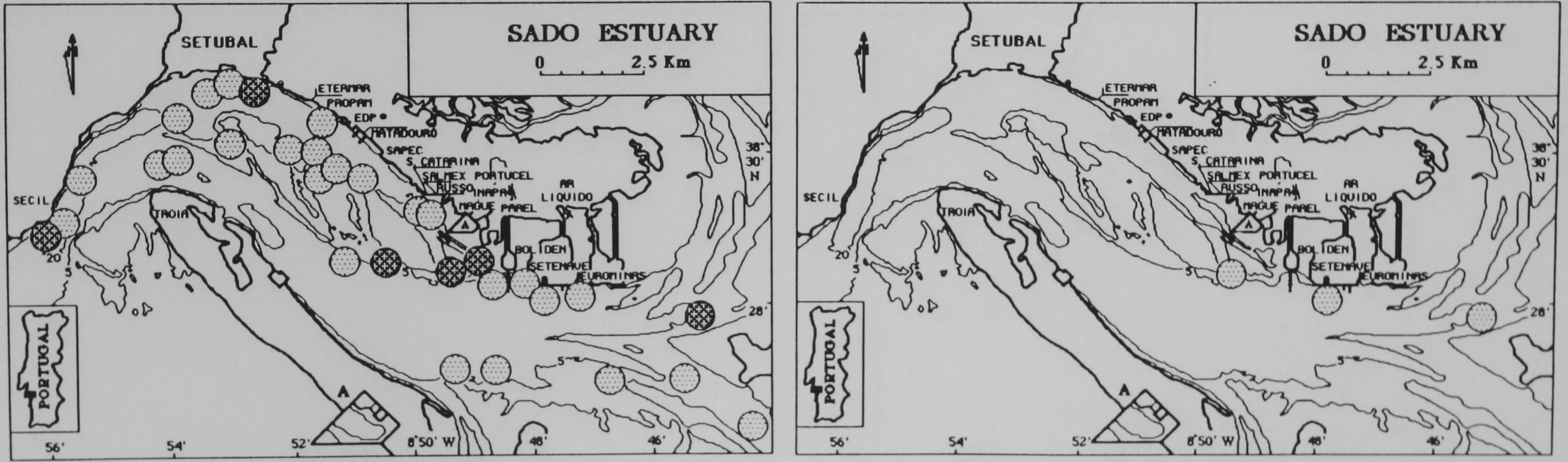


Corophium annulatum

○ 1 - 20 ▨ 21 - 40 ▩ 41 - 60 ● > 60

Corophium runcicorne

▨ 1 - 10 ▩ > 10



Corophium sextonae

▨ 1 - 10 ▩ > 10

Corophium 'complex'

▨ 1, 2

Figure 5.22 - Sado Estuary. Spatial distribution and local density (ind./0.1m^2) of the Corophids, *Corophium annulatum*, *C. runcicorne*, *C. sextonae* and *C.* "complex".

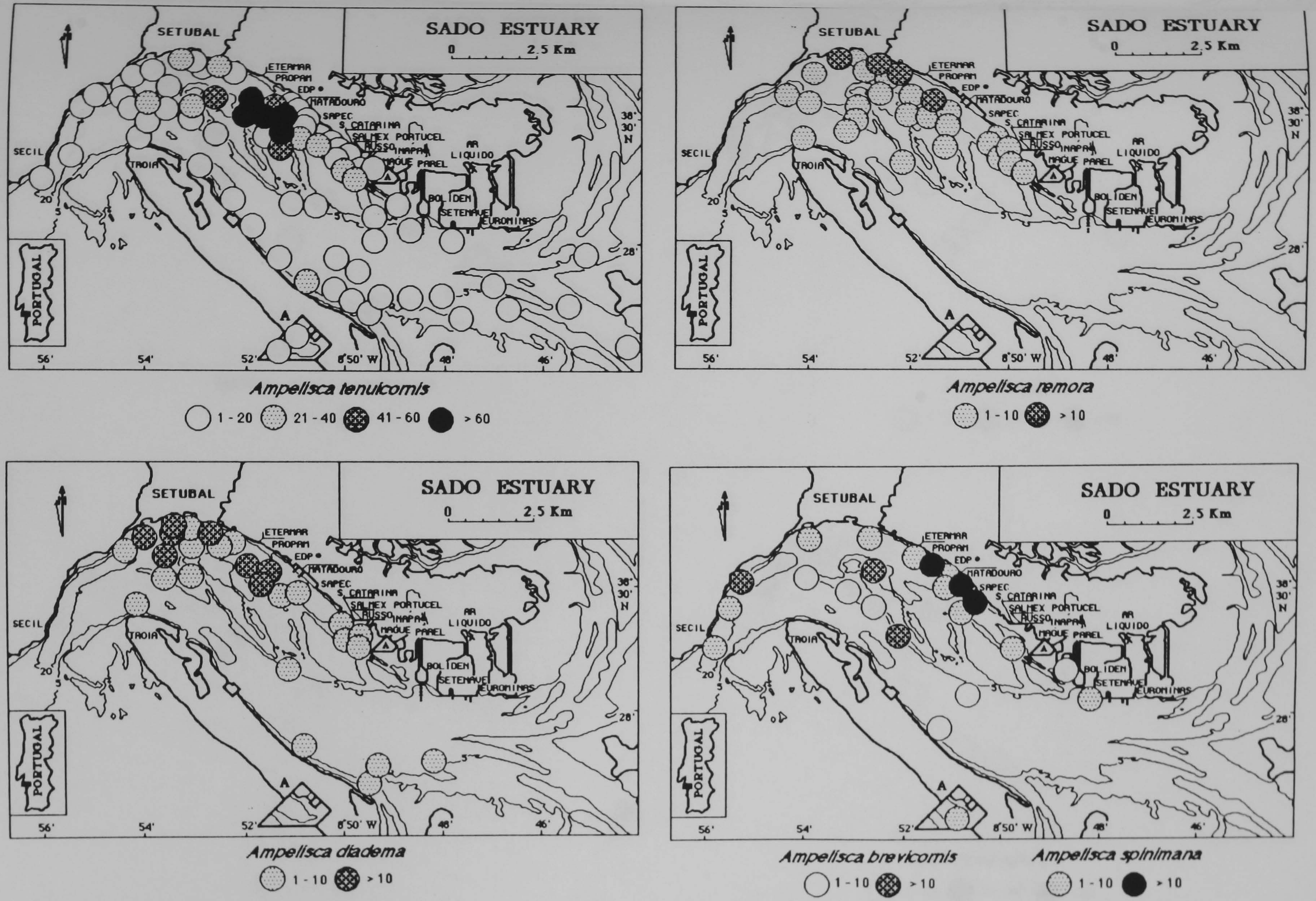
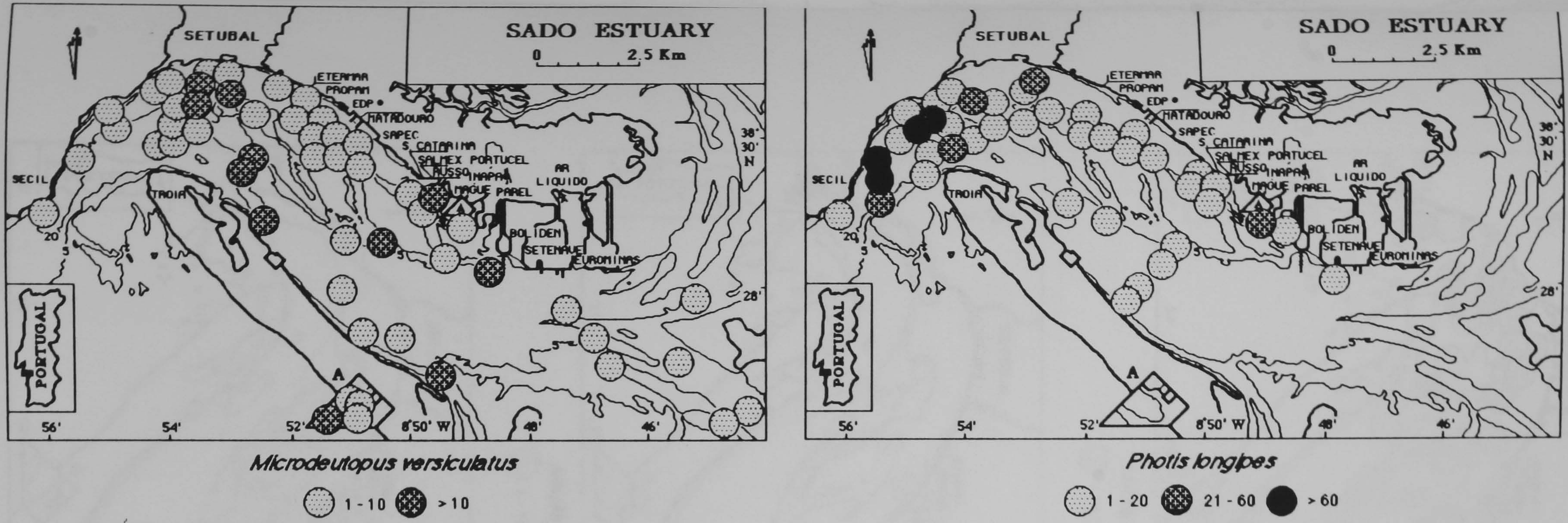
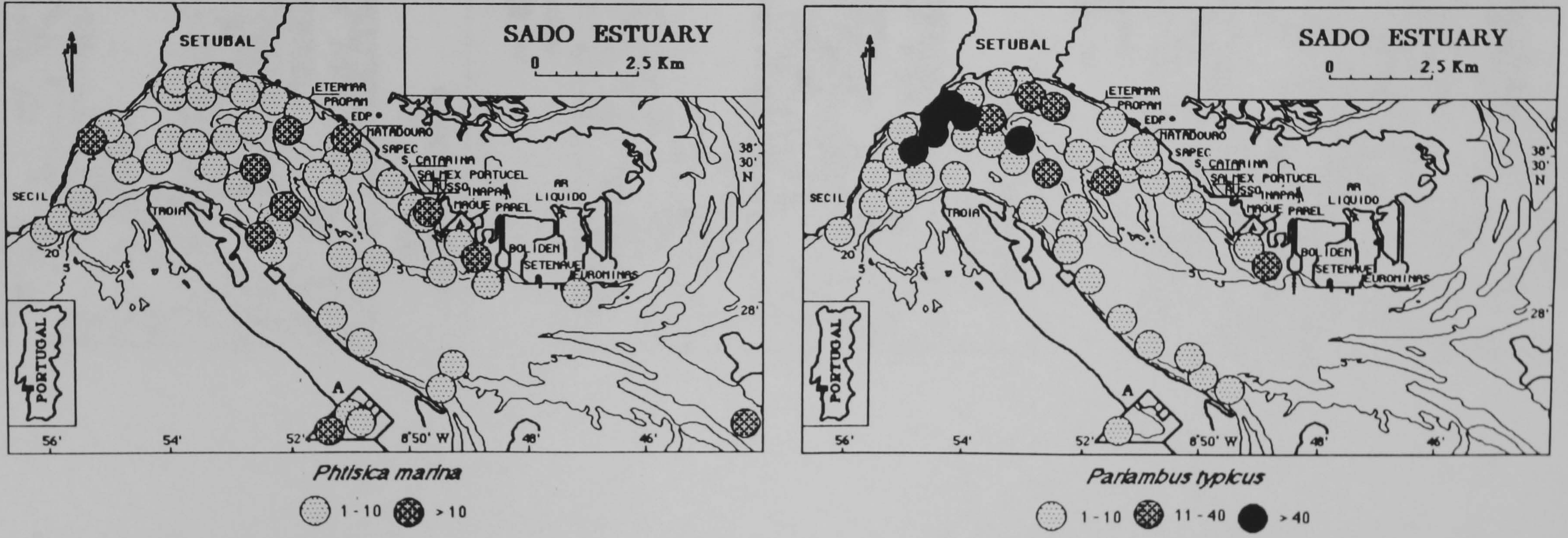


Figure 5.23 - Sado Estuary. Spatial distribution and local density (ind./0.1m^2) of the Ampeliscids, *Ampelisca tenuicornis, A. remora, A. diadema, A. brevicornis* and *A. spinimana.*



Microdeutopus versiculatus

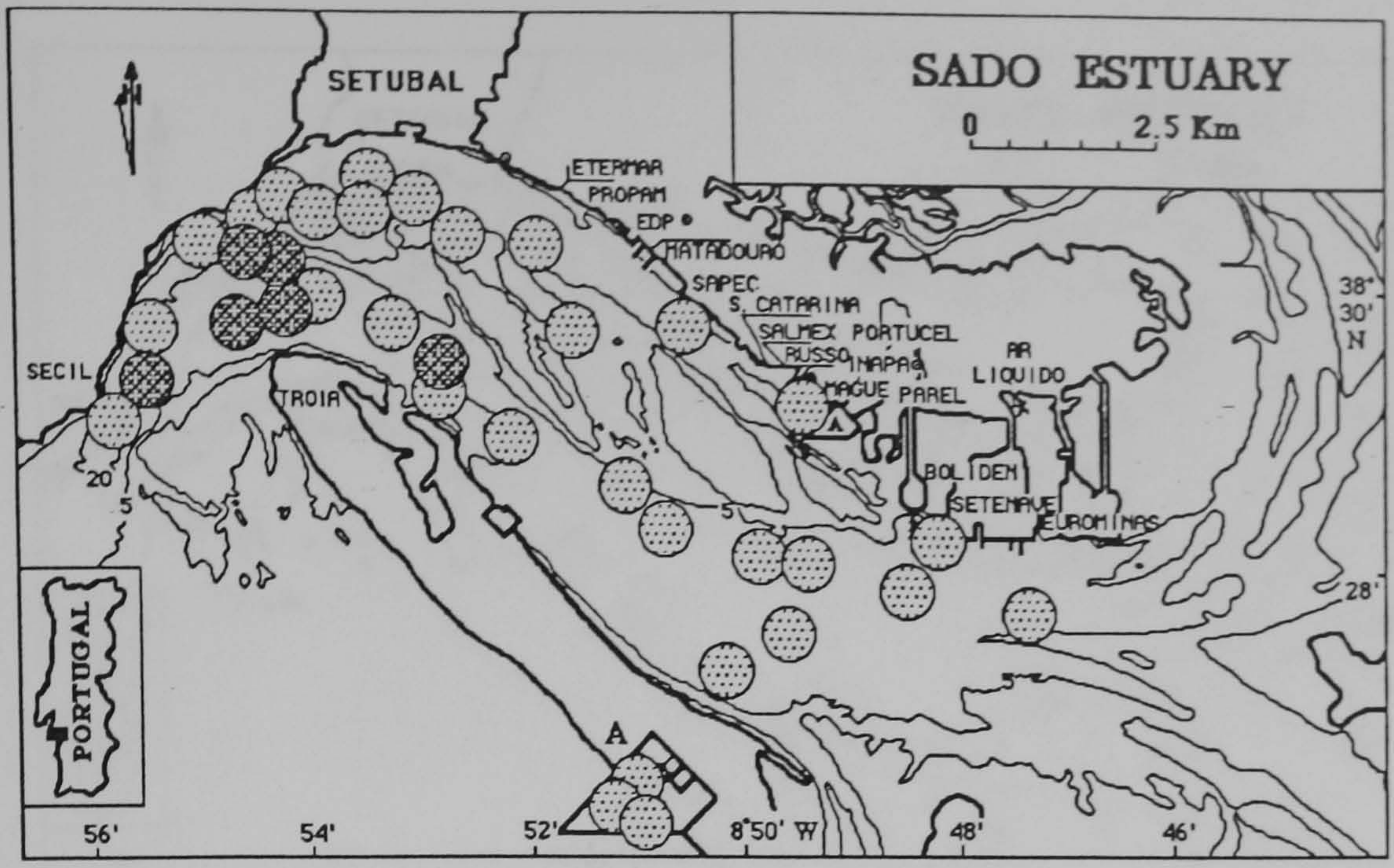
Photis longipes



Phtisica marina

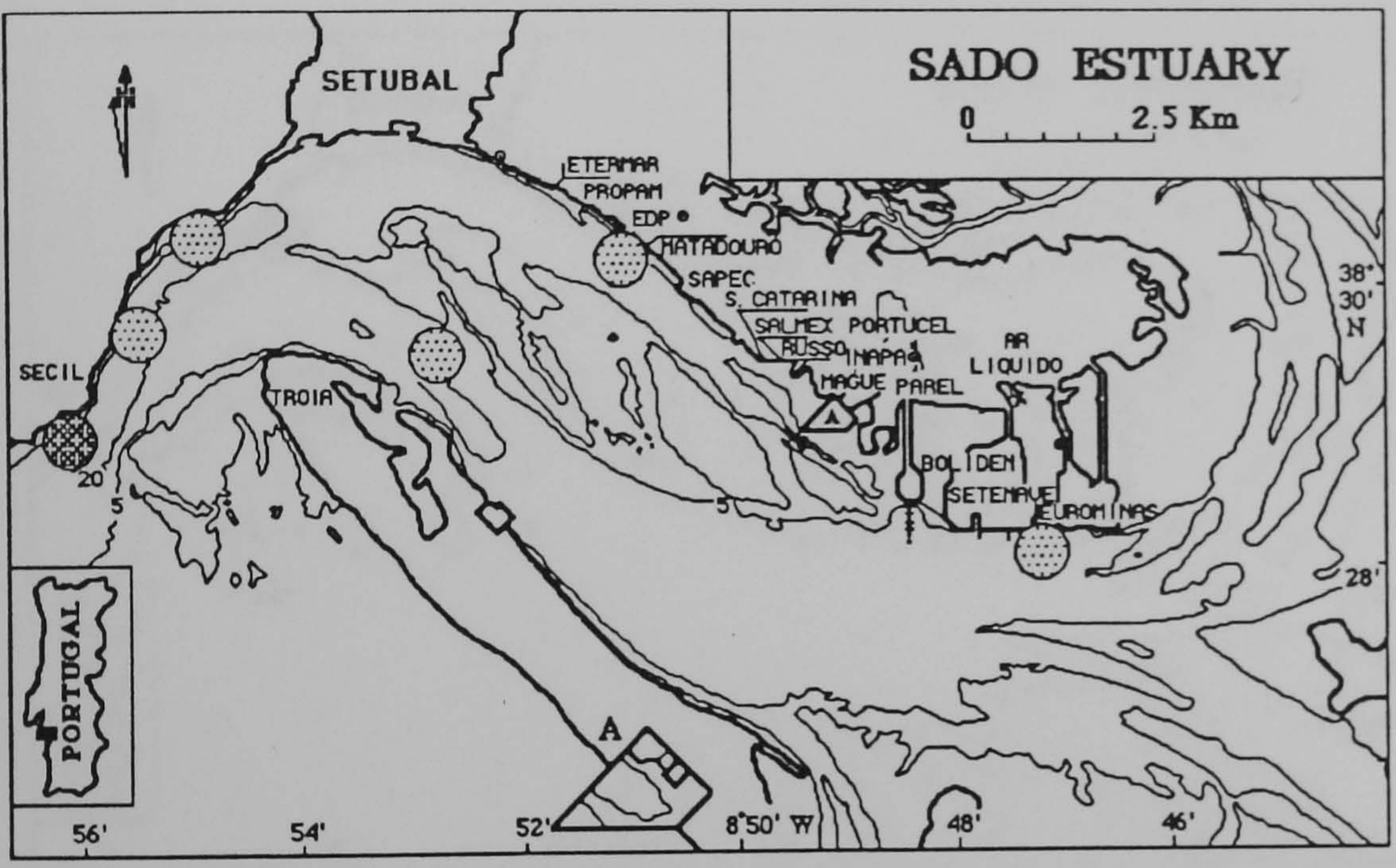
Pariambus typicus

Figure 5.24 - Sado Estuary. Spatial distribution and local density (ind./0.1m^2) of *Microdeutopus versiculatus*, *Photis longipes*, *Phtisica marina* and *Pariambus typicus*.



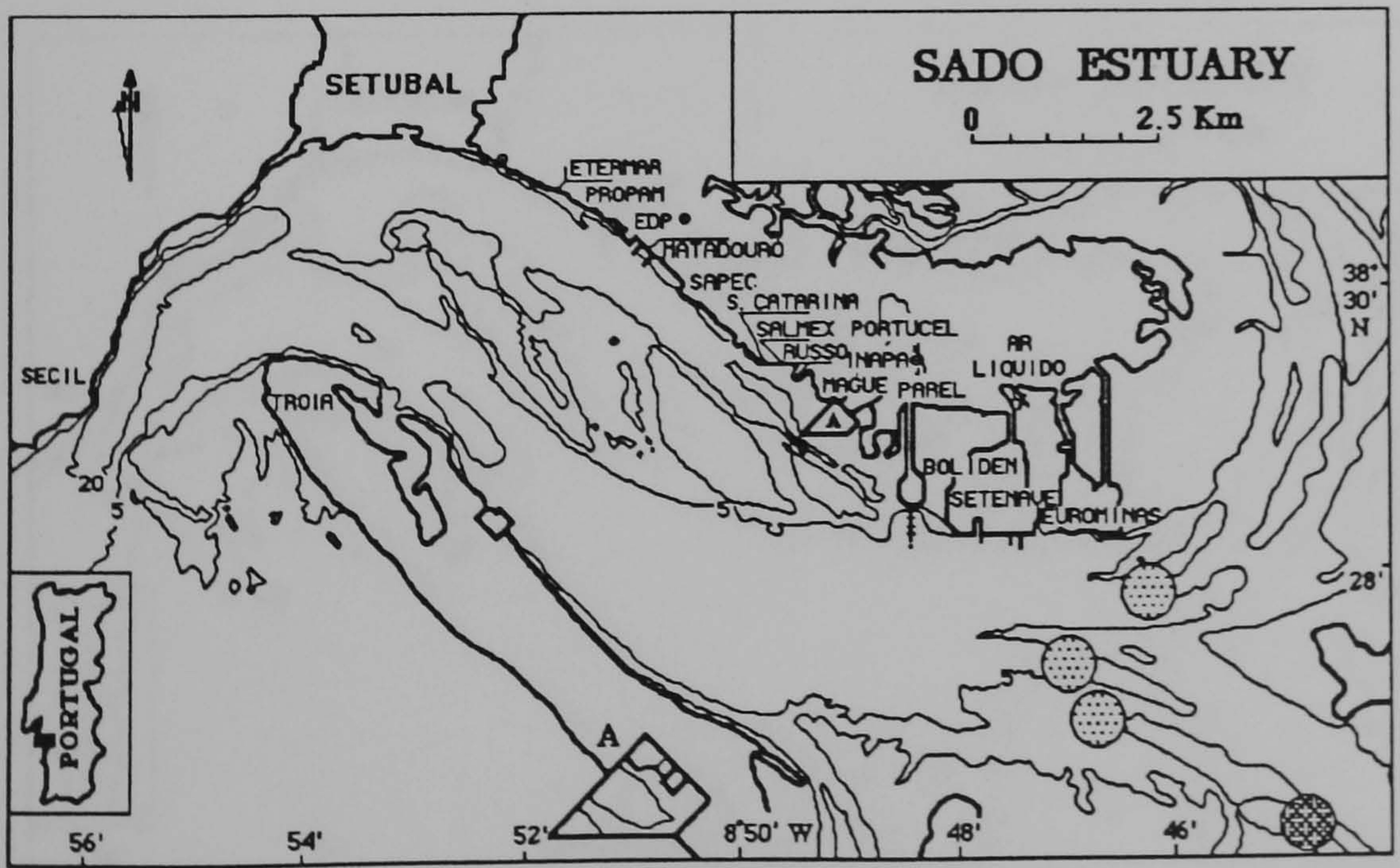
Melita obtusata

○ 1-10 ● >10



Melita gladiosa

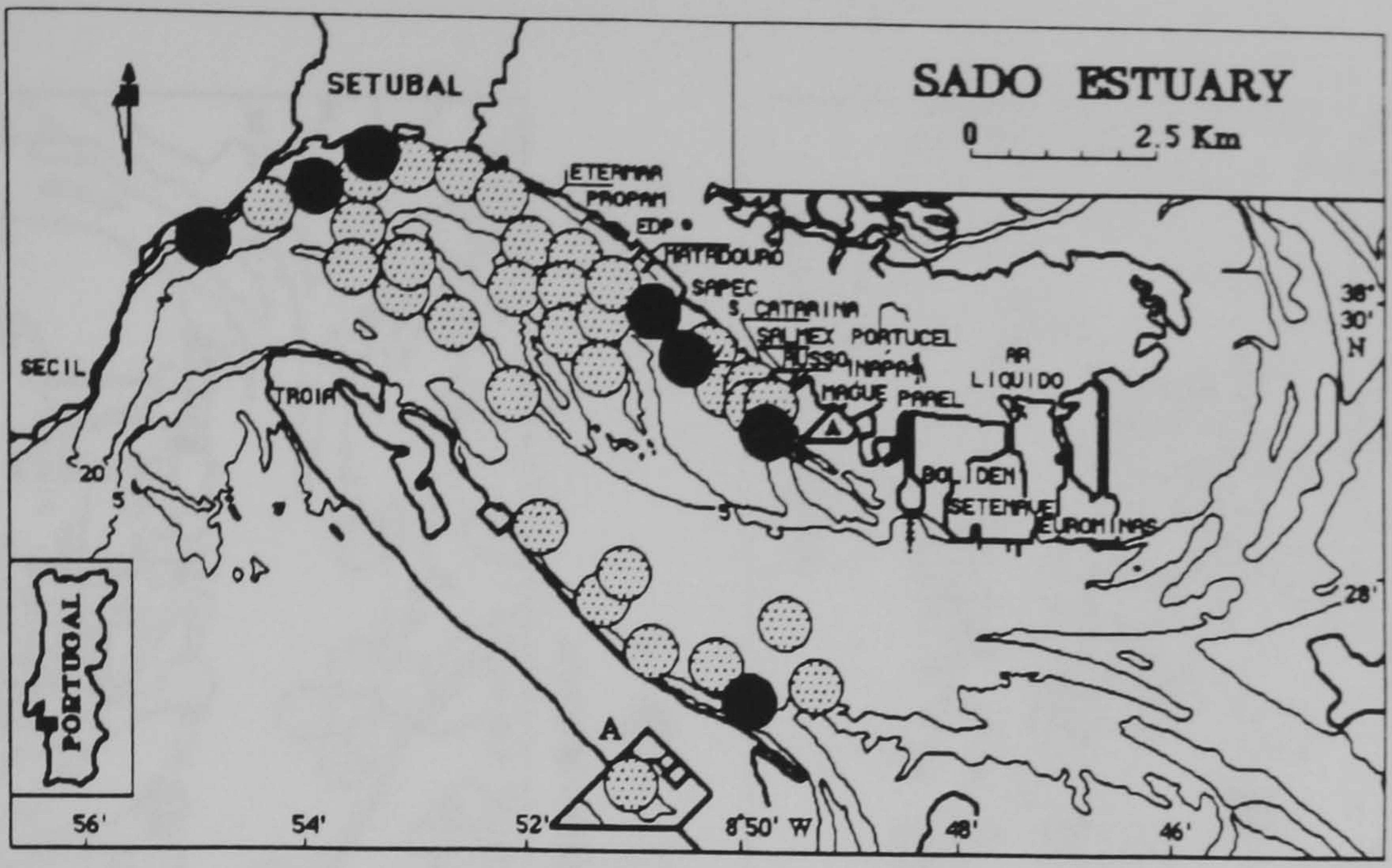
○ 1-10 ● >10



Melita palmata

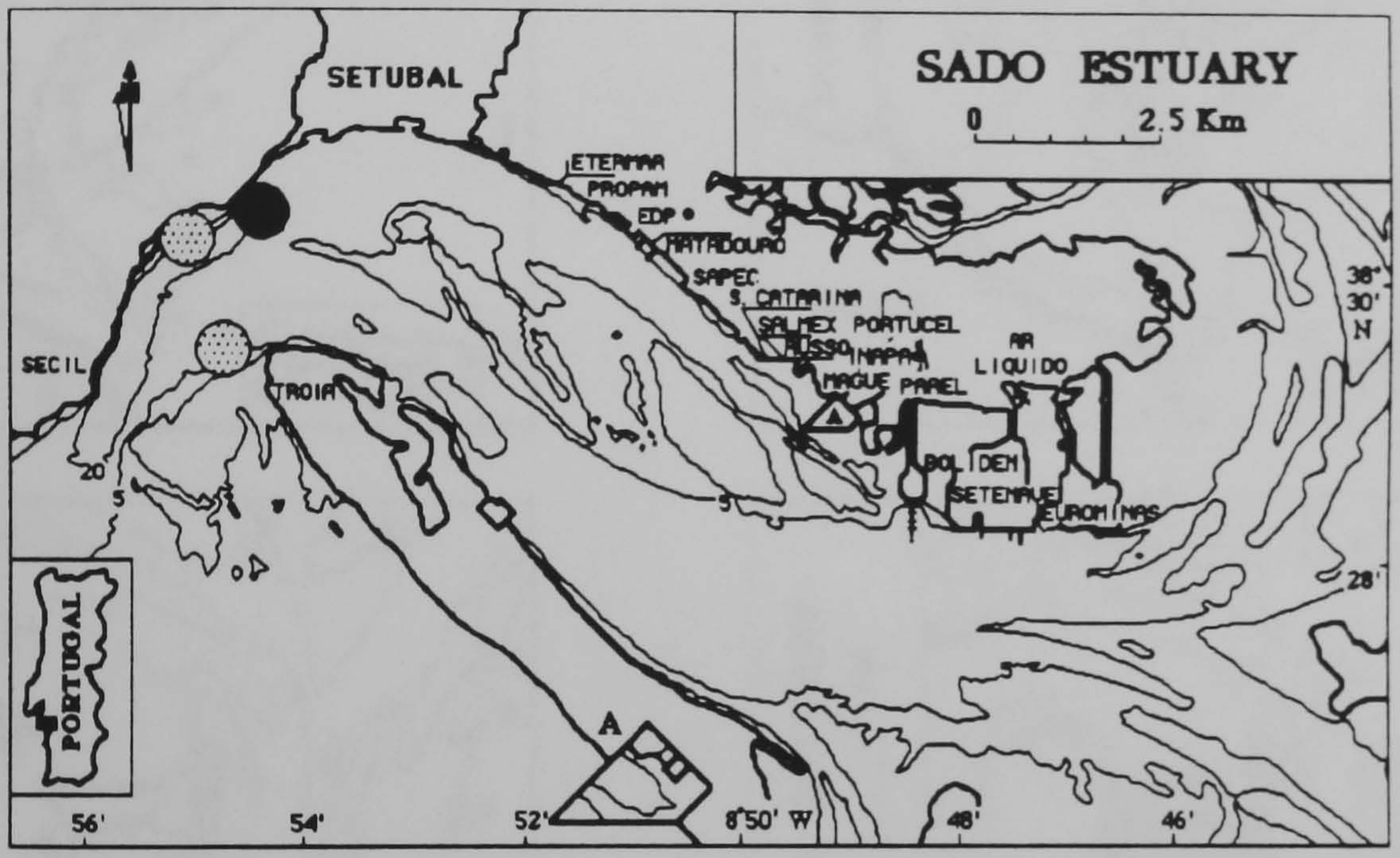
○ 1-5 ● >5

Figure 5.25 - Sado Estuary. Spatial distribution and local density (ind./0.1m^2) of the Melitids, *Melita obtusata*, *Melita gladiosa* and *Melita palmata*.



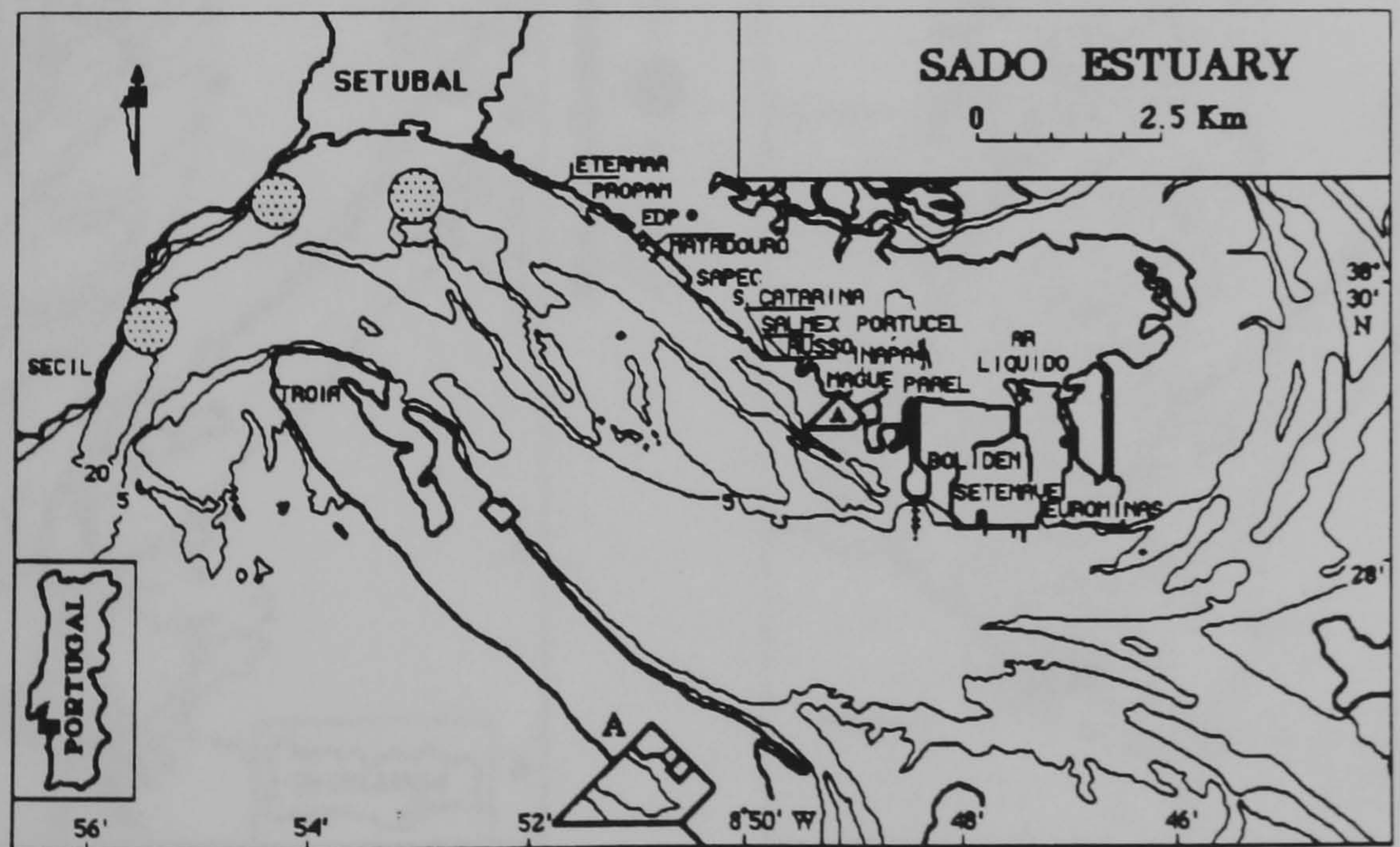
Harpinia pectinata

○ 1 - 10 ● > 10



Harpinia antennaria

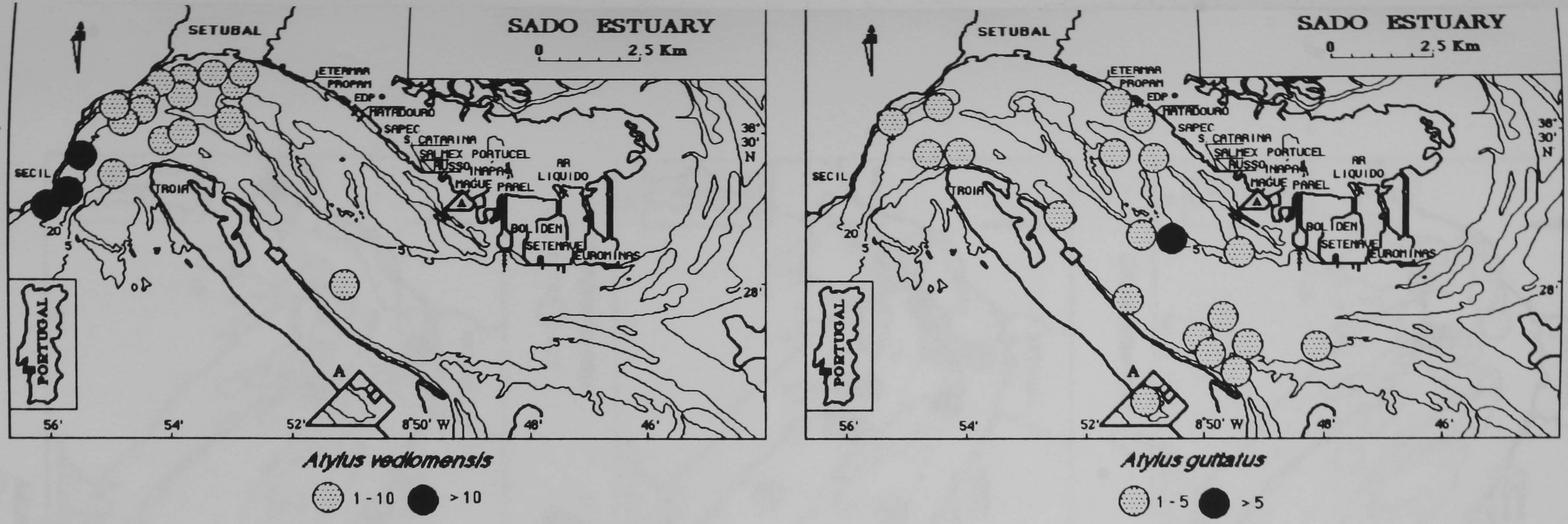
○ 1 - 10 ● > 10



Harpinia laevis

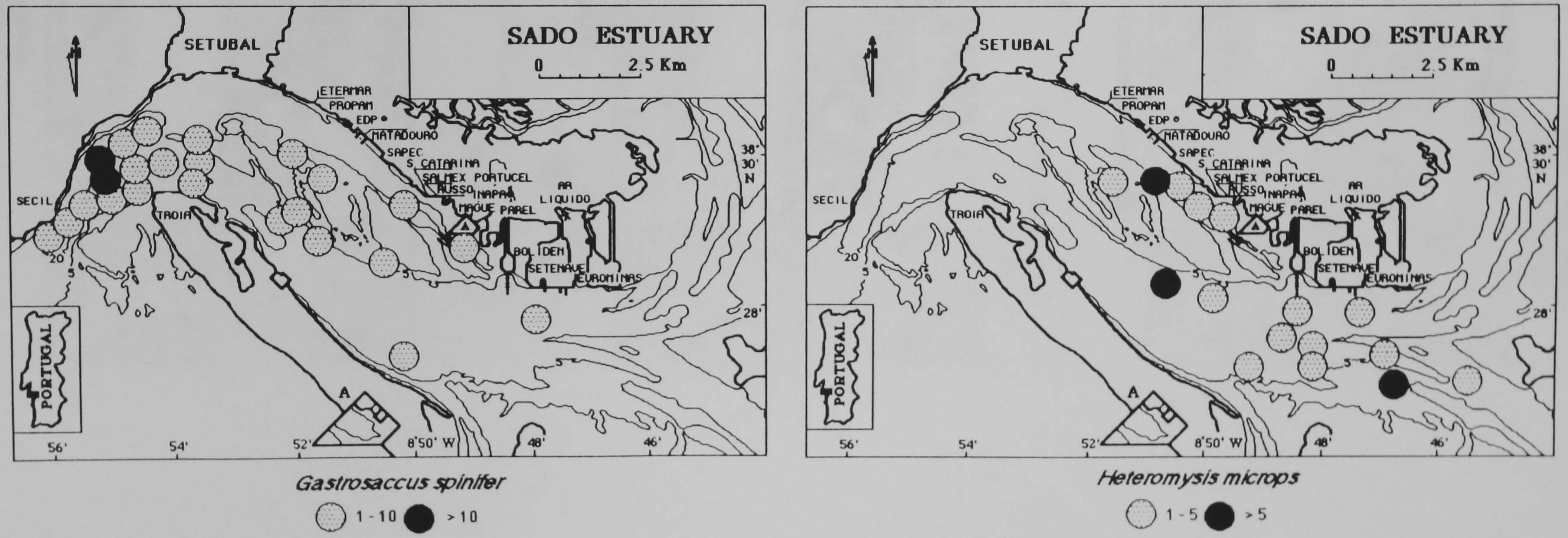
○ 1 - 10

Figure 5.26 - Sado Estuary. Spatial distribution and local density (ind./0.1m^2) of the Phoxocephalids *Harpinia pectinata*, *Harpinia antennaria* and *Harpinia laevis*.



Atylus vedlomensis

Atylus guttatus



Gastrosaccus spinifer

Heteromysis microps

Figure 5.27 - Sado Estuary. Spatial distribution and local density (ind./0.1m^2) of *Atylus vedlomensis*, *Atylus guttatus*, *Gastrosaccus spinifer* and *Heteromysis microps*.

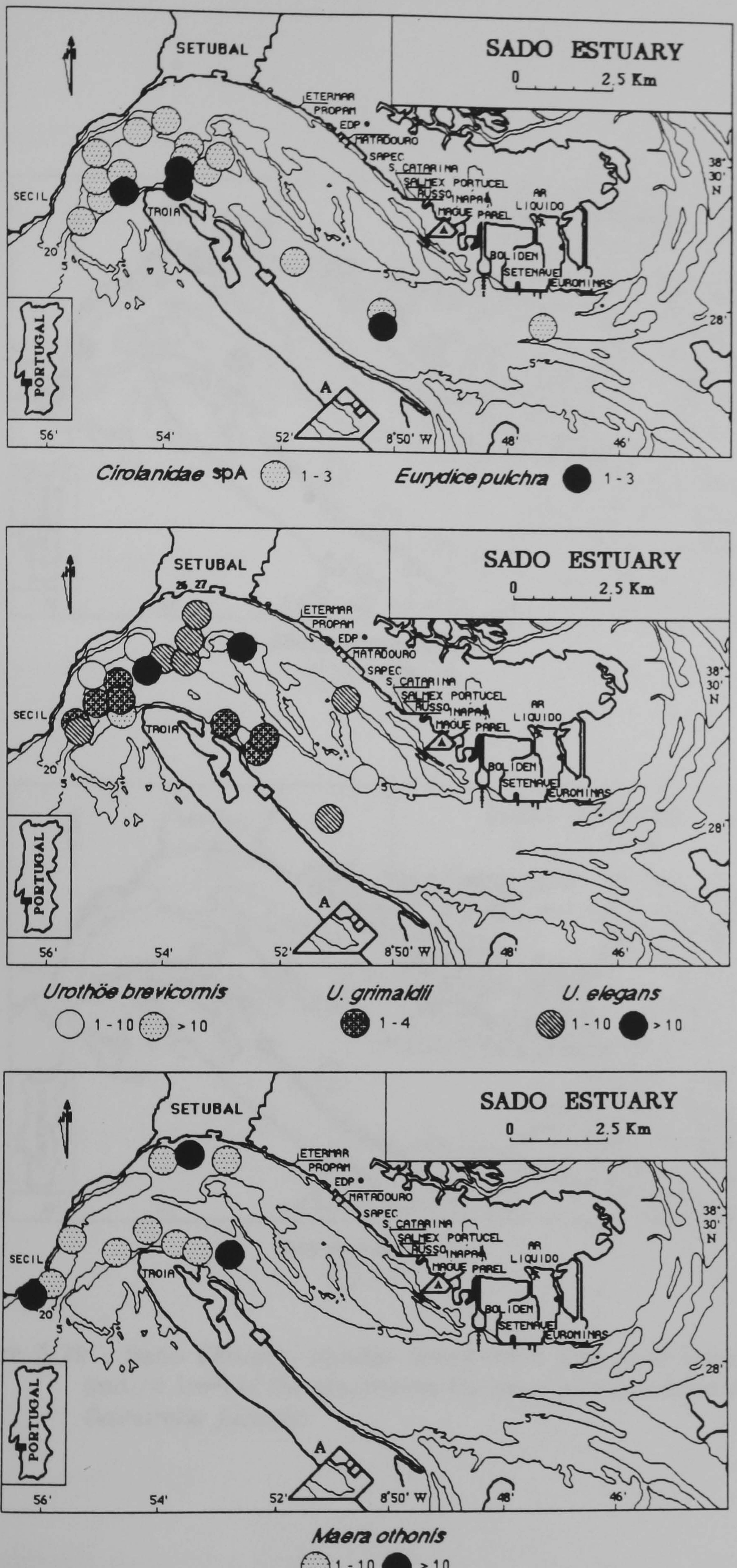
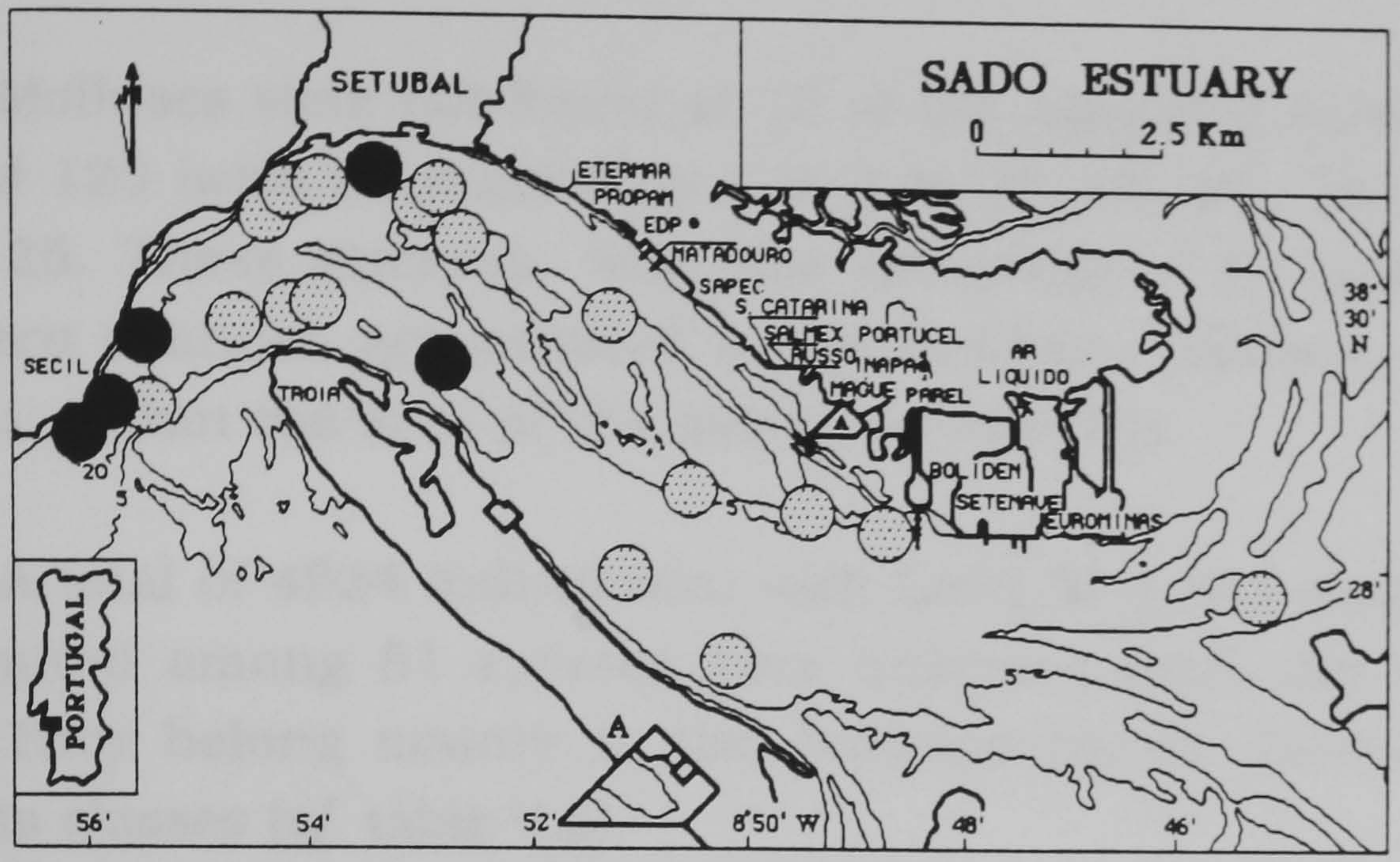
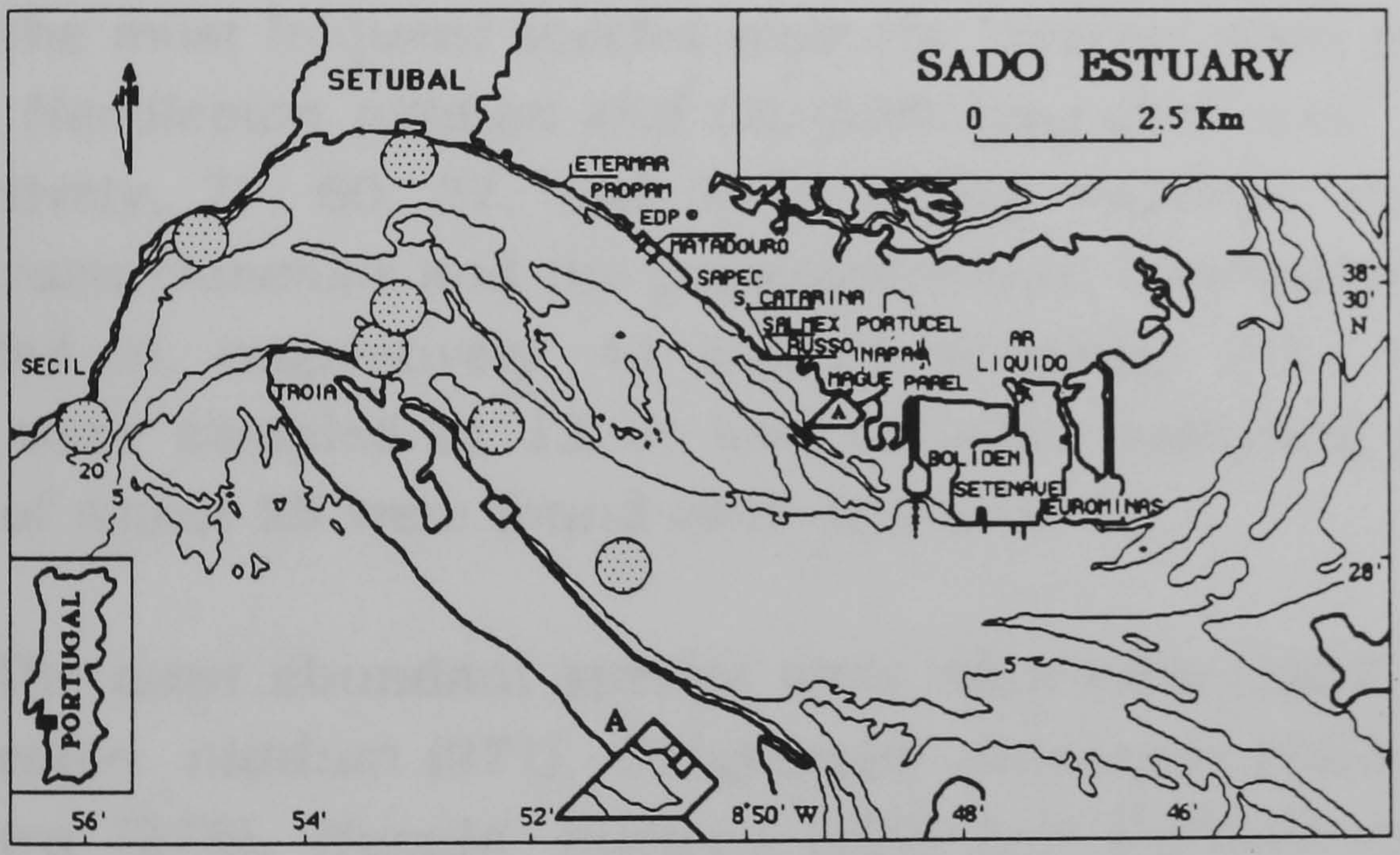


Figure 5.28 - Sado Estuary. Spatial distribution and local density (ind./0.1m^2) of the Isopods *Cirolanidae* spA and *Eurydice pulchra* and the Amphipods *Urothōe brevicornis*, *U. grimaldii*, *U. elegans* and *Maera othonis*.



Gammaropsis maculata

○ 1 - 10 ● > 10



Gammarella fucicola

○ 1 - 5

Figure 5.29 - Sado Estuary. Spatial distribution and local density (ind./0.1m^2) of the amphipods *Gammaropsis maculata* and *Gamarella fucicola*.

Molluscs

Molluscs were not found at 10 of the sampling stations, namely 95 and 120 (with no macrofauna) and at 31, 65, 67, 78, 92, 93, 117 and 125. These stations, with the exception of 31 and 67 in the southern channel, are situated in the northern channel, close to the margin, within the area of the industrial complex.

A total of 4934 individuals, with 2054.62 g wet-weight biomass, distributed among 81 species were analysed from the whole study area. They belong mainly to the Polyplacophora, Gasteropoda and Bivalvia classes (*cf.* table V.1).

Bivalves were the most important group with 54 species (67%), 4203 individuals (85%) and 1709.53 wet-weight biomass (83%).

The most frequent species were the bivalves *Abra alba, Corbula gibba, Hemilepton nitidum* and *Cardium paucicostatum* (present in, respectively, 77, 60, 37, and 35 sampling stations), the gastropod *Calyptraea chinensis* and the polyplacophoran *Chaetopleura angulata* (sampled in, respectively, 44 and 39 stations). Fifty four species (79%) were sampled at 13 or less stations (sampling frequency ≤ 10%), of which 25 were found once and 8 twice.

The most abundant species were *Abra alba* (1652 specimens), *Hemilepton nitidum* (971), *Calyptraea chinensis* (346), *Venerupis pullastra* (275), *Nucula nucleus* (196) and *Corbula gibba* (187). Together, they comprise 3627 individuals, representing 74% of the total number of Molluscs. On the other hand there were 35 species (43%) represented by a total number of 10 or less individuals.

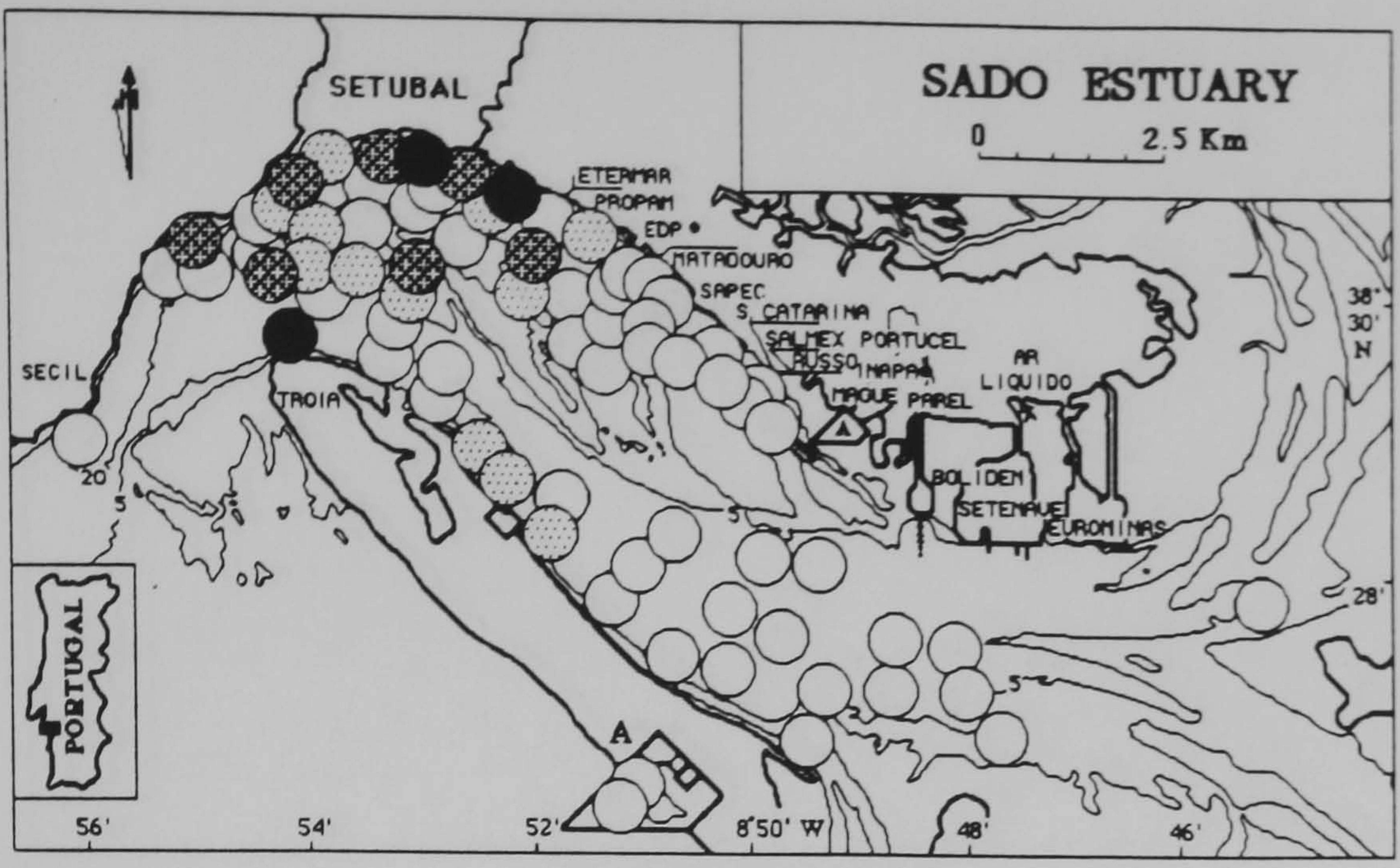
Nineteen mollusc species are represented by a total wet-weight biomass higher than 10.0 g. These species comprise 96% of Mollusc total biomass. *Cardium paucicostatum, Venerupis pullastra, Chaetopleura angulata, Solen marginatus, Nassarius reticulatus* and *Abra alba,* are the six species with higher total biomass, both for Molluscs and total macrofauna. They are all represented by more than 100.0 g, wet-weight.

Both the number and the abundance of Mollusc species and abundance per sampling station show distinct and uniform patterns, with the general tendency towards higher values mainly in a region between the entrance and the beginning of the sandbanks, the northern channel and near the southern margin of the estuary. The mouth of the estuary, the sampling stations closer to the industrial belt, along the northern margin, the middle part of the southern channel and the northern part of the upper region in the vicinity of industrial facilities (petrolear shipyard), all have low species richness and low abundance. Biomass distribution areas, as expected, show a pattern very similar to the one obtained with total macrofauna data.

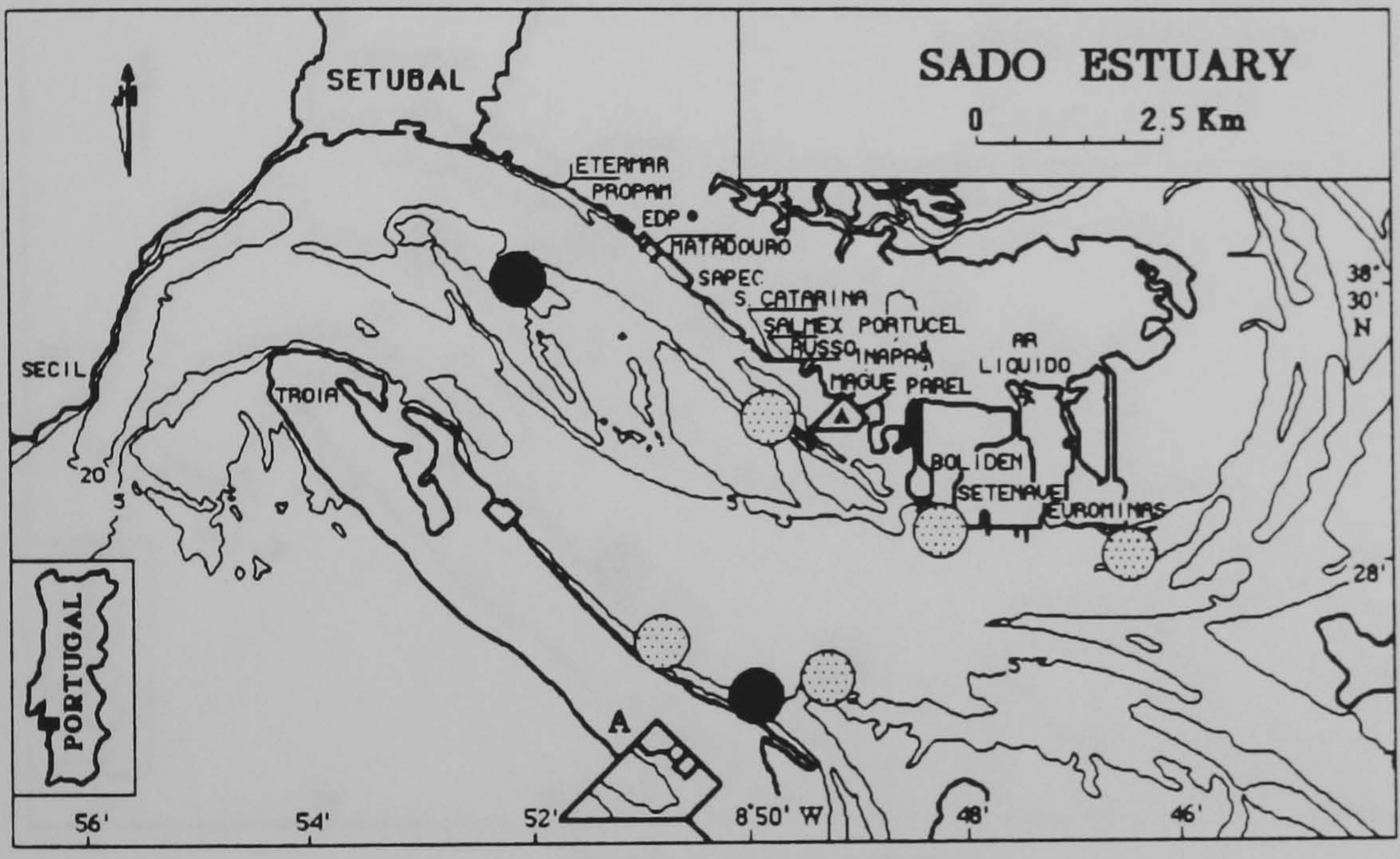
Only a few Mollusc species have wide distribution areas. Nevertheless *Abra alba* and *Corbula gibba*, tend to occupy both the northern and southern channels and the upper region (figure 5.30). Both species are very rare near the entrance. *Abra alba* is present at higher densities in the outer parts of its distribution range, while *Corbula gibba* tends to be more abundant in the inner regions of the northern channel. *Abra nitida*, though much less frequent and abundant than *Abra alba* settles mainly in the innermost part of both channels and in the upper region of the outer estuary.

Other Molluscs are more commonly found in the northern channel and when extending to the southern channel tend to occur in the inner part and in the vicinity of the margin. This is the case which *Chaetopleura angulata*, *Cardium paucicostatum* and *Nucula nucleus*, although this latter species clearly occupies more outer areas than the other two (figure 5.31).

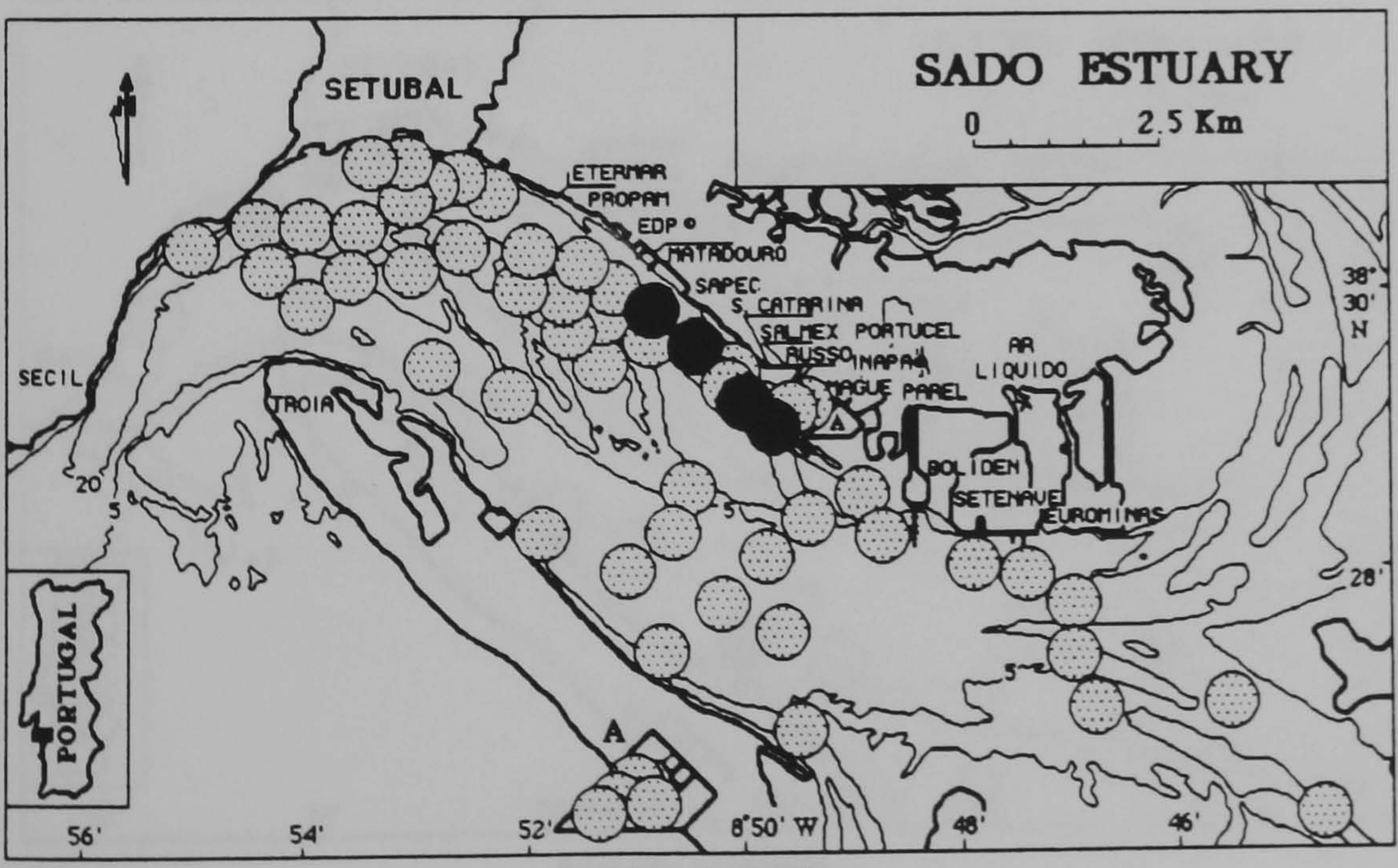
Calyptraea chinensis also extends from the entrance to the inner estuary (figure 5.32), though very rare in the northern channel and upper region. On the contrary, *Hemilepton nitidum* (figure 5.32) is almost absent from the mouth up to half the length of the northern and southern channels. *Spisula solida*, *Venerupis pullastra* and *Ervilia castanea*, occupy almost complementary distribution areas in the vicinity of the entrance and beginning of both channels (figure 5.33).



Abra alba

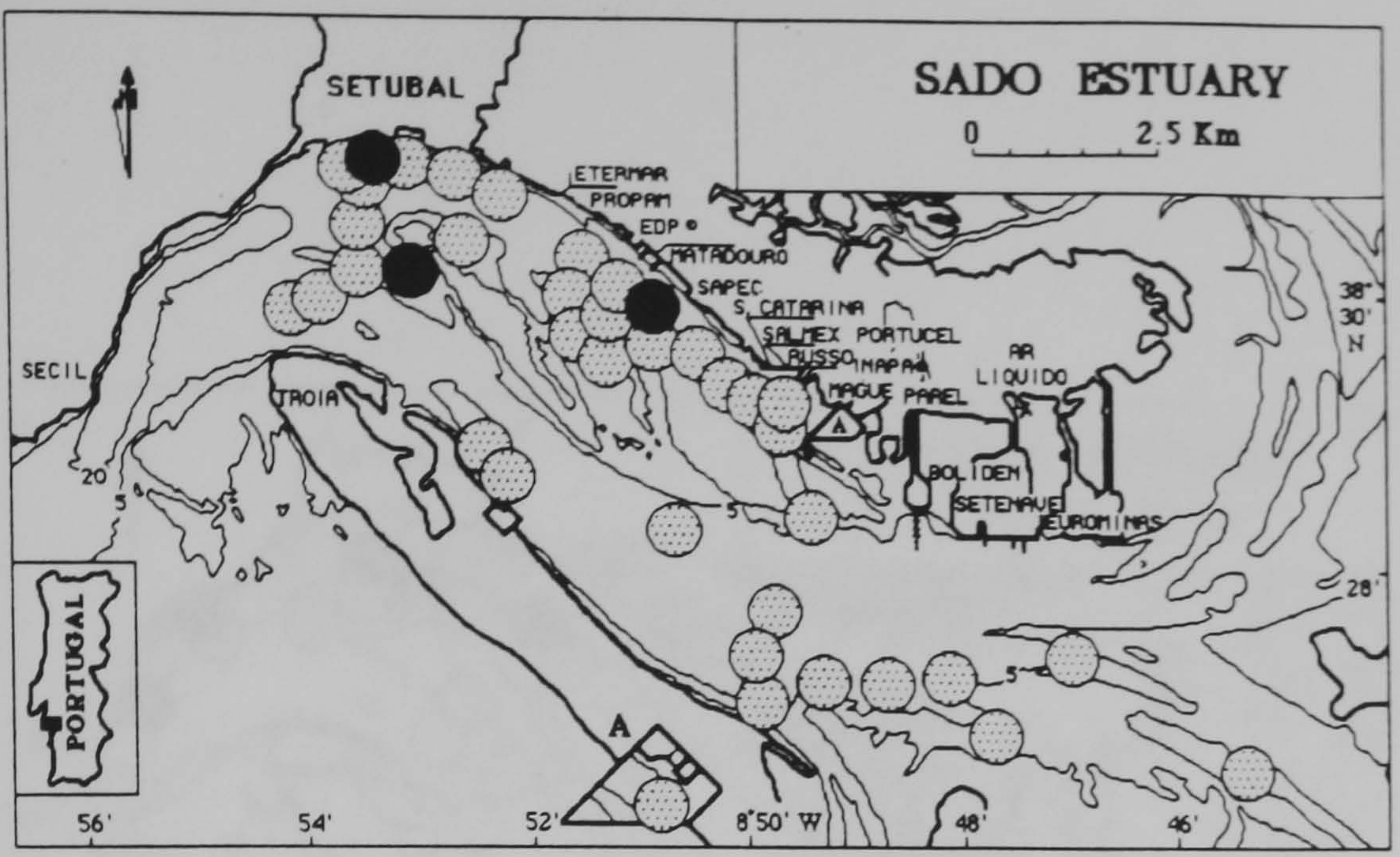


Abra nitida



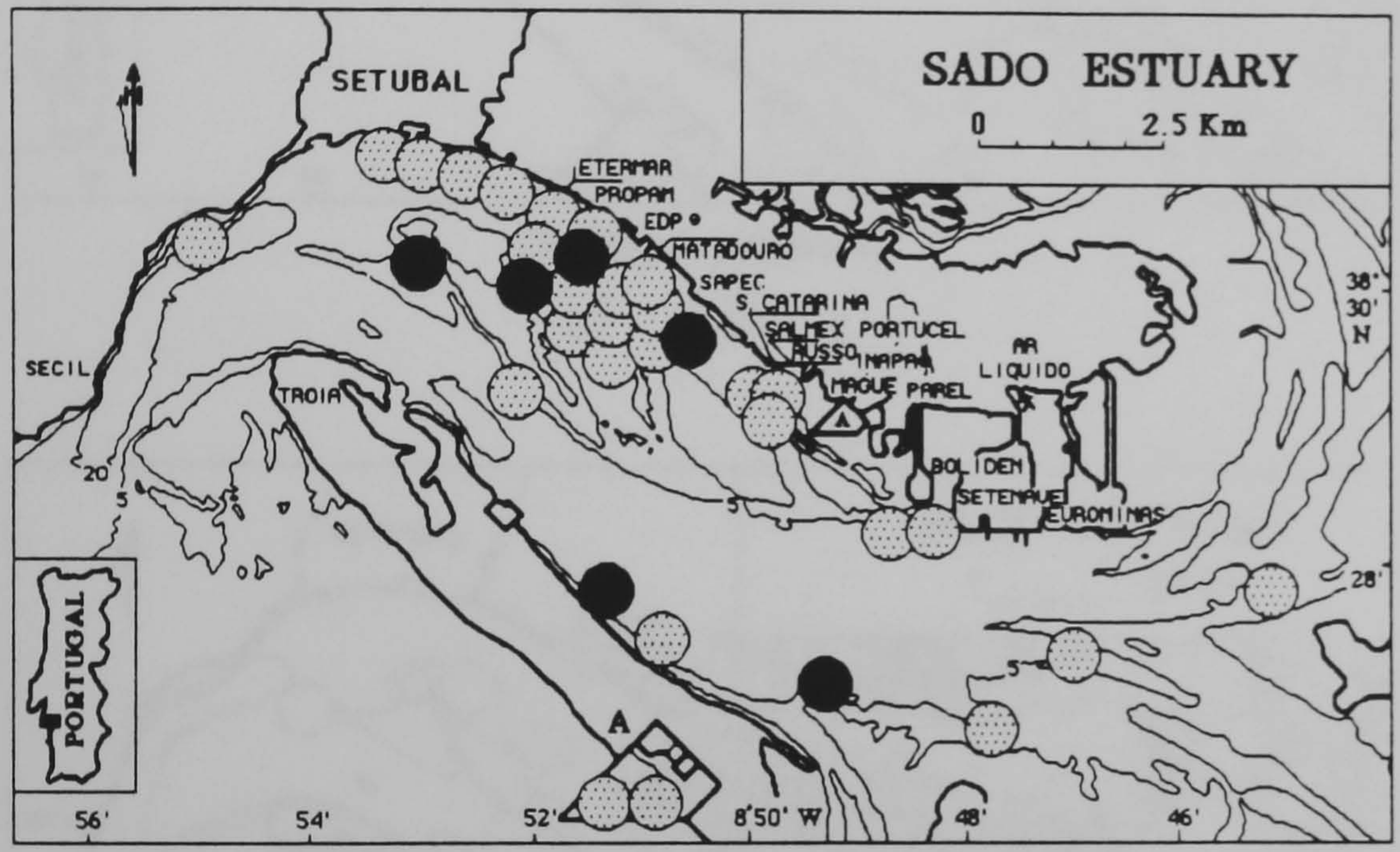
Corbula gibba

Figure 5.30 - Sado Estuary. Spatial distribution and local density (ind./0.1m^2) of the Bivalves *Abra alba*, *Abra nitida* and *Corbula gibba*.



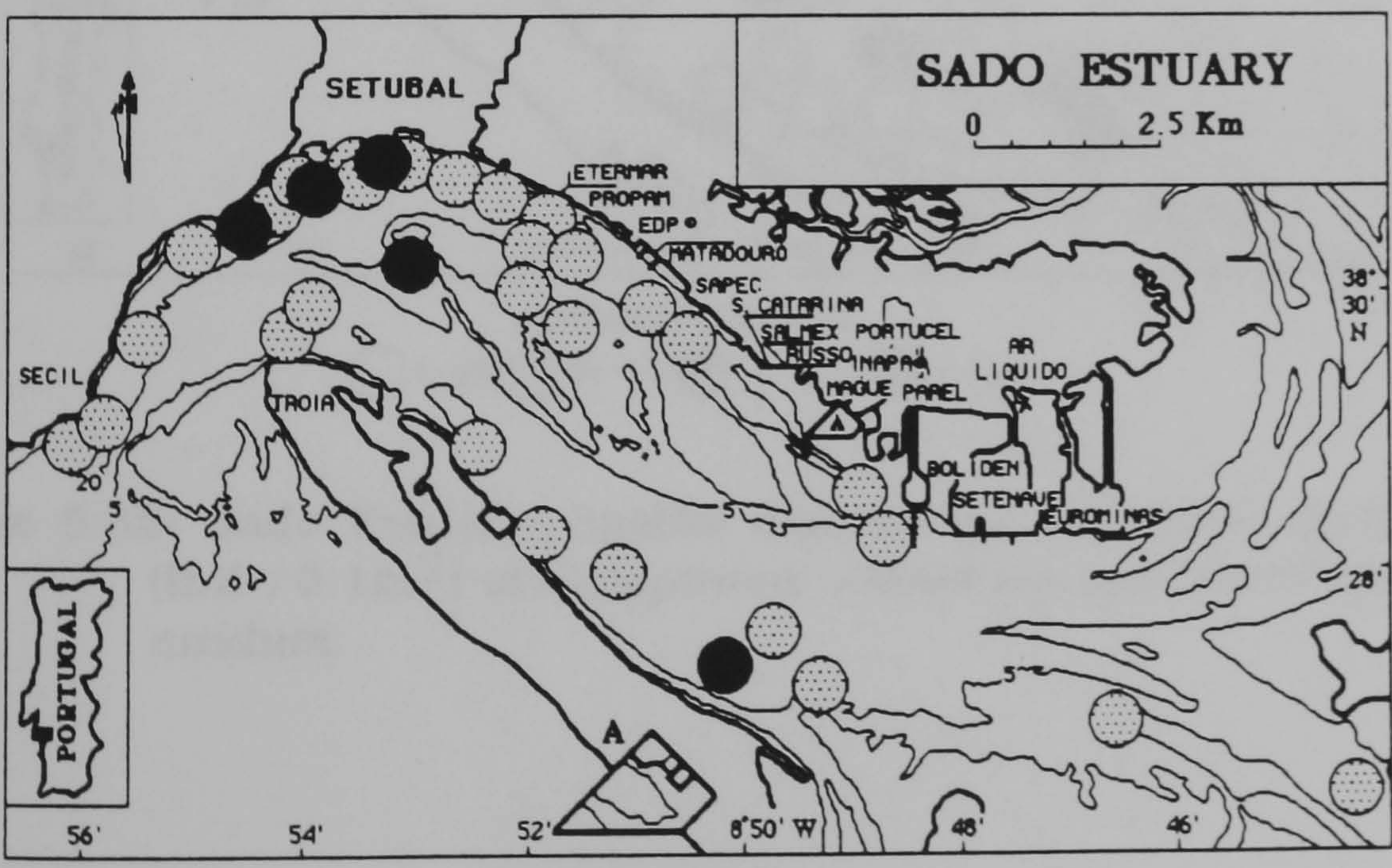
Chaetopleura angulata

○ 1 - 5 ● > 5



Cardium paucicostatum

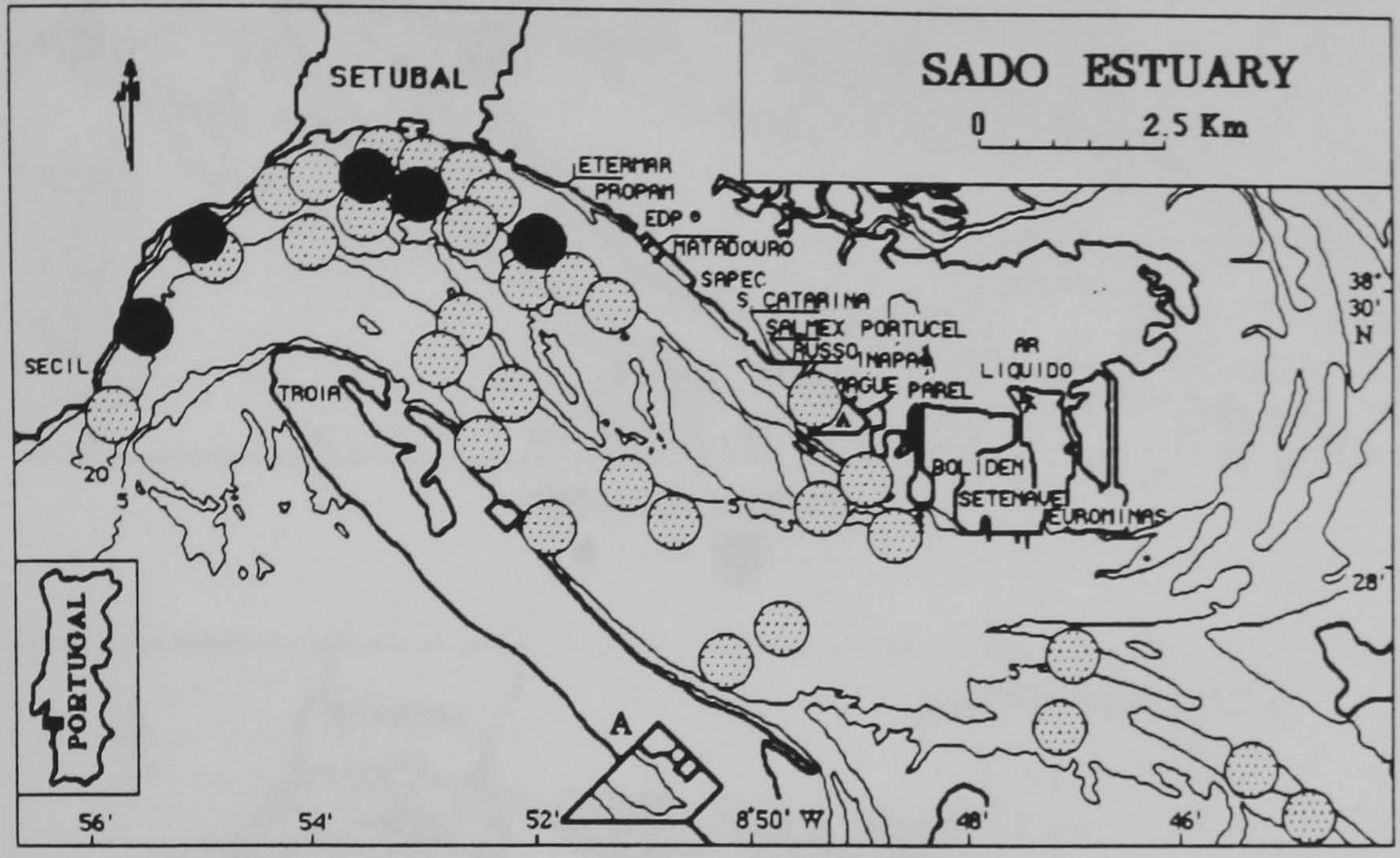
○ 1 - 5 ● > 5



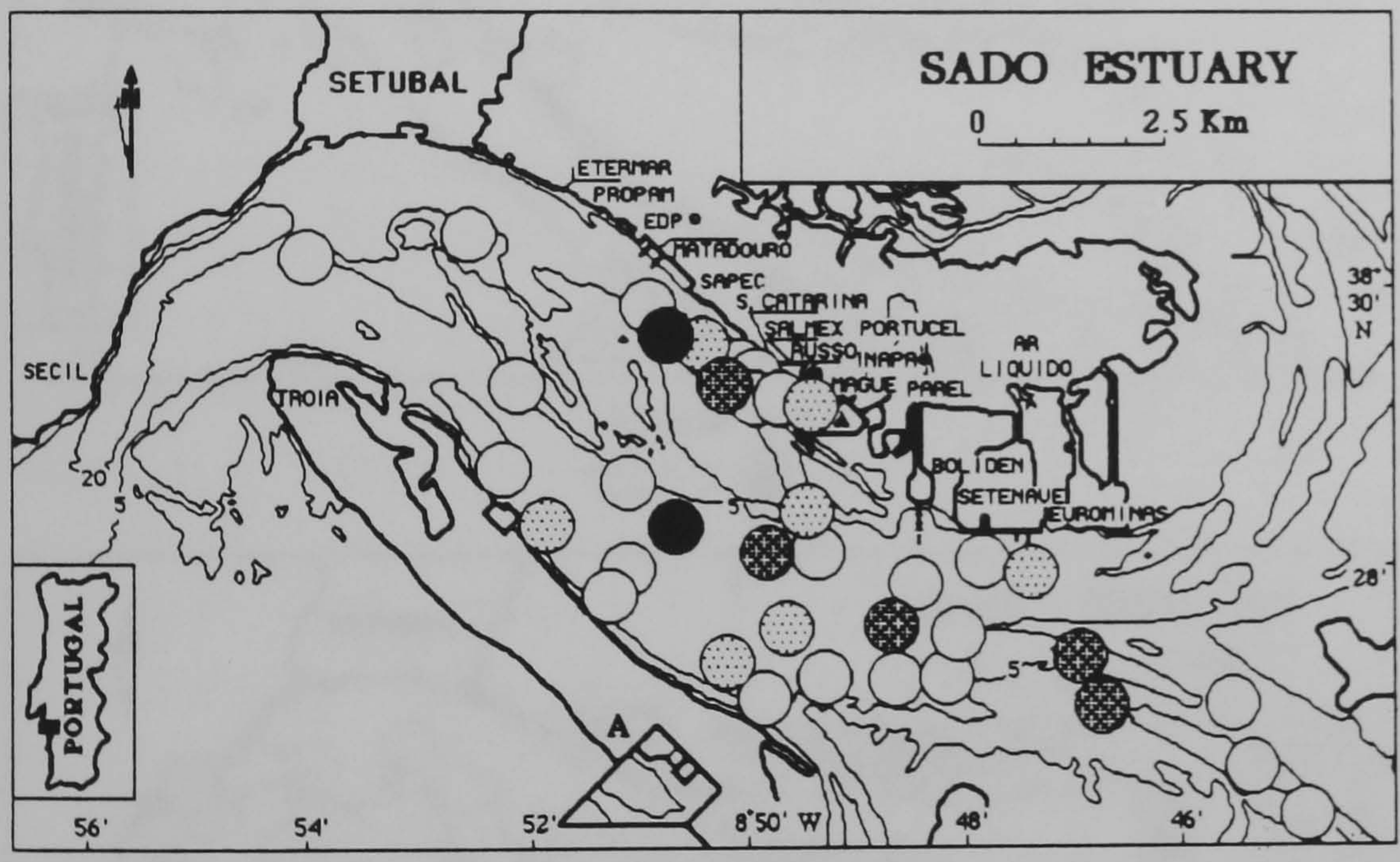
Nucula nucleus

○ 1 - 10 ● > 10

Figure 5.31 - Sado Estuary. Spatial distribution and local density (ind./0.1m^2) of *Chaetopleura angulata*, *Cardium paucicostatum* and *Nucula nucleus*.

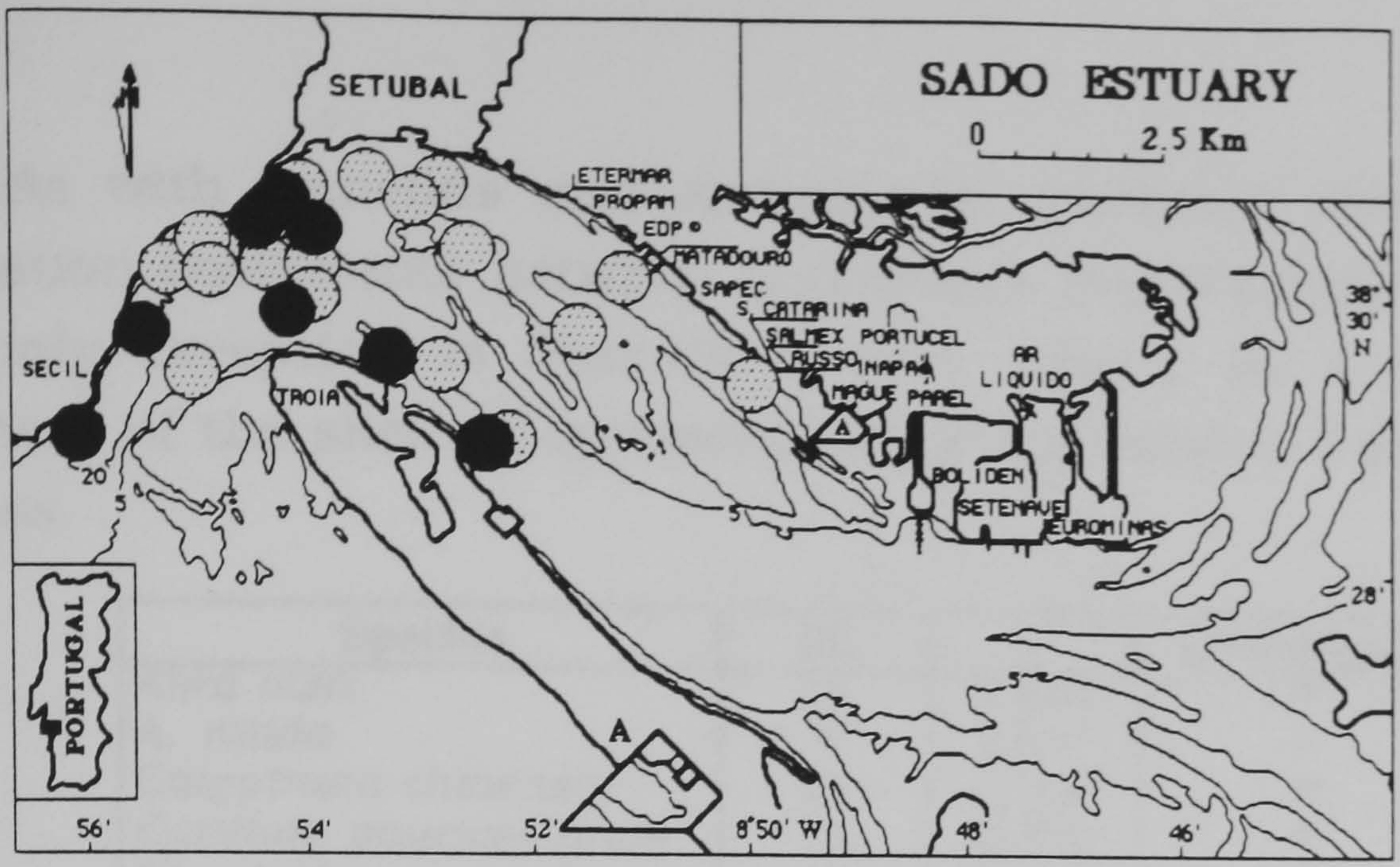


Calyptraea chinensis



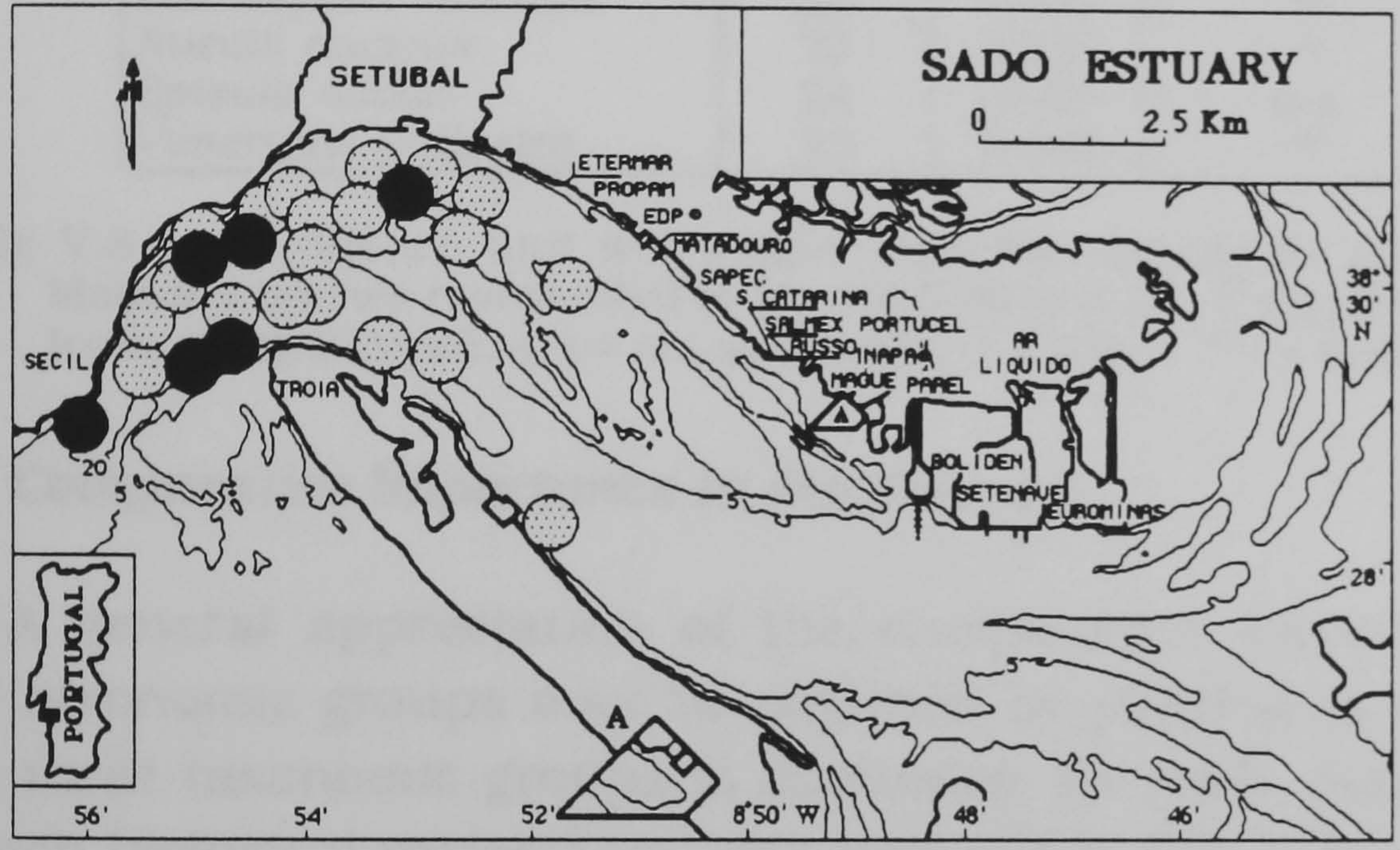
Hemilepton nitidum

Figure 5.32- Sado Estuary. Spatial distribution and local density (ind./0.1m^2) of *Calyptraea chinensis* and *Hemilepton nitidum.*



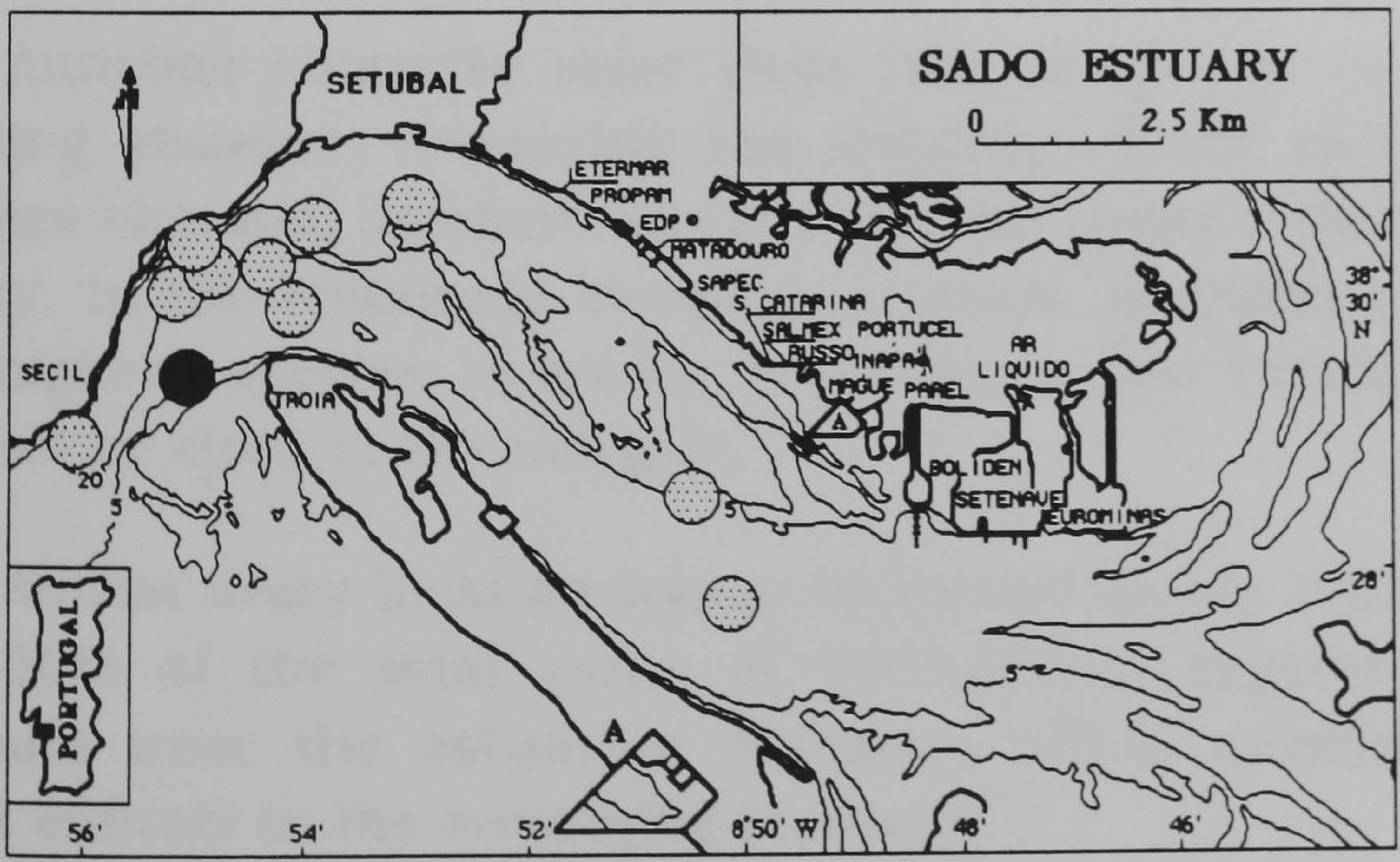
Venerupis pullastra

▨ 1 - 10 ● > 10



Spisula solida

▨ 1 - 5 ● > 5



Ervilia castanea

▨ 1 - 5 ● > 5

Figure 5.33 - Sado Estuary. Spatial distribution and local density (ind./0.1m^2) of *Venerupis pullastra*, *Spisula solida* and *Ervilia castanea*.

As with Annelids and Arthropods, Molluscs show very high correlation coefficients between abundance and biomass (Table V.8). The only exception is *Spisula solida*, which, as a result of the thickness of the shell of occasional large specimens, has a very high biomass.

Species	**Df.**	**r**	**level signif.**
Abra alba	75	0.857	**
A. nitida	5	0.937	*
Calyptraea chinensis	42	0.659	**
Cardium paucicostatum	33	0.802	**
Chaetopleura angulata	37	0.737	**
Corbula gibba	58	0.956	**
Ervilia castanea	9	0.993	**
Hemilepton nitidum	35	0.991	**
Nucula nucleus	32	0.816	**
Spisula solida	24	0.084	n.s.
Venerupis pullastra	23	0.606	**

Table V.8 - Abundance and wet-weight biomass correlation coefficients for Molluscs species represented in figures 5.30 to 5.33. df=degrees of freedom; levels of significance: n.s.= not significant, * < 0.01 , ** << 0.001.

Comparative Importance in the Estuary

A general appreciation of the comparative importance of the major taxonomic groups may be obtained by plotting in a map which of the three taxonomic groups is dominant, for each sampling station and each biological variable (*cf.* also tables V.2, V.3, V.4 and V.5). This is shown in figure 5.34.

Annelids comprise more than 50% of species richness in 63 sampling stations, occupying the majority of the entrance region, southern channel, northern margin and the upper region of the outer estuary. In the remaining sampling stations, Annelids are the group with highest species richness, excepting a few locations near the entrance or close to the margins.

Almost every location has a taxonomic group comprising more than 50% of the total value of abundance. Arthropods tend to dominate near the estuarine entrance, while Annelids dominate almost entirely in the remaining locations.

Biomass in each sampling station is clearly dominated by Molluscs. The most important exception to this is seen in the sampling locations close to the industrial complex in the northern margin, where Annelids represent more than 50% of total biomass.

Figure 5.34 - Partitioning of the relative proportion of species richness, abundance and wet-weight biomass by Annelids, Arthropods and Molluscs in each of the sampling stations.

5.2.1.3. - Other taxonomic groups

The subtidal macrofauna of the Sado estuary is principally made up of Annelids, Arthropods and Molluscs (*cf.* table V.1). The other taxonomic groups represent 6.6% of the total species richness, 6.7% of the biomass (wet-weight) and only 1.9% of total abundance.

Echinoderms are rare comprising only 1.9%, 0.1% and 0.2% of respectively the total number of species, abundance and biomass (wet-weight). The ophiurid *Amphipholis squamata* and the holothurid *Leptosynapta inharens* were the most frequent species, present in 18 and 9 stations, and comprised a total of 106 individuals, which represents 92% of the total Echinoderms abundance.

The remaining taxonomic groups, Phoronids, Sipunculids, Anthozoans, Nemerteans, Ascidians, Cephalocordates, Platyhelminthes and Fishes (included in Varia, *cf.* table V.1), represent 4,7% of the total number of species, 1.8% of the abundances and 6.5% of the total wet-weight biomass.

The species with sampling frequency > 10% were the Anthozoan spA, Nemertean spC, *Phoronis* sp, Nemertean spA, *Virgularia mirabilis* and the Nemertean spB, present respectively in 18, 23, 25, 35, 53 and 71 sampling stations.

In terms of total abundance the Nemerteans spA and spB, *Virgularia mirabilis* and *Phoronis* sp, represented respectively by 464, 288, 299 and 110 individuals, comprise 83% of the total abundances of the Varia. Of these species, *V. mirabilis* presents a particular distribution in the estuary as shown in figure 5.35.

Considering the wet-weight biomass, the most important species were the Anthozoan spA (86.4 g), *Virgularia mirabilis* (52.2 g), the Nemertean spC (27.3 g) and the Sipunculids (11.9 g). Together they represent 96% of the total Varia wet-weight biomass.

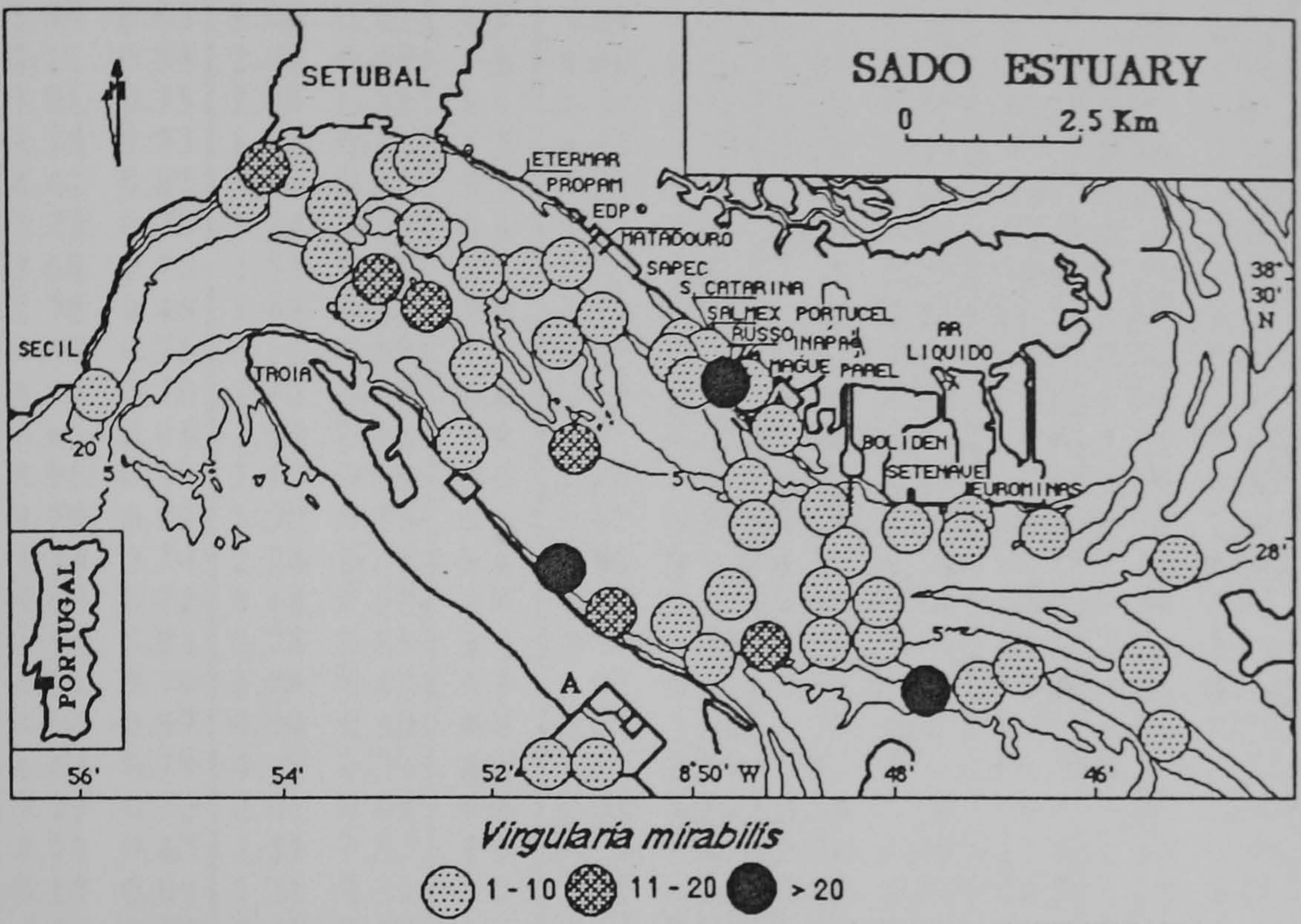


Figure 5.35 - Sado Estuary. Spatial distribution and local density (ind./0.1m2) of *Virgularia mirabilis*.

5.2.2. - Species Diversity (H') and Eveness (J)

5.2.2.1. - Total Macrofauna

Species diversity (H') and eveness (J) were calculated for each of the sampling stations both with the abundance and wet-weight biomass values (table V.9).

The values of H', based on abundances, were in the range from 0.15 to 4.98 and 44% of the sampling stations (=58) showed values between 3.5 to 4.5.

The spatial distribution of this parameter is shown in figure 5.36. In general, H' decreases along the longitudinal axis seawards-inwards and horizontally in the northern channel, from the sandbanks towards the margins, and in the southern channel, from the sandbanks and the south margin towards the deeper regions.

St.	H'a	J a	H'b	J b	St.	H'a	J a	H'b	J b	St.	H'a	J a	H'b	J b
1	4.79	0.78	1.48	0.24	**45**	4.71	0.80	3.55	0.60	**89**	2.83	0.54	2.24	0.43
2	4.04	0.71	2.95	0.52	**46**	3.25	0.60	2.66	0.49	**90**	2.19	0.52	2.51	0.60
3	2.78	0.68	1.62	0.40	**47**	4.62	0.75	2.15	0.35	**91**	3.85	0.69	2.80	0.50
4	2.06	0.38	3.03	0.56	**48**	4.57	0.89	3.31	0.65	**92**	3.57	0.94	2.10	0.55
5	3.87	0.63	3.49	0.57	**49**	3.45	0.71	3.15	0.65	**93**	0.50	0.18	0.36	0.13
6	2.11	0.38	2.64	0.48	**50**	4.09	0.75	2.02	0.37	**94**	4.10	0.83	2.70	0.55
7	3.01	0.75	2.03	0.51	**51**	4.34	0.79	1.70	0.31	**96**	3.29	0.62	2.83	0.53
8	3.15	0.73	1.48	0.34	**52**	4.47	0.78	2.58	0.45	**97**	3.06	0.53	2.06	0.36
9	4.41	0.82	3.43	0.64	**53**	4.08	0.73	2.59	0.46	**98**	4.20	0.76	2.89	0.52
10	3.28	0.73	1.74	0.39	**54**	3.86	0.68	3.39	0.60	**99**	2.23	0.46	2.46	0.51
11	3.68	0.70	3.57	0.68	**55**	3.27	0.57	1.43	0.25	**100**	2.59	0.46	2.76	0.49
12	2.75	0.46	3.43	0.58	**56**	3.64	0.72	1.41	0.28	**101**	4.06	0.69	3.72	0.64
13	4.90	0.75	4.12	0.63	**57**	3.45	0.77	1.40	0.31	**102**	3.28	0.82	1.09	0.27
14	4.34	0.70	1.82	0.29	**58**	2.79	0.58	1.36	0.28	**103**	3.58	0.70	3.10	0.61
15	2.61	0.46	2.54	0.45	**59**	3.51	0.64	2.38	0.44	**104**	1.45	0.42	1.59	0.46
16	4.96	0.77	3.13	0.48	**60**	3.80	0.65	3.19	0.55	**105**	4.39	0.77	3.11	0.55
17	4.79	0.81	3.50	0.59	**61**	1.97	0.48	2.08	0.51	**106**	1.78	0.42	1.95	0.46
18	4.38	0.74	2.26	0.38	**62**	2.92	0.97	0.25	0.08	**107**	3.79	0.86	1.43	0.33
19	4.63	0.72	3.18	0.50	**63**	4.00	0.77	1.93	0.37	**108**	3.40	0.74	1.86	0.41
20	4.96	0.81	3.73	0.61	**64**	3.52	0.63	2.67	0.48	**109**	3.74	0.77	2.31	0.48
21	4.32	0.70	3.96	0.64	**65**	3.00	0.77	2.07	0.53	**110**	3.55	0.70	2.54	0.50
22	4.04	0.67	0.59	0.10	**66**	3.79	0.67	1.77	0.31	**111**	4.37	0.77	2.21	0.39
23	4.64	0.79	4.19	0.71	**67**	3.44	0.82	1.43	0.34	**112**	2.56	0.53	2.51	0.52
24	3.29	0.72	2.01	0.44	**68**	2.81	1.00	1.74	0.62	**113**	2.02	0.40	2.74	0.54
25	4.11	0.67	3.51	0.57	**69**	4.18	0.81	3.04	0.59	**114**	1.93	0.44	2.74	0.62
26	0.15	0.04	1.31	0.32	**70**	3.85	0.64	2.66	0.44	**115**	2.57	0.68	1.82	0.48
27	4.46	0.78	2.45	0.43	**71**	4.42	0.80	3.36	0.61	**116**	3.52	0.73	0.90	0.19
28	4.98	0.78	3.06	0.48	**72**	3.79	0.69	3.29	0.60	**117**	2.99	0.90	1.73	0.52
29	4.61	0.74	4.10	0.66	**73**	2.58	0.70	1.33	0.36	**118**	2.38	0.69	2.59	0.75
30	4.34	0.74	3.47	0.59	**74**	3.30	0.65	2.77	0.55	**119**	4.24	0.92	1.63	0.35
31	2.41	0.93	1.19	0.46	**75**	4.32	0.78	3.51	0.63	**121**	1.99	0.77	1.24	0.48
32	3.75	0.96	1.41	0.36	**76**	3.43	0.65	2.32	0.44	**122**	3.76	0.75	2.47	0.49
33	4.28	0.82	0.67	0.13	**77**	2.99	0.51	2.90	0.49	**123**	2.29	0.59	2.44	0.63
34	3.13	0.63	2.88	0.58	**78**	3.34	0.85	2.09	0.53	**124**	3.90	0.74	1.80	0.34
35	4.12	0.75	3.08	0.56	**79**	4.12	0.69	3.59	0.60	**125**	0.45	0.23	0.99	0.49
36	4.50	0.75	2.07	0.35	**80**	4.08	0.77	1.84	0.35	**126**	1.81	0.78	1.58	0.68
37	4.87	0.80	4.17	0.69	**81**	4.16	0.71	2.63	0.45	**127**	3.28	0.84	1.28	0.33
38	4.21	0.73	2.59	0.45	**82**	2.43	0.46	2.84	0.54	**128**	2.18	0.59	1.98	0.54
39	3.46	0.58	3.11	0.52	**83**	4.70	0.79	3.88	0.65	**129**	4.04	0.74	2.37	0.43
40	3.86	0.65	3.48	0.58	**84**	3.48	0.62	1.97	0.35	**130**	4.01	0.79	2.26	0.44
41	3.85	0.70	3.25	0.59	**85**	4.24	0.76	2.36	0.42	**131**	3.36	0.78	2.03	0.47
42	3.47	0.68	2.94	0.57	**86**	2.80	0.61	0.68	0.15	**132**	3.57	0.84	2.84	0.67
43	4.89	0.78	4.06	0.65	**87**	3.48	0.72	2.79	0.58	**133**	4.02	0.87	0.64	0.14
44	4.68	0.79	3.47	0.58	**88**	3.71	0.76	2.82	0.58					

Table V.9 - Species diversity (H') and eveness (J) for each of the sampling stations, based on their abundance (a) and wet-weight biomass (b).

The highest values (H'>4.50) correspond mainly to stations between the entrance and the sandbanks, though extending inwards through the southern channel. The lowest values (H≤2.50) are concentrated in the upper region of the estuary but are also scattered along the northern margin.

The spatial distribution of eveness is shown in figure 5.37. The J index varied between 0.04 to 1.00, with most stations having values between 0.6 and 0.8.

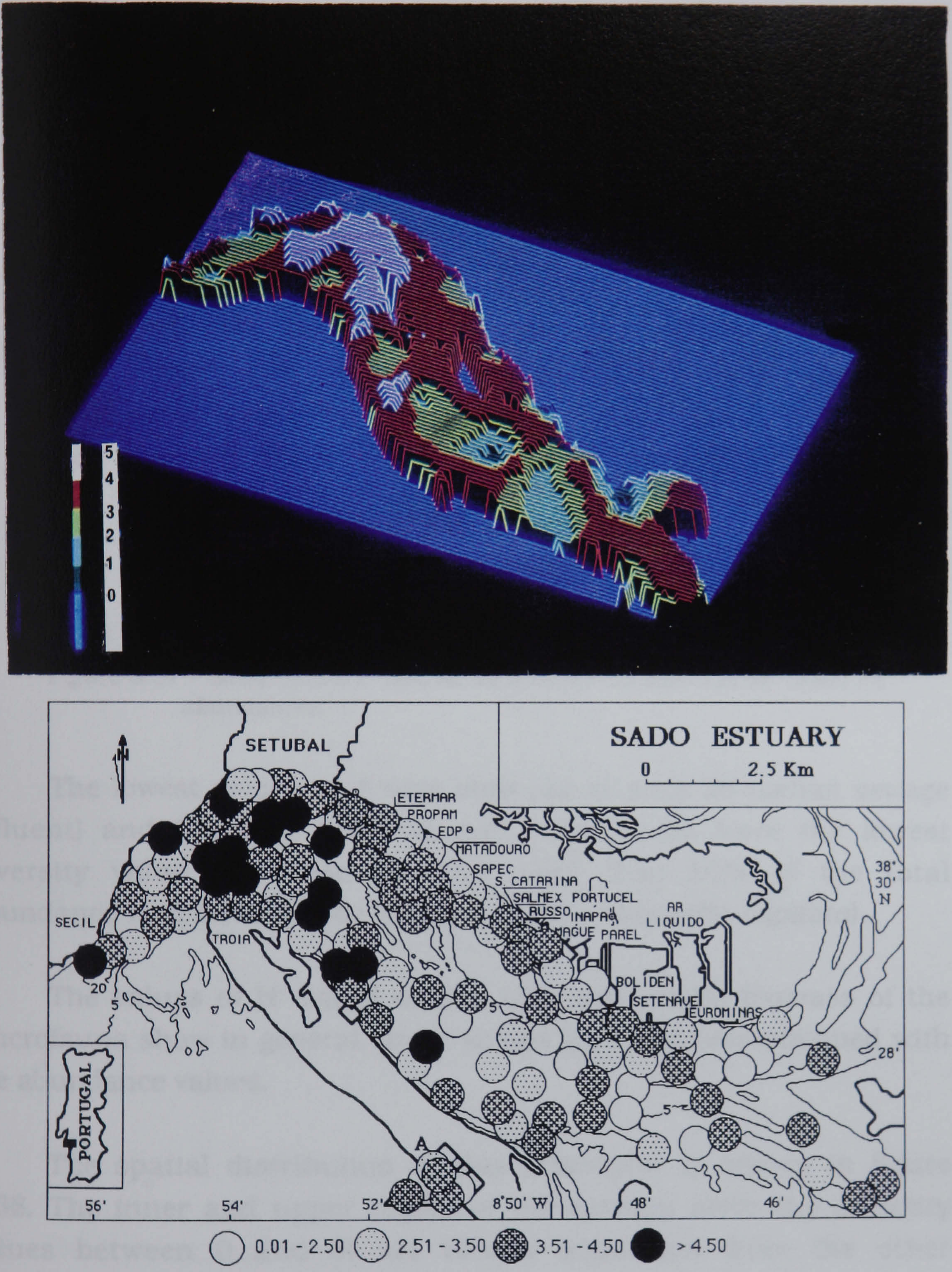


Figure 5.36 - Sado Estuary. Spatial distribution of species diversity (H') based on abundances. General (upper graph) and detailed view (lower graph).

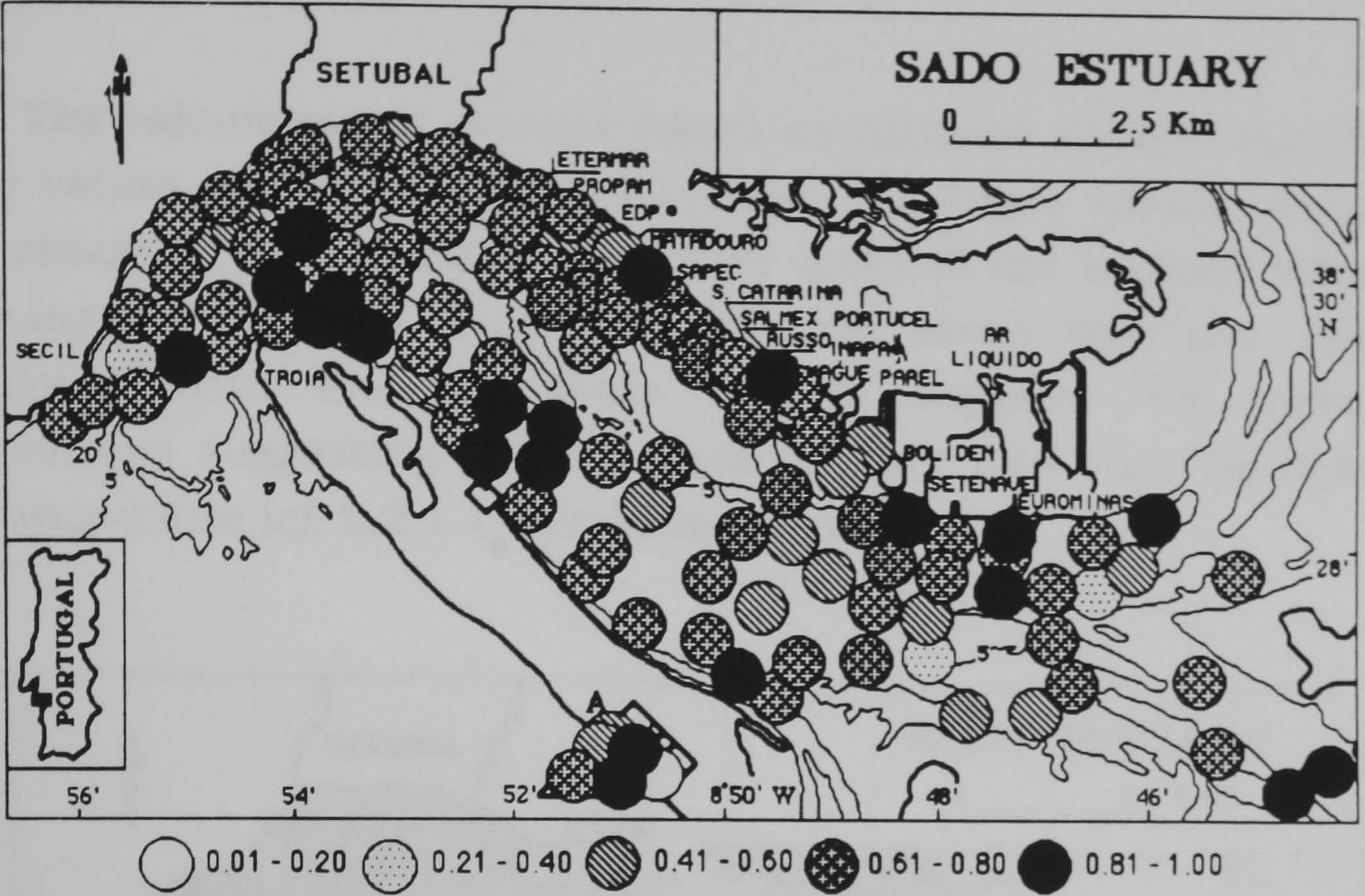


Figure 5.37 - Sado Estuary. Spatial distribution of Eveness (J) based on abundances.

The lowest values of J were obtained at sites 26 (urban sewage effluent) and 93 (pulp mill effluent), which also have the lowest diversity value. At these stations more than 50% of the total abundance is contributed by a single species (*Capitella capitata*).

The values of H' based on the total wet-weight biomass of the macrofauna show in general, lower values than the ones obtained with the abundance values.

The spatial distribution of this descriptor is shown in figure 5.38. The inner and upper region of the estuary (with the diversity values between 0 and 3) are clearly separated from the other estuarine areas with higher diversity values (> 3). Low values are also found in the northern channel, between Etermar and Sapec.

The longitudinal gradients defined previously on the basis of abundance data (*cf.* figure 5.36) are also evident here: thus values increase initially from the entrance towards the sandbanks and then, in general, the decrease towards the inner areas. However, the transverse gradients are not so clear as the ones derived from the abundance data.

The calculation of eveness based on biomass showed that 56% of the values are in the range of 0.4-0.6, i. e. lower values than the ones obtained with abundances, where most of the stations were in the range of 0.6-0.8. Together with the lower diversity values calculated with biomass these results support the previous observations suggesting that biomass is more unevenly distributed than abundance (*cf.* 5.2.1.1. Total Macrofauna).

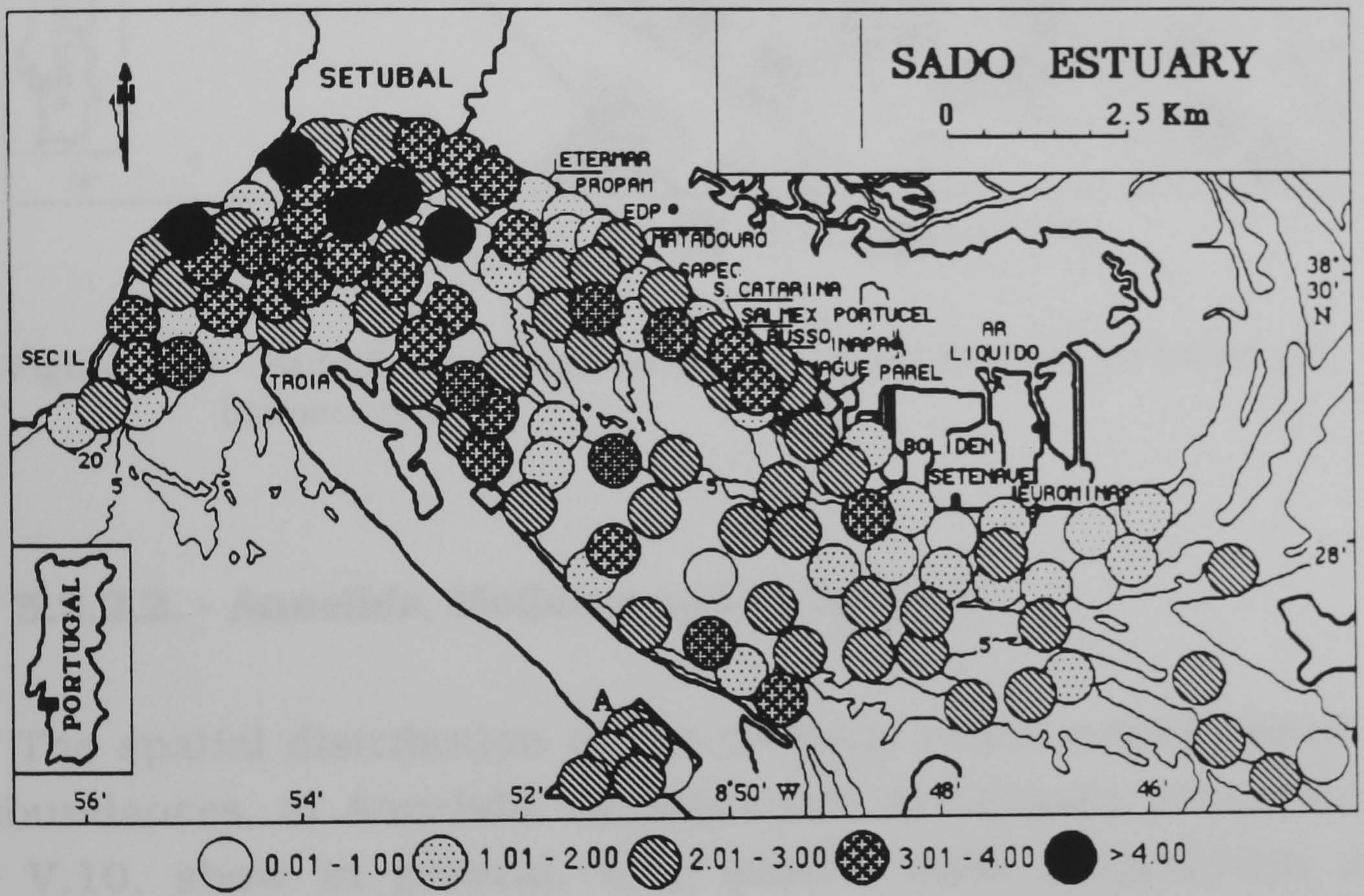


Figure 5.38 - Sado Estuary. Spatial distribution of species diversity (H') based on biomass data.

The spatial distribution of eveness based on biomass shown in figure 5.39, clearly separates the northern and southern channels of the estuary. The lowest values in both channels are found mainly near the margin.

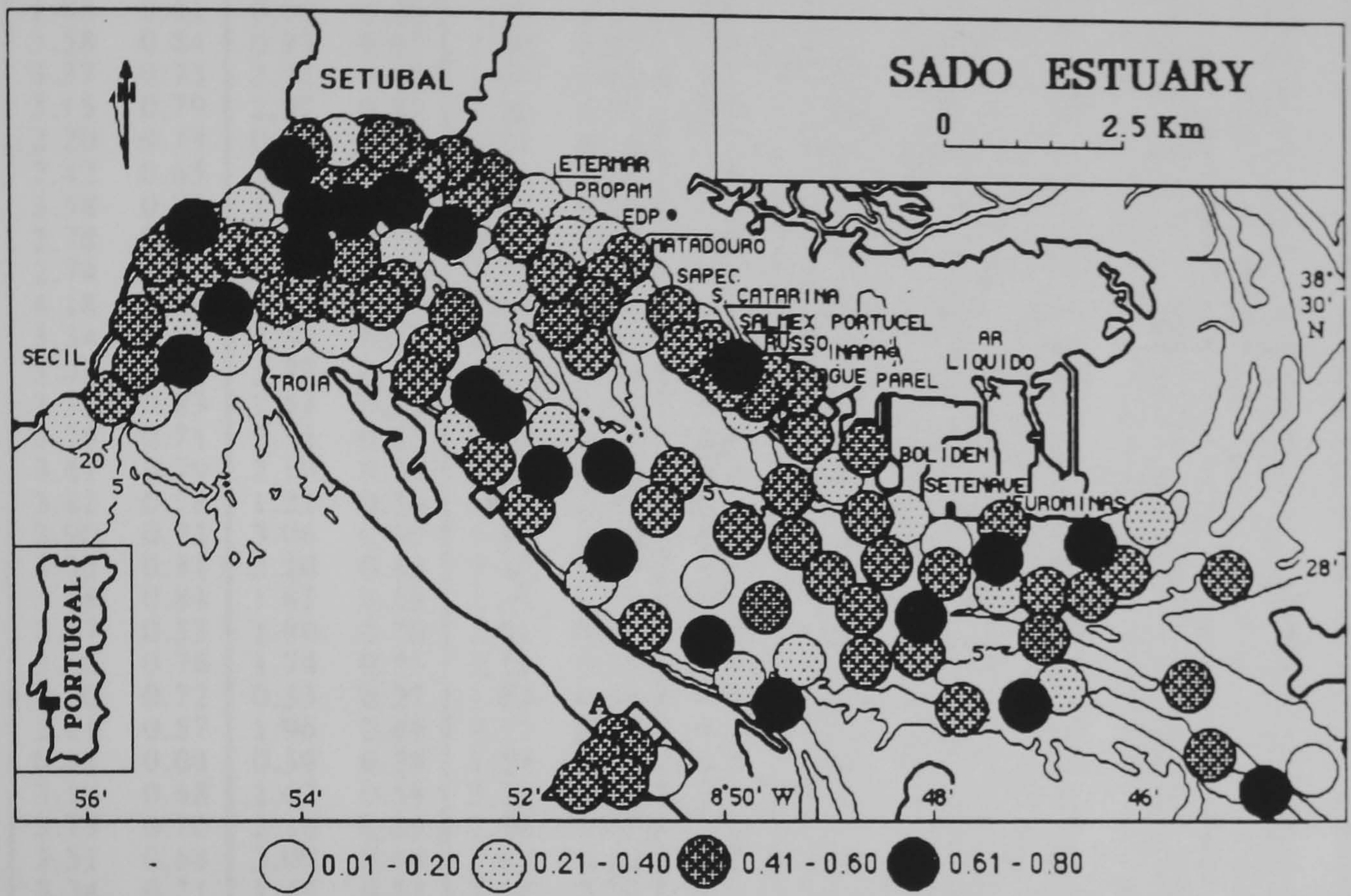


Figure 5.39 - Sado Estuary. Spatial distribution of Eveness (J) based on biomass data.

5.2.2.2. - Annelids, Molluscs and Arthropods

The spatial distribution of the diversity index values based on the abundances, of Annelids, Molluscs and Arthropods presented in table V.10, show in general, very similar close longitudinal and horizontal gradients, to the ones defined for the global macrofauna, with the values for the Annelids showing the closest similarities in spatial distribution.

Molluscs show a decreasing gradient from the margins towards the deeper areas of the entrance region, in the northern and southern channels. The area with the highest values extends further inside the two channels than the one obtained with global macrofauna. The stations with the lowest values are located mainly in the deeper region near the entrance, along the northern margin industrial belt, in deeper areas of the southern channel and near the beginning of Comporta channel.

St.	Ann.		Moll.		Arth.	
	H'	J	H'	J	H'	J
1	3.23	0.69	2.48	0.62	3.46	0.74
2	3.10	0.65	2.59	0.86	2.36	0.59
3	1.83	0.61	0.00	0.00	1.20	0.43
4	3.58	0.84	0.92	0.92	1.00	0.25
5	3.37	0.73	2.71	0.65	1.97	0.45
6	3.15	0.79	2.97	0.89	1.20	0.28
7	2.20	0.73	0.92	0.92	1.49	0.58
8	2.42	0.65	0.00	0.00	1.38	0.59
9	3.58	0.79	1.19	0.51	3.17	0.92
10	2.78	0.84	1.16	0.73	1.84	0.61
11	2.74	0.63	0.00	0.00	3.21	0.79
12	4.18	0.84	2.36	0.71	1.53	0.39
13	3.34	0.67	2.34	0.53	3.43	0.71
14	3.05	0.60	2.77	0.77	3.03	0.70
15	3.71	0.83	1.63	0.82	1.68	0.38
16	3.78	0.71	2.73	0.63	3.49	0.76
17	3.81	0.79	2.19	0.69	3.59	0.86
18	3.81	0.76	1.21	0.33	2.87	0.75
19	3.90	0.72	3.06	0.80	3.85	0.86
20	3.95	0.81	2.10	0.63	3.43	0.77
21	4.18	0.84	1.62	0.58	2.40	0.52
22	2.47	0.53	1.96	0.70	2.94	0.61
23	3.86	0.76	1.74	0.55	2.56	0.74
24	2.80	0.72	0.53	0.27	1.84	0.92
25	2.81	0.57	1.96	0.65	3.35	0.72
26	0.11	0.04	0.59	0.29	1.55	0.77
27	3.18	0.68	1.67	0.56	3.29	0.82
28	3.73	0.70	2.18	0.69	3.56	0.75
29	3.51	0.68	3.09	0.89	3.61	0.82
30	3.34	0.71	1.45	0.52	3.26	0.73
31	1.46	0.92	0.00	0.00	1.38	0.87
32	3.02	0.95	1.37	0.86	1.52	0.96
33	3.95	0.90	1.66	0.59	3.00	1.00
34	2.60	0.61	0.79	0.40	2.73	0.97
35	3.36	0.71	0.53	0.34	3.27	0.88
36	3.60	0.75	1.88	0.63	2.93	0.64
37	3.91	0.78	2.63	0.79	2.86	0.66
38	3.34	0.71	1.96	0.76	2.66	0.61
39	2.24	0.47	0.97	0.31	3.83	0.87
40	2.65	0.56	1.50	0.41	2.80	0.69
41	2.77	0.64	1.15	0.36	2.76	0.72
42	2.72	0.62	0.70	0.35	2.79	0.88
43	3.74	0.75	2.96	0.86	3.44	0.71
44	3.35	0.71	2.91	0.81	3.66	0.83
45	4.02	0.85	2.45	0.87	3.02	0.71
46	2.51	0.60	2.28	0.88	1.51	0.38
47	3.87	0.78	3.12	0.75	2.73	0.62
48	4.03	0.89	1.00	1.00	2.65	0.83
49	3.18	0.74	0.00	0.00	2.72	0.97
50	2.91	0.70	1.89	0.73	2.94	0.73
51	3.39	0.85	2.45	0.77	2.71	0.66
52	3.19	0.71	3.13	0.94	3.02	0.72
53	3.37	0.77	3.08	0.89	2.35	0.60
54	2.65	0.58	1.27	0.42	2.63	0.63
55	2.21	0.49	2.54	0.80	3.06	0.73
56	3.16	0.77	2.22	0.86	1.42	0.47
57	2.65	0.74	0.40	0.40	1.69	0.60
58	1.18	0.33	0.00	0.00	3.03	0.78
59	2.42	0.56	2.39	0.93	2.35	0.60
60	2.70	0.56	2.55	0.91	2.82	0.68
61	2.05	0.65	0.92	0.92	0.25	0.11
62	2.25	0.97	0.00	0.00	0.92	0.92
63	3.03	0.71	2.15	0.77	2.86	0.86
64	2.40	0.53	2.45	0.77	2.58	0.72
65	2.65	0.84	0.00	0.00	1.19	0.51
66	2.93	0.66	0.47	0.17	2.93	0.69
67	3.02	0.82	0.00	0.00	1.84	0.92
68	1.58	1.00	1.00	1.00	1.00	1.00
69	3.41	0.82	0.83	0.32	3.16	0.91
70	2.96	0.60	2.38	0.63	3.33	0.80
71	3.43	0.75	1.79	0.90	3.20	0.84
72	2.60	0.60	2.17	0.65	2.97	0.76
73	0.99	0.49	0.00	0.00	2.95	0.98
74	2.58	0.62	0.85	0.53	1.83	0.58
75	3.31	0.75	3.12	0.98	2.97	0.83
76	2.53	0.62	0.89	0.35	2.80	0.73
77	1.97	0.42	2.55	0.77	3.24	0.73
78	2.99	0.86	0.00	0.00	2.00	1.00
79	3.21	0.66	2.90	0.92	2.96	0.68
80	2.84	0.69	2.15	0.77	2.93	0.79
81	3.53	0.73	1.43	0.62	2.35	0.53
82	1.74	0.41	0.94	0.33	2.94	0.89
83	3.87	0.77	2.79	0.81	2.79	0.73
84	2.58	0.60	2.67	0.80	1.72	0.42
85	3.18	0.71	3.06	0.85	2.40	0.69
86	2.22	0.57	1.92	0.96	1.92	0.96
87	3.13	0.75	0.55	0.28	2.16	0.93
88	3.00	0.77	0.87	0.37	2.10	0.75
89	2.16	0.52	1.92	0.96	3.43	0.90
90	1.48	0.44	1.91	0.95	1.79	0.90
91	2.80	0.60	2.25	0.97	2.65	0.70
92	3.06	0.92	0.00	0.00	1.92	0.96
93	0.47	0.18	0.00	0.00	0.00	0.00
94	3.14	0.80	2.25	0.97	2.95	0.98
96	2.19	0.51	0.88	0.56	2.60	0.70
97	3.02	0.64	1.99	0.86	1.79	0.43
98	3.14	0.74	1.53	0.51	2.84	0.68
99	1.80	0.43	1.50	0.95	2.69	0.96
100	1.98	0.44	2.38	0.64	2.29	0.62
101	3.36	0.69	2.18	0.69	1.77	0.43
102	1.90	0.82	1.02	0.51	1.65	0.64
103	2.63	0.66	1.92	0.96	3.25	0.88
104	1.29	0.41	0.00	0.00	0.00	0.00
105	3.45	0.74	2.64	0.83	2.83	0.77
106	1.37	0.40	0.67	0.42	2.24	0.96
107	2.89	0.83	1.58	1.00	2.22	0.86
108	2.89	0.76	0.92	0.92	2.29	0.82
109	3.26	0.83	0.40	0.20	2.61	0.93
110	2.82	0.66	1.49	0.64	2.78	0.93
111	3.44	0.76	2.54	0.80	2.31	0.59
112	1.78	0.48	2.29	0.81	2.41	0.86
113	1.63	0.39	1.38	0.59	2.93	0.92
114	1.37	0.37	1.92	0.96	1.50	0.95
115	2.31	0.67	0.00	0.00	1.00	1.00
116	2.45	0.68	0.56	0.28	2.86	0.86
117	1.91	0.95	0.00	0.00	1.89	0.81
118	1.10	0.70	0.83	0.53	1.92	0.96
119	3.42	0.92	1.50	0.95	2.85	0.95
121	1.75	0.76	0.00	0.00	0.00	0.00
122	3.19	0.78	0.56	0.22	3.06	0.92
123	1.22	0.43	1.55	0.77	1.52	0.96
124	3.18	0.74	0.48	0.19	2.50	0.75
125	0.13	0.13	0.00	0.00	0.92	0.92
126	0.92	0.92	0.50	0.50	0.00	0.00
127	3.07	0.83	0.65	0.65	0.00	0.00
128	1.72	0.57	0.00	0.00	2.00	1.00
129	3.49	0.82	2.37	0.92	1.92	0.49
130	3.09	0.76	0.61	0.38	2.58	0.72
131	2.36	0.74	1.99	0.77	0.59	0.59
132	2.42	0.76	1.10	0.69	1.92	0.74
133	3.05	0.92	0.31	0.31	3.17	0.88

Table V.10 - Species diversity (H') and eveness (J) values, based on the abundance data of Annelids, Arthropods and Molluscs, for each sampling station. St.-Stations, Ann.-Annelids, Moll.-Molluscs, Arth.-Arthropods.

Arthropods showed lowest values near the entrance, along the northern margin industrial belt, in the upper region, at the beginning of Alcácer channel and in some patches in the southern channel. Highest values were mainly found between the entrance and the beginning of the intertidal sandbanks.

Eveness based on the abundance of the three groups didn't show clear areas of similar values in the estuary. Both Annelids and Arthropods showed higher and lower values in both channels, near the entrance and in the upper region. Molluscs are the only group which show a distinction between the region near the southern and northern margins, the latter with the lowest values. In addition a patch of very low values (stations 117, 120, 121, 125 and 128) was presented in the upper region.

Species diversity indices based on the biomass values of each the three groups (table V.11) show that the Annelids had lowest values in the northern channel, mainly near the margin, and in the upper region of the estuary in front of Boliden/Setenave/Eurominas. Higher values were found in the region between the entrance and the beginning of the sandbanks and along the southern margin.

Molluscs did not show a clear distinction between northern and southern channels and most of the highest values are concentrated near the entrance region (stations 16,19,21, 29, 37, 39, 40 and 41).

Arthropods most clearly showed a distinction between the region from the estuarine entrance to the end of the sandbanks of Campanário e Cabra, with the highest values, and the remaining landward region of the estuary. This is in fact very similar to the spatial distribution of Arthropods biomass, being mainly determined by the high proportion of *U. cf. typica* biomass in the upper region of the estuary. This group also delineates clearly the proximal region of the northern channel with very low values.

The spatial distribution of the H' values of the global macrofauna based in biomass seems thus to be mostly a result of the diversity of all the different groups and not as in the case of H' values based on abundance, a result mainly due to Annelids.

St.	Ann.		Moll.		Arth.		St.	Ann.		Moll.		Arth.	
	H'	J	H'	J	H'	J		H'	J	H'	J	H'	J
1	3.25	0.70	1.26	0.32	3.63	0.77	67	1.65	0.45	0.00	0.00	0.25	0.13
2	3.21	0.68	1.38	0.46	2.42	0.61	68	0.89	0.56	0.86	0.86	0.99	0.99
3	0.50	0.17	0.00	0.00	1.93	0.69	69	2.88	0.69	1.38	0.53	0.27	0.08
4	1.42	0.32	0.79	0.79	1.65	0.40	70	3.10	0.63	1.67	0.44	0.40	0.10
5	2.99	0.64	2.50	0.60	2.61	0.59	71	3.34	0.73	0.61	0.30	2.14	0.56
6	1.93	0.48	1.90	0.57	1.35	0.31	72	2.58	0.60	2.15	0.65	1.08	0.28
7	0.42	0.14	0.84	0.84	0.62	0.24	73	0.44	0.22	0.00	0.00	1.40	0.47
8	2.50	0.68	0.00	0.00	1.06	0.46	74	2.66	0.64	1.04	0.66	1.23	0.39
9	3.43	0.76	1.37	0.59	2.45	0.71	75	2.83	0.64	2.03	0.64	0.50	0.14
10	0.66	0.20	0.56	0.35	0.76	0.25	76	1.23	0.30	1.76	0.68	1.59	0.42
11	2.57	0.60	0.00	0.00	2.59	0.63	77	2.92	0.62	1.36	0.43	1.12	0.25
12	1.71	0.35	1.04	0.31	2.03	0.52	78	1.55	0.45	0.00	0.00	1.20	0.60
13	3.09	0.62	3.68	0.84	3.26	0.67	79	2.00	0.41	2.36	0.74	1.17	0.27
14	2.73	0.54	1.29	0.36	2.91	0.67	80	1.94	0.47	1.34	0.48	2.27	0.61
15	2.50	0.56	1.74	0.87	2.11	0.48	81	1.56	0.32	0.59	0.25	3.17	0.72
16	3.93	0.74	2.25	0.52	2.92	0.64	82	1.69	0.40	1.70	0.61	0.28	0.08
17	2.60	0.54	1.78	0.56	2.56	0.61	83	3.70	0.73	2.47	0.71	1.94	0.51
18	3.12	0.62	1.40	0.38	2.79	0.73	84	2.36	0.55	1.42	0.43	2.49	0.61
19	4.12	0.76	2.13	0.56	0.69	0.15	85	3.34	0.75	1.95	0.54	2.72	0.79
20	3.42	0.70	1.85	0.56	3.36	0.75	86	1.58	0.41	0.20	0.10	1.40	0.70
21	3.40	0.68	1.59	0.57	3.05	0.66	87	2.91	0.70	1.48	0.74	0.05	0.02
22	3.04	0.65	0.33	0.12	1.95	0.41	88	1.96	0.50	0.66	0.28	0.47	0.17
23	3.37	0.66	2.15	0.68	2.33	0.65	89	1.65	0.39	1.11	0.56	3.25	0.85
24	1.63	0.42	0.06	0.03	1.70	0.85	90	2.11	0.64	1.60	0.80	0.41	0.20
25	3.02	0.62	1.88	0.63	2.97	0.64	91	2.70	0.58	0.88	0.38	1.68	0.44
26	0.07	0.02	0.56	0.28	0.44	0.22	92	1.74	0.52	0.00	0.00	0.97	0.48
27	2.10	0.45	1.81	0.60	2.86	0.72	93	0.32	0.13	0.00	0.00	0.00	0.00
28	3.26	0.61	1.64	0.52	2.18	0.46	94	2.69	0.69	1.61	0.69	0.30	0.10
29	3.91	0.76	2.17	0.63	2.62	0.60	96	1.97	0.45	1.11	0.7	2.53	0.68
30	3.45	0.73	1.93	0.69	3.54	0.79	97	1.06	0.23	2.12	0.91	1.94	0.47
31	0.94	0.59	0.00	0.00	0.33	0.21	98	1.26	0.30	1.65	0.55	0.80	0.19
32	0.38	0.12	0.42	0.27	1.04	0.66	99	1.80	0.43	0.87	0.55	0.90	0.32
33	3.02	0.69	0.60	0.22	1.82	0.61	100	2.08	0.47	1.64	0.44	1.23	0.33
34	1.89	0.45	1.90	0.95	2.27	0.81	101	3.51	0.72	1.30	0.41	0.74	0.18
35	3.86	0.81	0.40	0.25	2.80	0.76	102	1.43	0.62	0.71	0.35	1.81	0.70
36	2.89	0.60	1.58	0.53	3.49	0.76	103	2.50	0.62	1.29	0.64	2.83	0.77
37	3.15	0.63	2.41	0.73	3.13	0.72	104	0.90	0.29	0.00	0.00	0.00	0.00
38	3.32	0.71	0.74	0.29	2.31	0.53	105	3.07	0.66	2.09	0.70	1.60	0.43
39	3.46	0.73	2.05	0.65	0.51	0.12	106	1.03	0.30	0.85	0.54	1.94	0.83
40	2.39	0.50	2.22	0.60	2.72	0.67	107	1.26	0.36	1.10	0.69	2.12	0.76
41	2.57	0.60	2.45	0.77	2.21	0.58	108	2.44	0.64	0.02	0.02	1.52	0.54
42	2.65	0.60	1.06	0.53	2.08	0.66	109	2.99	0.76	0.19	0.09	0.15	0.05
43	3.78	0.76	1.59	0.46	3.79	0.78	110	2.03	0.48	0.51	0.22	1.36	0.45
44	2.86	0.61	1.40	0.39	3.23	0.73	111	3.40	0.75	1.41	0.45	1.15	0.29
45	2.93	0.62	0.83	0.30	3.11	0.73	112	1.71	0.46	1.67	0.59	2.26	0.81
46	1.89	0.45	1.60	0.62	2.00	0.50	113	1.58	0.38	1.05	0.45	0.15	0.05
47	2.92	0.59	0.91	0.22	3.32	0.76	114	2.26	0.61	1.34	0.67	0.10	0.06
48	3.44	0.76	0.07	0.07	0.51	0.16	115	1.10	0.32	0.00	0.00	0.12	0.12
49	2.72	0.63	0.00	0.00	1.82	0.65	116	2.02	0.56	0.38	0.19	1.32	0.40
50	2.74	0.66	0.88	0.34	2.41	0.60	117	1.02	0.51	0.00	0.00	1.97	0.85
51	2.57	0.64	1.38	0.44	2.67	0.65	118	0.31	0.19	1.49	0.94	1.08	0.54
52	3.11	0.70	2.13	0.64	3.03	0.73	119	2.87	0.78	0.25	0.16	0.26	0.09
53	2.47	0.56	1.20	0.35	1.88	0.48	121	1.17	0.50	0.00	0.00	0.00	0.00
54	2.41	0.53	2.16	0.72	2.13	0.51	122	3.15	0.77	1.41	0.54	0.10	0.03
55	1.25	0.28	0.61	0.19	1.95	0.47	123	1.32	0.47	1.04	0.52	0.91	0.57
56	2.82	0.69	0.51	0.2	1.05	0.35	124	2.48	0.57	1.80	0.70	0.11	0.03
57	1.37	0.38	0.88	0.88	1.74	0.62	125	0.04	0.04	0.00	0.00	0.02	0.02
58	0.48	0.13	0.00	0.00	0.18	0.05	126	0.22	0.22	0.15	0.15	0.00	0.00
59	1.62	0.38	1.57	0.61	1.80	0.46	127	1.03	0.28	0.45	0.45	0.00	0.00
60	3.67	0.76	1.83	0.65	2.59	0.62	128	1.69	0.56	0.00	0.00	1.63	0.81
61	1.80	0.57	0.28	0.28	0.34	0.14	129	3.06	0.72	0.50	0.19	1.51	0.39
62	0.09	0.04	0.00	0.00	0.67	0.67	130	3.16	0.77	0.32	0.20	0.78	0.22
63	2.16	0.51	1.45	0.52	2.01	0.61	131	2.14	0.67	1.08	0.42	1.00	1.00
64	2.80	0.62	1.77	0.56	2.07	0.58	132	2.18	0.69	1.12	0.70	1.09	0.42
65	1.48	0.47	0.00	0.00	0.41	0.18	133	0.73	0.22	0.07	0.07	3.10	0.87
66	2.63	0.59	0.54	0.19	2.12	0.50							

Table V.11 - Species diversity (H') and eveness (J) values, based on the biomass data of Annelids, Arthropods and Molluscs, for each sampling station. St.-Stations; Ann.-Annelids; Moll.-Molluscs; Arth.-Arthropods.

Eveness values based on the biomass of Annelids clearly separate the northern channel and the upper region, with lower values, in the entrance area and southern channel of the estuary. With the Arthropods and mainly with the Molluscs this distincton is not so clear. It is nevertheless evident in the spatial distribution of eveness derived from Arthropods biomass that most of the stations located near the northern margin and upper region have low values.

5.2.3 - SAB model, Abundance ratio (A/S) and Size ratio (B/A)

The abundance ratio and the size ratio were calculated for all the sampling stations (table V.12). Groups of stations of low A/S values appeared in the entrance region, in the northern channel (mainly along the margin), in the southern channel (in areas of coarse sediments), in the upper region of the estuary (in front of Boliden Setenave and Eurominas), and in the Alcácer channel. Some of these regions also presented the lowest B/A ratio: stations 2, 3, 7 to 9 and 11 near the entrance region, 73 and 92 in the northern channel, 71 and 48 in the southern channel, stations 107, 114 to 117, 119, 121 and 126 to 128 in the upper region, and stations 123, and 131 to 133 in the Alcácer channel.

The succession of the size ratio and the abundance ratio together with species richness, abundance, and biomass were analysed along some sets of stations. The objective was to identify if in the estuary there were gradients of organic enrichment, able to induce in the benthic community parameters the changes suggested by the SAB model (Pearson & Rosenberg, 1978) and by the A/S and B/A sucession (Pearson *et al.*, 1982).

Stations	A/S	B/A	Stations	A/S	B/A	Stations	A/S	B/A
1	8.1	103.0	45	12.8	13.3	89	10.6	22.3
2	6.1	7.9	46	8.8	27.5	90	6.3	32.4
3	7.0	9.2	47	13.1	39.0	91	13.9	26.2
4	16.9	2.3	48	2.7	7.3	92	1.9	8.2
5	26.1	34.4	49	8.7	2.0	93	172.0	3.4
6	21.5	16.0	50	9.5	36.8	94	2.9	130.0
7	4.8	4.7	51	6.4	152.1	96	10.3	8.4
8	4.7	6.4	52	6.6	131.1	97	29.2	16.0
9	4.7	5.2	53	10.2	46.3	98	10.7	70.1
10	4.0	36.3	54	17.5	18.7	99	13.0	14.0
11	5.4	2.6	55	18.9	75.2	100	23.3	33.9
12	32.2	1.9	56	6.9	55.6	101	13.7	9.3
13	8.9	89.1	57	11.7	72.0	102	5.0	66.4
14	15.1	79.3	58	7.2	47.6	103	10.5	16.2
15	21.1	5.2	59	15.4	57.4	104	7.7	44.7
16	13.7	38.5	60	23.6	31.5	105	9.4	72.0
17	9.8	16.0	61	15.6	23.0	106	17.5	10.3
18	11.9	57.7	62	1.3	298.0	107	3.0	45.8
19	11.8	39.8	63	13.2	99.3	108	10.6	26.7
20	10.3	16.5	64	12.5	45.1	109	9.7	52.6
21	17.5	5.2	65	3.7	23.0	110	9.0	20.7
22	16.1	124.7	66	12.8	23.4	111	10.3	89.2
23	12.0	19.5	67	3.8	20.1	112	14.0	99.3
24	6.5	22.6	68	1.0	63.4	113	28.3	14.4
25	12.9	14.8	69	5.2	56.2	114	6.6	64.5
26	866.5	5.0	70	13.4	57.7	115	4.0	17.9
27	14.6	43.7	71	6.9	17.2	116	5.0	148.0
28	11.9	39.9	72	15.3	28.5	117	2.2	16.8
29	9.2	21.0	73	2.4	17.9	118	10.7	15.5
30	10.9	21.9	74	15.1	29.3	119	2.3	82.0
31	2.2	42.9	75	6.1	68.9	121	2.5	16.0
32	1.5	390.9	76	15.8	12.9	122	12.0	44.6
33	3.3	1406.4	77	21.2	44.7	123	4.7	53.4
34	9.1	32.9	78	2.9	4.9	124	12.6	24.6
35	10.4	19.1	79	15.1	84.4	125	15.0	54.0
36	13.8	104.3	80	13.2	97.4	126	2.8	94.5
37	10.0	13.2	81	19.5	25.7	127	5.1	8.7
38	9.9	25.1	82	24.2	12.1	128	4.7	13.4
39	17.6	54.7	83	10.1	27.1	129	8.2	53.8
40	26.0	45.9	84	19.3	74.2	130	7.9	37.2
41	16.6	116.6	85	11.0	161.9	131	5.8	54.4
42	15.1	19.4	86	5.1	90.5	132	4.8	14.2
43	8.2	9.0	87	19.9	20.7	133	3.7	231.6
44	10.1	24.2	88	11.1	21.6			

Table V.12 - Abundance (A/S) and size ratios (B/A) for each of the sampling stations.

A list of the cases tested is presented in table V.13. The sequence of the sites was searched having in mind the potential sources of anthropogenic and natural organic inputs (the effluents along the northern margin, Marateca, Comporta and Alcácer channel) and also the general hydrodynamics of the estuary.

In only two sets of stations did the sucession of S, A and B follow that suggested by the SAB model. These gradients were established from station 26, the urban outfall, to 25, 21, 16 and 8, and from 95 to 93 (pulp mill outfall) to 96, 97, 105, 108 and 104.

Entrance	North Channel	Upper Region
26-25-21-16 -8	41-42-43	107-105-98-81-71
26-25-21-20-8	41-54-53-51-64	116-107-105-98-82
26-25-22	41-54-53-52-64	116-107-105-99-82
26-25-22-22-15	56-54-51	117-118-119
26-27-37-36-30/31	56-55-52-64	120-118-115-108
26-27-38-42	57-53-52-64	120-126-128-125
26-27-39-40-41-56	57-55-53-51-64	120-126-128-125-121-119
26-28-37-43	57-55-53-52-64	120-126-128-129
26-28-29-30	58-59-53-51	
	58-59-60-52	**Alcácer Channel**
South Channel	58-59-60-64	132-131-122-114
102-101-100-86	61-59-53-51	132-131-124
102-101-100-87-98	61-59-60-64	132-131-124-113-110
102-101-100-87-99	61-63-60-52/64	133-130-121
102-101-100-99	62-63-60-52	133-130-122-114-108
102-101-100-104	62-63-60-64	133-132-131
102-101-100-109	62-63-66/64	
102-111-110-113	65-72-76-77-80	
102-111-112-123	70-68-67	
	78-79-80	
	84-83-82-81	
	88-79-77-76	
	88-79-80	
	89-90-91	
	92-90-79-77-76	
	92-94-96-97-105	
	93-94-91	
	93-94-96-97-105	
	95-93-92-89-90-94-96-97-105-104	
	95-93-92-90-94-96-97-105-104	
	95-93-92-94-96-97-105-108-104	
	95-93-92-96-105-108-104	
	95-93-96-97-105-108-104	
	95-93-96-97-105-108-104-82/98/99	
	95-94-96-97-105-108-104	
	106-97-105-99/98	

Table V.13 - Sets of stations where the sucession of S, A, B, A/S and B/A was analysed.

Tables V.14 and V.15 show the variation of S, A, B, A/S and B/A in these two sets of stations. In table V.14 it is clear that there is a peak of abundance and biomass (peak of opportunists) at station 26, a decrease of abundance along the sets of stations and the opposite variation sense of the A/S ratio and the B/A ratio.

	STATIONS				
	26	25	21	16	8
S	17	71 +	73 +	89 +	20 -
A	14731	966 -	1279 -	1218 -	94 -
B(ww)	73.75	14.25 -	6.68 +	46.89 +	0.61 -
A|S	866.5	12.9 -	17.5 +	13.7 -	4.7 +
B|A	5.0	14.8 +	5.2 -	38.5 +	6.4 -

Table V.14 - Variation of the species richness (S), abundance (A), biomass (B), abundance ratio (A/S) and size ratio (B/A) along stations near the urban outfall. The signs + and - indicates in a certain station the variability of a parameter in relation to the one of the station before.

The second gradient presented in table V.15, begins at station 95, where no macrofauna was found (grossly polluted area), towards 93 where the opportunists appear in high numbers. Then it was possible to identify a transition zone and an area disturbed in a lesser extent, by the input of organic material from the pulp mill (sites 108 and 104). Along this gradient B/A has a continuous increase which agrees with a decreasing disturbance, but A/S did not show the expected variation.

	STATIONS						
	95	93	96	97	105	108	104
S	0	7 +	40 +	53 +	51 -	24 -	11 -
A	0	1204 +	413 -	1548 +	477 -	254 -	85 -
B(ww)	0	4.12 +	3.47 -	24.7 +	34.36 +	6.78 -	3.80 -
A|S	0	172.0 +	10.3 -	29.2 +	9.4 -	10.6 +	7.7 -
B|A	0	3.4 +	8.4 +	16.0 +	72.0 +	26.7 -	44.7 -

Table V.15 - Variation of the species richness (S), abundance (A), biomass (B), abundance ratio (A/S) and size ratio (B/A) along stations near the pulp mill. The signs + and - indicates in a certain station the variability of a parameter in relation to the one of the anterior station.

The sets of stations situated in the region of EDP inflow and outflow, and also near the outfall of the abattoir effluent presented in table V.16 also show some similarities with the expected variations of S, A, B, A/S and B/A.

	STATIONS			
	61	59	53	51
S	17	44 +	49 +	45 -
A	266	678 +	499 -	287 -
B(ww)	6.13	38.89 +	23.12 -	43.65 +
A|S	15.6	15.4 -	10.2 -	6.4 -
B|A	23.0	57.4 +	46.3 -	152.1 +

	STATIONS			
	58	59	53	51
S	28	44 +	49 +	45 -
A	201	678 +	499 -	287 -
B(ww)	9.56	38.89 +	23.12 -	43.65 +
A|S	7.2	15.4 +	10.2 -	6.4 -
B|A	47.6	57.4 +	46.3 -	152.1 +

Table V.16 - Variation of the species richness (S), abundance (A), biomass (B), abundance ratio (A/S) and size ratio (B/A) along stations near EDP and the abbattoir. The signs + and - indicates in a certain station the variability of a parameter in relation to the one of the anterior station.

With most of the other station sets of the north channel an increase in at least 2 at the 3 primary biological variables, is apparent, when moving from the site nearest to margin,out towards the sandbanks.

For the southern channel some sets of sampling stations beginning at station 102 were analysed (*cf.* table V.13). This station is located in the region of this channel which showed sediments with the highest organic content. In most of these gradients the peak of species richness appears first (station 101) and only then the maximum of abundance together with the peak of biomass (station 100). A/S initially increases towards station 100 then decreases and B/A decreases towards station 101, increases from 101 to 100 and then decreases.

After analysing all the sets of stations presented in table V.13 it seems that it is not generally possible to establish spatial gradients in the Sado estuary by analysing individual stations, which match well with the SAB model and with the expected variation of A/S and B/A ratios along an organic gradient. The only two situations where this was possible were the most extreme cases identified in the estuary: the urban sewage and the pulp mill effluent.

The Sado estuary has heterogeneous sediments marked by different grades relatively close to each other, complex hydrodynamics and a complex mixture of anthropogenic inputs affecting the northern channel, in particular. These inputs could be responsible not only for disturbance due to organic enrichment but also, for example, toxicity due to heavy metals or other persistent chemicals. This could be the reason why sediments with similar granulometry and organic content show very different values for the same biological variables, sometimes within a short distance. In combination, all these interactive characteristics together with the variability introduced by sampling procedures, make it difficult to show "clear" effects and to identify and trace any one source of pollution (disturbance) or to assess its specific effect on the communities. This could also be the reason for the identification of only two clear gradients: these correspond to particular "hot spots" in the estuary but also, spatially, they are located at the two extremities of the northern channel.

These analyses will be developed in chapter 6 by modifying the spatial scale of analysis and by combining the individual values of stations in affinity groups.

5.3. - PRODUCTION

5.3.1. Introduction

Spatial analysis of the biomass values at each sampling station has allowed the identification of different areas in the estuary where the standing crop of benthic organisms differs widely. The production estimations which will be presented give some idea of the turnover rates of the benthic organisms within any particular area, taking into consideration that the single biomass measurement obtained could correspond to a mean value observed over certain period of time, namely one year (see Methods, Chapter 3)

5.3.2 - Results

The production estimations and the $P/\bar{B}$ ratio obtained for each of the sampling stations are presented in table V.17. The values ranged from a maximum of 218.15 g afdw/m^2/year, in station 26 (urban effluent), to a minimum of 0.26 g afdw/m^2/year, in station 115 and the turnover ratio from 0.63 in station 33 to 7.63 in station 73.

The production estimation for the Sado estuary, derived from allometric considerations, tends to show production increasing with increasing biomass, though dependant on the relative size of the organism. In the Sado estuary high total biomass at any station has two main causes: either high abundance of small specimens, namely opportunistic polychaetes, or the presence of larger organisms, namely Molluscs. As a result, in stations with similar biomass, production will be higher in the one with the lowest mean individual weight, which means with the highest number of small organisms. The following examples illustrate this effect:

Stations	Biomass(0.1m2)	Total Nb. Ind.	Production(0.1m2)
2	0.2322	317	0.671
4	0.2309	725	0.86
8	0.0551	94	0.17
31	0.052	13	0.09
32	1.0012	22	0.824
50	1.007	408	2.011
46	1.1312	370	2.117
58	1.1228	201	1.749
48	0.1579	93	0.353
65	0.1579	55	0.301
54	2.965	873	5.374
60	2.9461	1321	6.068
62	0.3463	10	0.31
104	0.3409	85	0.589
82	1.0263	920	2.609
114	1.0329	138	1.472
97	3.4158	1548	7.058
98	3.4608	501	5.055
101	2.9197	796	5.169
112	2.909	406	4.202
109	1.3787	280	2.232
113	1.363	963	3.223

Stations	Total Nb. Individuals	Total Biomass (g. afdw/0.1m2)	Mean Biomass Kcal	P:B	P (g. afdw/m2)
1	585	4.530	0.0387	1.411	63.90
2	317	0.232	0.0037	2.890	6.71
3	119	0.143	0.0060	2.488	3.55
4	725	0.231	0.0016	3.723	8.60
5	1123	3.902	0.0174	1.800	70.4
6	990	1.759	0.0089	2.207	38.82
7	76	0.039	0.0025	3.233	1.20
8	94	0.055	0.0029	3.092	1.70
9	198	0.116	0.0029	3.095	3.58
10	88	0.278	0.0158	1.852	5.15
11	206	0.076	0.0018	3.562	2.70
12	1994	0.420	0.0010	4.221	17.72
13	807	6.877	0.0426	1.370	94.23
14	1084	10.255	0.0473	1.327	136.12
15	1230	0.843	0.0034	2.949	24.84
16	1218	5.063	0.2078	1.704	86.29
17	589	2.542	0.0216	1.685	42.84
18	739	5.527	0.0374	1.426	78.80
19	989	3.875	0.1959	1.735	67.25
20	699	1.985	0.0142	1.914	37.99
21	1279	0.745	0.0029	3.098	23.07
22	1079	10.819	0.0501	1.304	141.09
23	710	1.583	0.0112	2.060	32.60
24	155	0.320	0.0103	2.109	6.75
25	966	3.676	0.0190	1.751	64.36
26	14731	6.458	0.0022	3.378	218.15
27	758	7.697	0.0508	1.300	99.99
28	986	4.123	0.0209	1.701	70.15
29	668	1.391	0.0104	2.103	29.26
30	643	1.525	0.0119	2.021	30.83
31	13	0.052	0.0200	1.724	0.90
32	22	1.001	0.2276	0.823	8.24
33	126	13.853	0.5497	0.630	87.24
34	282	1.042	0.0185	1.767	18.40
35	468	1.084	0.0116	2.036	22.08
36	868	9.044	0.0521	1.289	116.58
37	670	0.912	0.0062	2.393	21.82
38	543	1.776	0.0164	1.833	32.56
39	1108	8.050	0.0363	1.438	115.78
40	1638	7.008	0.0214	1.690	118.40
41	764	5.600	0.0366	1.434	80.33
42	527	0.938	0.0089	2.206	20.68
43	623	0.959	0.0077	2.305	21.61
44	607	1.407	0.0116	2.035	28.65
45	765	1.978	0.0129	1.969	38.95
46	370	1.131	0.0153	1.871	21.17
47	954	3.178	0.0167	1.823	57.93
48	93	0.158	0.0085	2.238	3.53
49	253	0.188	0.0037	2.878	5.40
50	408	1.007	0.0123	1.997	20.11
51	287	3.663	0.0638	1.212	44.39
52	343	4.267	0.0622	1.221	52.11
53	499	2.004	0.0201	1.722	34.51
54	873	2.965	0.0170	1.812	53.74
55	982	4.571	0.0233	1.647	75.27
56	228	1.029	0.0226	1.662	17.11
57	258	1.041	0.0202	1.720	17.90
58	201	1.123	0.0279	1.558	17.49
59	678	2.712	0.0200	1.724	46.77
60	1321	2.946	0.0112	2.060	60.68
61	266	0.479	0.0090	2.198	10.54
62	10	0.346	0.1732	0.895	3.10
63	487	3.575	0.0367	1.434	51.26
64	587	1.758	0.0150	1.883	33.10
65	55	0.158	0.0144	1.908	3.01

Table V.17 - Production estimations for each of the sampling station.

St.	Total N.ºInd.	Total Biomass	Mean Biomass	P:B	P
66	655	0.918	0.0070	2.372	21.77
67	68	0.163	0.0120	2.014	3.29
68	7	0.043	0.0306	1.515	0.65
69	186	1.284	0.0345	1.461	18.76
70	858	5.208	0.0304	1.519	79.12
71	319	1.045	0.0164	1.832	19.15
72	702	1.946	0.0139	1.928	37.51
73	31	0.065	0.0104	7.628	4.93
74	499	1.861	0.0186	1.761	32.79
75	281	2.085	0.0371	1.429	29.79
76	618	0.918	0.0074	2.331	21.39
77	1269	3.856	0.0152	1.875	72.29
78	44	0.028	0.0031	3.033	0.83
79	939	7.192	0.3830	1.415	101.80
80	513	2.994	0.0292	1.537	46.02
81	1130	4.121	0.0182	1.774	73.08
82	920	1.026	0.0056	2.542	26.09
83	617	3.501	0.0284	1.550	54.29
84	965	4.177	0.0216	1.684	70.33
85	537	5.648	0.0526	1.285	72.60
86	123	0.765	0.0311	1.508	11.54
87	556	1.180	0.0106	2.091	24.67
88	323	0.836	0.0129	1.969	16.45
89	403	1.090	0.0135	1.942	21.17
90	113	0.436	0.0193	1.743	7.60
91	665	1.298	0.0098	2.145	27.84
92	27	0.029	0.0053	2.577	0.74
93	1204	0.494	0.0020	3.447	17.03
94	86	0.827	0.0481	1.321	10.92
96	413	0.431	0.0052	2.596	11.18
97	1548	3.416	0.0110	2.066	70.58
98	501	3.461	0.0345	1.461	50.55
99	376	0.637	0.0085	2.239	14.27
100	1163	3.650	0.0157	1.856	67.76
101	796	2.920	0.0183	1.770	51.69
102	80	0.389	0.0243	1.625	6.32
103	356	0.574	0.0080	2.274	13.04
104	85	0.341	0.0201	1.723	5.89
105	477	2.670	0.0280	1.557	41.57
106	333	0.422	0.0063	2.446	10.31
107	63	0.391	0.0310	1.509	5.90
108	254	0.687	0.0135	1.942	13.35
109	280	1.379	0.0246	1.619	22.32
110	296	0.971	0.0164	1.831	17.79
111	517	3.315	0.0321	1.494	49.53
112	406	2.909	0.0358	1.444	42.02
113	963	1.363	0.0071	2.365	32.23
114	138	1.033	0.0374	1.425	14.72
115	56	0.126	0.0112	2.055	0.26
116	141	2.852	0.1011	1.054	30.04
117	22	0.052	0.0117	2.029	1.05
118	118	0.220	0.0093	2.174	4.79
119	55	0.351	0.0319	1.497	5.25
121	15	0.032	0.0106	2.089	0.67
122	396	1.329	0.0168	1.819	24.17
123	70	0.435	0.0311	1.508	6.56
124	479	1.469	0.0153	1.870	27.46
125	60	0.417	0.0348	1.458	6.08
126	14	0.126	0.0451	2.565	3.24
127	77	0.094	0.0061	2.475	2.32
128	61	0.120	0.0090	2.199	2.41
129	362	1.903	0.0263	1.587	30.20
130	267	0.924	0.0173	1.802	16.66
131	115	0.446	0.0194	1.741	7.76
132	92	0.162	0.0088	2.212	3.59
133	93	1.629	0.0876	1.101	17.93

Table V.17 - Production estimations for each of the sampling stations (cont).

The spatial distribution of the production estimations are presented in figure 5.40. The highest values appear in the region between the entrance and the beginning of the sand banks, mainly close to the northern margin. The lowest values were found in the estuarine entrance, along the northern margin in the vicinity of the industrial complex, in the upper estuary, occupying almost all the region in front of Boliden/Setenave/Eurominas, in the beginning of the inner estuary (Alcácer channel) and also in some of the sampling stations of the southern channel, namely in sites of coarser sediments.

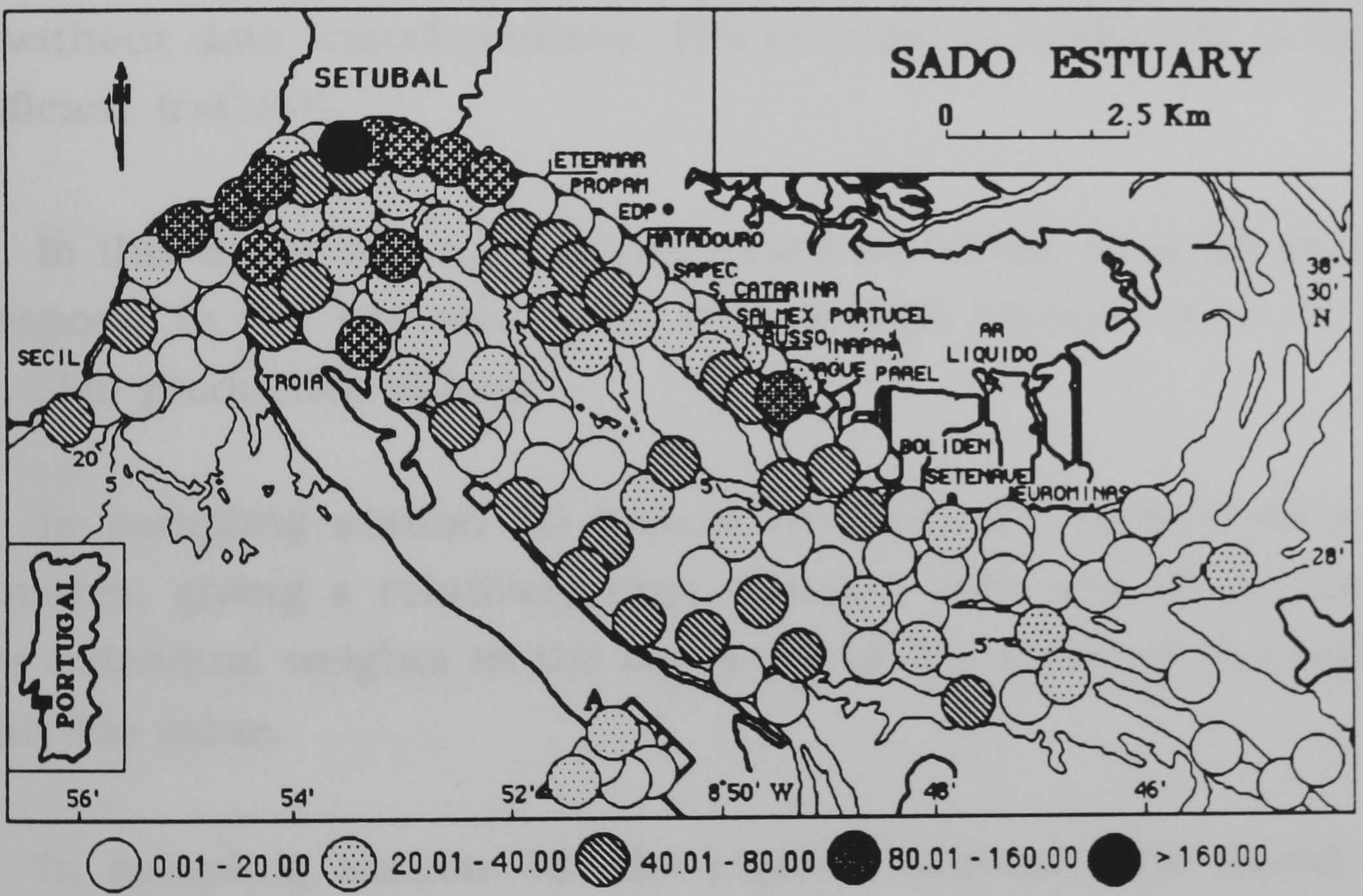


Figure 5.40 - Sado Estuary. Spatial distribution of production estimation per sampling station (gafdw/m^2/year).

Most of the low production areas correspond well with the low ash-free dry weight biomass areas, and in general, a good agreement was found between the spatial gradients of biomass (afdw) and production, shown respectivelly in figures 5.7 and 5.40.

A close comparison of both figures suggests a good correspondence between the areas of 0-10 g afdw/m^2 and 0-20 g afdw/m^2/year, 10-20 g afdw/m^2 and 20-40 g afdw/m^2/year, and 20-40 g afdw/m^2 and 40-80 g afdw/m^2/year. A less good correspondence is obtained between the highest biomass and the highest production areas. Some of the estuarine regions with high biomass (> 40 g afdw/m^2) also show high production estimates (> 80 g afdw/m^2/year), while others tend to show lower values (40-80 g afdw/m^2/year). This difference was essentially due to the presence of larger animals (mainly Molluscs), together with a lower number of individuals and so a high mean individual biomass.

Figure 5.41 shows the relation between ash free dry weight biomass and production estimates in the Sado estuary. A linear regression was used considering biomass as the independent variable and without data transformation. The correlation coefficient is highly significant (r=0.90).

In this figure the two extreme cases identified, sites 26 and 33, correspond to the two situations with a high biomass and, in this case, high production values.

In sampling station 26 (urban effluent), *C. capitata* strongly dominates, giving a relatively high biomass with one of the lowest mean individual weights in the estuary and the result is the highest production value.

In sampling station 33, the highest biomass was found and dominance was due to the bivalve *V. pullastra*, both in number and weight. The result is the highest mean individual weight found in the estuary, and a clearly lower production value than the one expected from a linear relation between biomass and production. Nevertheless, because of its high biomass the production value at this station is among the highest values considered.

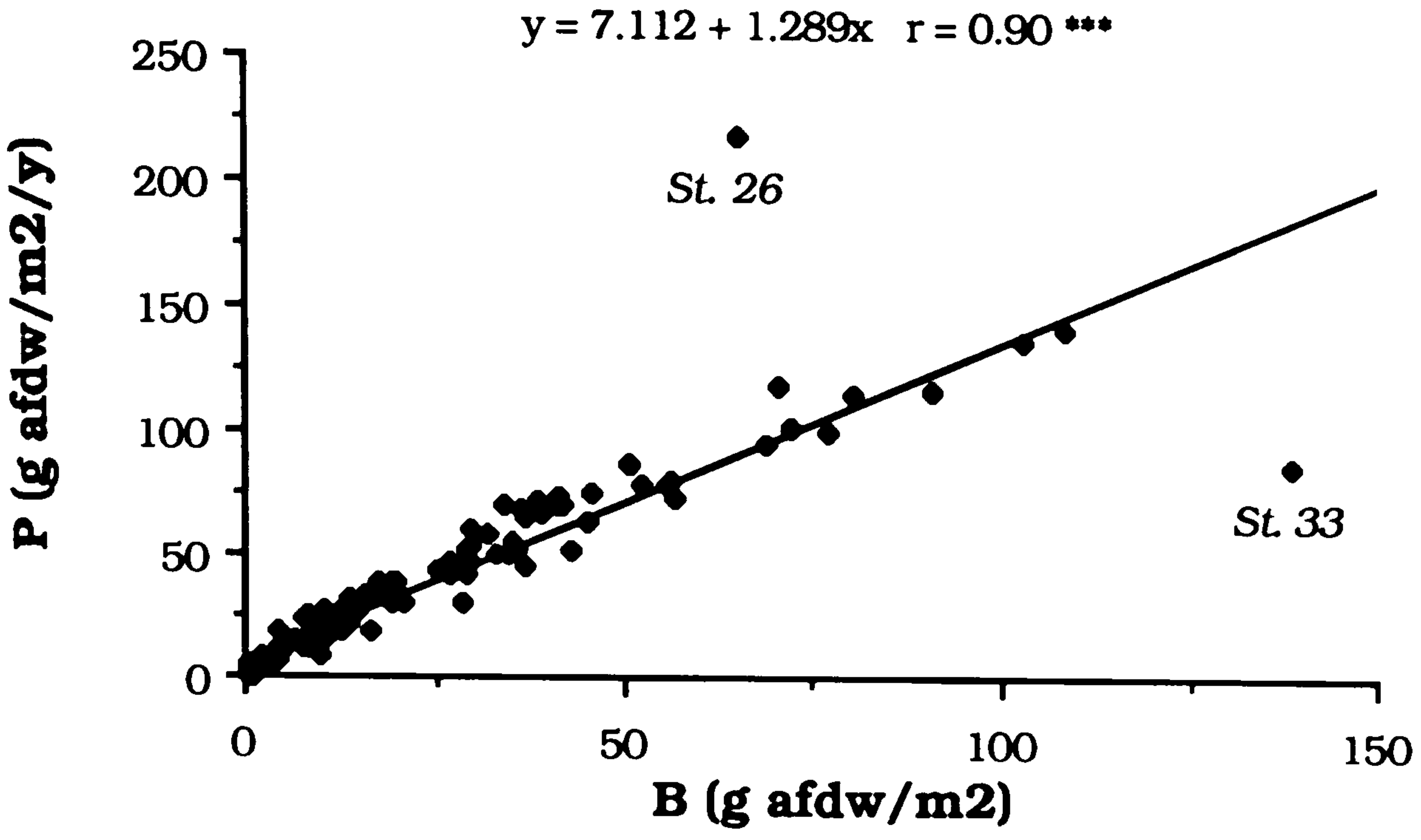


Figure 5.41 - Linear regression plot between biomass (B) and production (P) in the Sado estuary. The two extreme cases, sites 26 and 33 are clearly apart from the remaining sampling stations. *** P<< 0.001.

5.4. - TROPHIC GROUPS

5.4.1.- Introduction

The analysis of the trophic structure of the Sado estuary benthic macrofauna was based on the classification of species into eight different trophic groups, as presented in Chapter 3-Methods, namely, filter feeders (FF), surface deposit feeders (SDF), sub-surface deposit feeders (SSDF), filter feeders/surface deposit feeders (FF/SDF), carnivores (C), carnivores/deposit feeders (C/DF), herbivores (H) and herbivores/deposit feeders (H/DF). All the species considered in each group are mutually exclusive with the exception of the cirratulid *Tharyx* sp. and the Sipunculids classified as surface and sub-surface deposit feeders. In these two cases the abundance and the biomass in each sampling station was partitioned and included in each of the trophic groups mentioned before.

The data for the trophic groups analysis did not consider the entire set of species sampled in the estuary but only the top ten most abundant species in each sampling station. In some situations, the top ten species represent the whole set of species in a given station, sometimes they only omit species represented by one or two individuals. This choice was taken mainly for two reasons:

- The set of species omitted is essentially made up of rare species which inevitably increases the uncertainty of classification into trophic groups, and
- The most abundant species per site should represent well the major feeding strategies in each sampling location.

5.4.2.- Results

The data file considered for the trophic group analysis includes a total of 164 species (46% of the total number of taxa sampled), comprising 67930 specimens (85% of total abundance). In terms of wet-weight biomass, these specimens represent 39.6% of total biomass (1129.9 g). In each station, the abundance of the top ten species always represents more than 60% of the total abundance at that station, corresponding to 100% in 23 sampling sites.

Table V.18 shows the distribution of the set of species considered among the eight trophic groups, while table V.19 presents the total number of individuals and biomass (wet-weight in mg) for each of the trophic groups. Table V.20 gives the full set of data per sampling station, namely the number of species, individuals and biomass of each trophic group.

As shown in table V.18, the majority of the species belong to the surface and sub-surface deposit feeders (34 and 32 species respectively). Filter feeders/surface deposit feeders and carnivores are represented by 25 species each, filter feeders by 21, herbivore/deposit feeders by 15, carnivores/deposit feeders by 10 and the herbivores by 4 species.

In respect of the total abundance and biomass, the deposit feeders are clearly the most important group in the estuary; the surface deposit feeders had the highest total abundance, comprising 27272 specimens (40.2%) while the sub-surface deposit feeders had the highest total biomass, almost 900 g, wet weight (46.4%).

TROPHIC GROUPS							
FF	FF/SDF	SDF	SSDF	C	C/DF	H	H/DF
Anthozoa spa	Ampelisca b.	Abra a.	Abra n.	Anaitides l.	Caprella a.	Calyptrae c.	Anthuridae spa
Cardium p.	Ampelisca d.	Aonides o.	Aricia f.	Anaitides m.	Diopatra n.	Chaetopleura a.	Cirolanidae spa
Cerastoderma e.	Ampelisca r.	Apherusa o.	Bathyporeia g.	Bodotria s.	Eteone spa	Microphtalmus a.	Cyathura c.
Corbula g.	Ampelisca s.	Apseudes l.	Capitella	Crangon c.	Exogone v.	Pisione r.	Hydrobia u.
Dialychone a.	Ampelisca t.	Apseudes t.	Clymenura c.	Drilonereis f.	Leptonereis g.		Ophyotrocha spa
Ervilia c.	Amphipod spa	Arca l.	Cheirocratus s.	Eurydice p.	Nereis c.		Parapionosyllis e.
Lopha s.	Aora t.	Astacilla l.	Euclymene o.	Gastrosaccus s.	Nothria c.		Parapionosyllis l.
Lygdamis m.	Aoridae spa	Atylus g.	Euclymene p.	Glycera c.	Pariambus t.		Protodorvilea k.
Pandora a.	Corophium a.	Atylus v.	Hemilepton n.	Glycera t.	Pthisica m.		Schistomeringos n.
Parvicardium e.	Corophium i.	Caulleriella	Heteromastus f.	Glycera u.	Tryphosites l.		Schistomeringos r.
Phoronis	Corophium r.	Cirriformia	Loripes l.	Goniadella g.			Sphaeroma b.
Polydora a.	Corophium s.	Eunereis l.	Lucinoma b.	Harmothoe i.			Sphaerosyllis b.
Polydora c.	Ericthonius p.	Harpinia p.	Maera o.	Harmothoe l.			Sphaeroma h.
Sabella p.	Gammaropsis m.	Iphinoe t.	Mediomastus c.	Hesionura e.			Sphaeroma m.
Sabellaria s.	Gammaropsis s.	Malacoceros c.	Notomastus l.	Heteromysis m.			Syllis h.
Serpulids	Gammaropsis spa	Malacoceros f.	Nucula n.	Liocarcinus a.			
Solen ma.	Jassa m.	Melinna p.	Oligochaet spa	Lumbrinereis l.			
Spisula s.	Lanice c.	Melita g.	Oligochaet spb	Lumbrinereis p.			
Venerupis p.	Leptocheirus pil.	Melita o.	Ophelia n.	Marphysa s.			
Virgularia m.	Leptocheirus pect.	Melita p.	Orchomene n.	Nassarius i.			
	Microprotopus m.	Neoamphitrite a.	Paradoneis l.	Nassarius r.			
	Microdeutopus v.	Ostracod spa	Polygordius a.	Nemertean spa			
	Pseudopolydora a.	Ostracod spb	Saccocirrus p.	Nemertean spb			
	Scobicularia p.	Photis l.	Scalibregma i.	Nephtys c.			
	Tellina t.	Pista c.	Scoloplos a.	Nephtys h.			
		Polycirrus	Sipunculid				
		Prionospio c.	Tharyx				
		Pygospio e.	Tubificoides b.				
		Sipunculid	Upogebia t.				
		Spiochaetopterus c.	Urothoe b.				
		Spio d.	Urothoe e.				
		Stenothoe m.	Urothoe g.				
		Streblospio s.					
		Tharyx					

Table V.18 - Trophic groups of the top ten most abundant species in each sampling station.

Trophic Group	Abundance		Biomass (w.w.)		Presences	
	Number	%	Number	%	Number	%
FF	2152	3.2	603426	31.1	58	44.3
FF/SDF	7631	11.2	14399	0.7	99	75.6
SDF	27272	40.2	307667	15.9	127	96.9
SSDF	25605	37.7	898633	46.4	126	96.2
C	1225	1.8	87412	4.5	73	55.7
C/DF	2385	3.5	11697	0.6	39	29.8
H	433	0.6	9244	0.5	23	17.6
H/DF	1222	1.8	6081	0.3	63	48.1

Table V.19- Total abundance, wet-weight biomass (mg) and species present, of each of the trophic groups considered in the Sado estuary.

Surface and sub-surface deposit feeders were present in almost all the sampling stations, i. e. in 127 and 126 respectively. Herbivores and carnivores/deposit feeders were the least frequent groups, present only in 23 and 39 sampling stations, respectively.

The number of trophic groups per sampling location is shown in figure 5.42. At stations 95 and 120 no fauna was found. In 63 sites, 3 to 4 trophic groups were present, while in 57 sampling stations, 5 or 6 groups were identified. Only 11 sites were represented by 7 or 8 trophic groups.

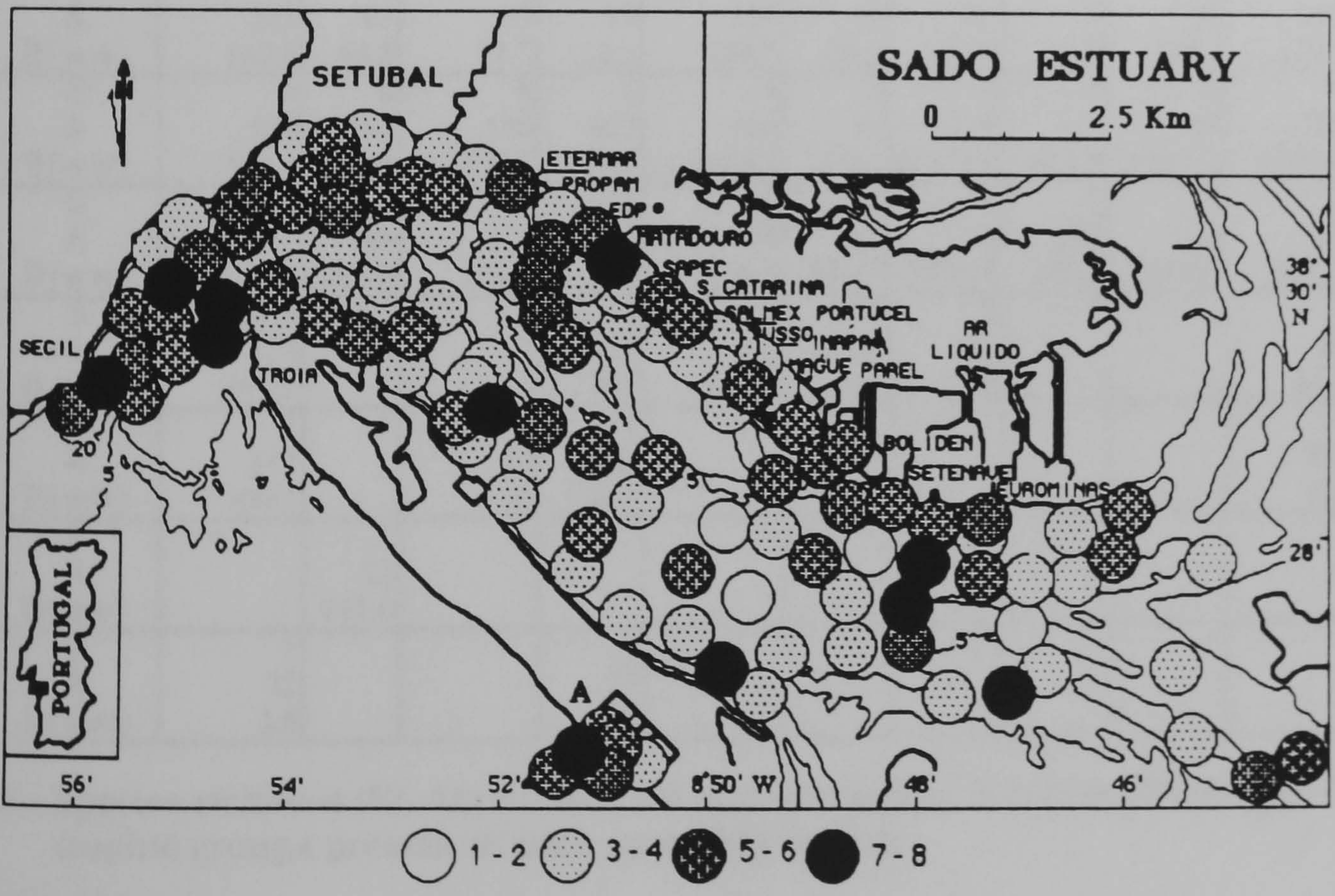


Figure 5.42 - Sado Estuary. Total number of trophic groups in each sampling station.

TROPHIC GROUPS		STATIONS										
		S001	S002	S003	S004	S005	S006	S007	S008	S009	S010	S011
FF	S	2	1			2		2		3	2	1
	A	40	7			115		3		51	9	3
	B(ww)	36717.7	106.0			14606.1		54.7		331.8	253.2	15.1
FF/SDF	S	2	2	1		2	2		1			
	A	88	88	6		163	38		2			
	B(ww)	117.0	133.1	505.2		225.0	50.0		1.0			
SDF	S	3	2	1	4	3	3	3		1	1	4
	A	92	23	29	577	471	750	7		5	1	26
	B(ww)	192.7	748.1	26.1	558.3	2234.4	733.6	8.8		48.5	0.9	40.0
SSDF	S	1	3	1	1	3	3	3	2	2	6	3
	A	65	90	3	11	77	63	6	10	13	54	48
	B(ww)	98.8	36.0	0.3	50.9	2405.0	791.0	2.5	5.2	34.4	382.2	9.3
C	S		1	3	3			3	5	4	7	1
	A		8	52	36			40	30	55	18	7
	B(ww)		26.4	508.3	632.6			282.2	142.3	145.2	2527.6	38.9
C/DF	S	1	1		1		2	1			3	1
	A	17	9		11		45	3			3	9
	B(ww)	11.9	6.3		5.5		31.5	1.5			13.8	4.5
H	S	1	1	2	1	1		1	1	1	1	1
	A	84	18	16	10	57		13	32	12	1	72
	B(ww)	786.9	10.4	3.2	0.7	1358.9		1.9	8.9	14.2	1.1	40.3
H/DF	S			3				3	2	1	2	1
	A			7				4	11	11	2	10
	B(ww)			24.0				6.9	418.5	15.3	0.2	1.0

TROPHIC GROUPS		STATIONS										
		S012	S013	S014	S015	S016	S017	S018	S019	S020	S021	S022
FF	S	1		1			3		3		1	1
	A	27		19			184		342		57	44
	B(ww)	812.8		63540.2			222.0		156.2		1935.8	24542.8
FF/SDF	S	3	1	1	3	2	1	1	1	3	2	2
	A	223	93	75	97	134	18	30	76	83	202	150
	B(ww)	160.6	46.5	37.5	113.1	249.7	26.5	15.0	112.6	64.6	129.0	99.7
SDF	S	4	6	6	2	5	3	4	4	5	4	5
	A	596	268	430	622	458	81	259	117	213	254	241
	B(ww)	560.0	6825.8	2704.2	617.7	3123.2	179.1	23579.8	417.8	1953.2	1291.9	1087.3
SSDF	S		3	2	1	3	2	4	3	3	2	2
	A		149	212	15	158	66	215	143	134	83	261
	B(ww)		499.6	234.6	18.1	878.5	1893.6	1103.7	485.1	816.0	262.1	471.1
C	S	3			2	1	1	1			2	
	A	136			27	27	19	24			63	
	B(ww)	197.0			76.5	151.6	28.5	27.9			81.3	
C/DF	S	1		1	1						1	1
	A	847		60	329						322	157
	B(ww)	400.1		30	164.5						161	78.5
H	S		1									
	A		23									
	B(ww)		961.0									
H/DF	S	1			1							
	A	22			27							
	B(ww)	3.6			7.4							

Table V.20 - Species richness (S), Abundance (A) and wet-weight biomass (Bww/mg) for the trophic groups present in each sampling station.

TROPHIC GROUPS		STATIONS									
		S023	S024	S025	S026	S027	S028	S029	S030	S031	S032
FF	S			1		1	1	1			
	A			50		72	27	13			
	B(ww)			35.9		64.8	417.8	11.7			
FF/SDF	S		1	4	1	5	2	2	1		1
	A		2	306	4	229	109	48	18		3
	B(ww)		1.2	379.5	0.4	274.0	76.1	40.2	9.0		208.1
SDF	S	6	6	3	5	6	4	4	6		2
	A	335	60	246	159	269	239	253	316		2
	B(ww)	4962.2	1752.2	898.8	123.3	2935.0	1216.1	841.0	3181.0		8.5
SSDF	S	4	4	2	2	2	3	2	4		3
	A	144	65	135	14498	41	205	91	158		3
	B(ww)	1953.9	48.0	2997.4	21837.2	45.8	350.0	369.5	1135.6		44.4
C	S		2	1	1			1		4	8
	A		16	15	39			20		8	13
	B(ww)		515.0	42.1	45151.7			1010.3		130.4	8338.8
C/DF	S				2						
	A				16						
	B(ww)				23.2						
H	S						1			1	
	A						29			3	
	B(ww)						726.1			9.6	
H/DF	S				1			2		1	1
	A				8			40		2	1
	B(ww)				0.8			192.6		417.6	0.9

TROPHIC GROUPS		STATIONS									
		S033	S034	S035	S036	S037	S038	S039	S040	S041	S042
FF	S	3	1	1			1				
	A	41	5	19			10				
	B(ww)	169013.4	2874.8	3317.4			5985.0				
FF/SDF	S			1	2	2	2		2	1	1
	A			13	219	106	43		255	16	10
	B(ww)			18.2	144.6	56.5	40.5		260.6	11.2	7.0
SDF	S	2	5	5	5	4	7	9	7	8	7
	A	20	72	235	220	168	307	325	1033	571	385
	B(ww)	70.0	1687.0	3301.0	1309.5	2383.7	1000.6	21446.6	23862.4	18993.3	6042.9
SSDF	S	2	5	4	3	2	1	3	2	2	1
	A	8	175	111	106	73	27	593	103	58	49
	B(ww)	36.9	1970.4	693.4	984.5	317.6	98.6	934.0	869.4	279.3	308.2
C	S	4				2					
	A	16				44					
	B(ww)	6828.0				810.4					
C/DF	S				1		1				1
	A				79		36				15
	B(ww)				39.5		18				7.5
H	S	1									
	A	5									
	B(ww)	432.5									
H/DF	S	1	1			1					1
	A	4	4			37					9
	B(ww)	3.6	3.6			33.3					60.3

Table V.20 (continued).

TROPHIC GROUPS		STATIONS									
		S043	S044	S045	S046	S047	S048	S049	S050	S051	S052
FF	S					1	1			1	1
	A					23	7			10	18
	B(ww)					3270.6	21.0			31694.8	16.2
FF/SDF	S	3	3	2		2			2	3	
	A	132	66	113		287			75	102	
	B(ww)	153.9	54.1	146.7		183.8			156.0	107.7	
SDF	S	3	6	3	4	2	1		5	5	6
	A	103	264	188	157	63	3		182	73	178
	B(ww)	467.5	3875.7	1245.3	323.7	377.4	5.7		1501.7	1412.4	961.0
SSDF	S	5	2	2	3	4	3	6	4	1	2
	A	162	51	88	137	174	25	92	55	21	28
	B(ww)	788.7	880.0	1145.5	1799.3	766.2	112.8	192.6	172.1	611.7	112.0
C	S	1		1	4		2	1			1
	A	23		35	18		10	5			7
	B(ww)	34.5		52.5	3136.4		48.6	3.5			30.1
C/DF	S		2	1	2	1	1		1		2
	A		48	43	16	97	7		11		20
	B(ww)		30	29.6	10	66	4.9		7.7		11.8
H	S						1	2			
	A						3	25			
	B(ww)						0.6	4.4			
H/DF	S			1			3	2			1
	A			22			11	103			8
	B(ww)			72.6			3.5	15.9			53.6

TROPHIC GROUPS		STATIONS									
		S053	S054	S055	S056	S057	S058	S059	S060	S061	S062
FF	S			1				1		2	
	A			25				12		2	
	B(ww)			25.6				10.8		3279.6	
FF/SDF	S	3	2	2	1	2	5	1	2	2	2
	A	185	112	61	3	57	20	102	228	166	3
	B(ww)	237.6	156.8	74.9	3.3	58.5	16.4	142.8	240.9	190.1	3.4
SDF	S	5	7	5	7	5	6	7	7	6	3
	A	127	579	675	138	102	30	418	709	77	3
	B(ww)	832.4	7840.9	9991.6	849.6	5511.9	53.6	5760.8	4121.4	1918.7	88.8
SSDF	S	1	2	1	2	2	3	1	1	2	
	A	18	27	30	21	63	112	8	155	10	
	B(ww)	13.0	29.1	16.6	15.0	44.1	51.3	5.6	451.6	42.2	
C	S	1		1	2	2	1			4	2
	A	15		15	8	14	2			9	3
	B(ww)	721.5		9.5	78.4	1075.8	266.3			689.9	4.5
C/DF	S						2			1	1
	A						25			1	1
	B(ww)						5022			0.5	2881.8
H	S		1								
	A		13								
	B(ww)		358.4								
H/DF	S	1		1	1			1	1	1	
	A	33		50	32			29	23	1	
	B(ww)	221.1		335.0	211.4			194.3	154.1	6.7	

Table V.20 (continued).

TROPHIC GROUPS		STATIONS									
		S063	S064	S065	S066	S067	S068	S069	S070	S071	S072
FF	S	2	1							2	
	A	69	39							30	
	B(ww)	5869.9	63.8							1933.9	
FF/SDF	S	2	2	2	1		1	1	1	3	1
	A	24	68	22	35		1	7	17	26	22
	B(ww)	37.2	81.7	23.7	49.0		32.9	4.2	23.8	255.6	30.8
SDF	S	7	6	6	7	3	2	6	7	4	7
	A	255	356	13	335	6	2	86	542	103	367
	B(ww)	6020.2	2865.0	41.4	1917.0	31.6	29.7	805.0	5506.5	899.3	1381.6
SSDF	S	2	1	2	2	4		4	3	1	2
	A	51	18	11	161	28		45	142	48	141
	B(ww)	67.2	13.6	8.6	344.4	160.9		430.2	458.2	495.1	262.0
C	S			5		2	2				
	A			8		20	2				
	B(ww)			739.1		139.4	171.1				
C/DF	S			1							
	A			1							
	B(ww)			420.5							
H	S					1					
	A					3					
	B(ww)					0.6					
H/DF	S		1		1	1	2			1	1
	A		16		30	3	2			18	31
	B(ww)		107.2		201.0	0.6	208.9			120.6	207.7

TROPHIC GROUPS		STATIONS									
		S073	S074	S075	S076	S077	S078	S079	S080	S081	S082
FF	S							3		2	1
	A							143		223	6
	B(ww)							19986.1		11740.1	1271.4
FF/SDF	S	3			1	2			2	4	
	A	3			17	46			76	408	
	B(ww)	3.7			23.8	299.4			73.1	286.0	
SDF	S	5	7	7	6	7	7	6	7	1	4
	A	7	401	156	367	940	21	426	283	79	613
	B(ww)	21.0	4969.4	1886.6	6060.8	8323.6	168.0	4580.9	3098.0	213.3	5466.8
SSDF	S	1	3	2	3	1	6	1	1	1	5
	A	17	43	23	149	47	17	67	19	39	233
	B(ww)	11.9	134.4	20.0	227.4	154.7	13.2	46.9	16.6	1054.3	522.0
C	S	2		1			2			1	1
	A	2		14			5			45	7
	B(ww)	98.0		9.2			25.0			42.9	35.7
C/DF	S	2						1			
	A	2						33			
	B(ww)	421.2						23.1			
H	S										
	A										
	B(ww)										
H/DF	S		1	1	1	1	1	1	1	1	
	A		17	15	22	46	1	60	21	74	
	B(ww)		113.9	100.5	147.4	308.2	6.7	402.0	140.7	66.6	

Table V.20 (continued).

TROPHIC GROUPS		STATIONS									
		S083	S084	S085	S086	S087	S088	S089	S090	S091	S092
FF	S		1						3		
	A		29						7		
	B(ww)		1222.0						96.5		
FF/SDF	S	1	2	3	1		1	2	2	2	2
	A	17	337	112	2		11	12	5	30	2
	B(ww)	8.5	193.2	83.5	2.8		110.0	68.4	195.6	22.6	1.6
SDF	S	5	4	6	4	4	5	5	5	6	5
	A	174	327	233	20	264	181	305	92	403	12
	B(ww)	510.9	2068.6	1955.2	155.6	2036.4	2222.2	5696.8	1787.6	2196.2	45.2
SSDF	S	4	4	2	3	7	4	2	1	1	4
	A	187	102	68	74	253	76	9	1	23	7
	B(ww)	1330.9	980.3	425.3	525.4	917.9	135.8	6.3	3.1	38.2	8.5
C	S	1			4			2	5	1	2
	A	17			11			31	6	11	2
	B(ww)	992.6			178.5			98.7	1152.8	11.0	119.8
C/DF	S							1	1	1	1
	A							5	1	43	2
	B(ww)							3.5	420.5	30.1	1.4
H	S										
	A										
	B(ww)										
H/DF	S	1			1		1		1	1	1
	A	27			4		13		1	52	2
	B(ww)	24.3			1.2		87.1		6.7	348.4	13.4

TROPHIC GROUPS		STATIONS									
		S093	S094	S096	S097	S098	S099	S100	S101	S102	S103
FF	S		3	1	1	1	1			1	
	A		10	16	98	61	9			10	
	B(ww)		1141.4	108.7	17137.2	12925.9	1571.4			7.4	
FF/SDF	S		2	1	2	2	1		1	1	3
	A		7	24	969	51	4		55	3	35
	B(ww)		92.4	36.0	820.5	42.3	6.8		27.5	1.5	35.4
SDF	S	2	5	3	3	5	5	6	5	4	4
	A	14	42	74	187	189	291	928	390	34	138
	B(ww)	26.8	567.8	104.1	1053.2	1367.1	2883.8	7586.4	1557.9	138.4	1809.6
SSDF	S	2	1	2	1	2	3	5	6	2	3
	A	1183	2	197	23	56	44	152	211	18	122
	B(ww)	3962.0	1.4	1717.1	21.2	285.4	238.0	554.2	2964.2	966.3	316.2
C	S	1	3	1		1				1	
	A	1	7	9		9				6	
	B(ww)	113.4	238.4	137.7		432.9				126.1	
C/DF	S				2					1	
	A				45					2	
	B(ww)				27.3					1	
H	S									1	
	A									2	
	B(ww)									4060.2	
H/DF	S	1	1	2	1	1					1
	A	1	2	34	26	49					7
	B(ww)	0.2	0.4	11.4	174.2	328.3					46.9

Table V.20 (continued).

TROPHIC GROUPS		STATIONS									
		S104	S105	S106	S107	S108	S109	S110	S111	S112	S113
FF	S		1				1	1		2	2
	A		19				9	5		36	7
	B(ww)		17.1				1571.4	22.8		19071.6	1073.2
FF/SDF	S	1	2	2	4			1	3		2
	A	1	47	16	16			5	127		8
	B(ww)	2034.9	377.9	866.7	59.5			3.0	87.9		8.5
SDF	S	1	6	2	5	6	4	5	4	5	5
	A	4	233	6	13	145	104	145	159	299	840
	B(ww)	33.4	2122.4	27.4	43.8	1400.2	941.6	2614.0	735.15	3949.5	7327.2
SSDF	S	4	1	2	2	5	6	5	3	4	5
	A	69	18	249	8	80	126	100	75	34	79
	B(ww)	1379.3	12.2	1768.3	42.5	524.4	456.1	549.8	495.2	88.7	300.6
C	S	3		4	1				1		1
	A	6		19	16				13		3
	B(ww)	350.7		422.9	1842.5				308.3		46.2
C/DF	S				1						
	A				2						
	B(ww)				841						
H	S										
	A										
	B(ww)										
H/DF	S	2	1	3							
	A	5	30	37							
	B(ww)	0.5	201.0	4.5							

TROPHIC GROUPS		STATIONS									
		S114	S115	S116	S117	S118	S119	S121	S122	S123	S124
FF	S	3	1	3	1	3	1	1		2	
	A	5	1	40	1	12	2	1		3	
	B(ww)	3223.9	0.9	19296.5	174.6	665.9	4.8	2.6		363.6	
FF/SDF	S	1	1	2	3					1	1
	A	1	1	4	11					5	32
	B(ww)	485.5	28.0	3.8	8.4					1053.4	16.0
SDF	S	6	2	5	4	3	7	1	5	3	4
	A	116	2	67	8	42	28	3	148	5	153
	B(ww)	1726.2	7.8	572.0	39.3	389.0	183.5	91.2	898.6	15.5	1370.4
SSDF	S	6	3	1		3	2	2	6	4	6
	A	10	32	2		59	6	9	192	48	213
	B(ww)	2864.0	446.4	6.2		521.65	56.4	143.7	536.05	2158.9	523.85
C	S	3	5	2	1	3	2	2		3	
	A	4	8	7	1	5	5	2		6	
	B(ww)	154.2	515.8	456.6	143.3	257.1	1135.3	2.0		144.2	
C/DF	S	1			1						
	A	1			1						
	B(ww)	431.4			0.7						
H	S		1							1	
	A		1							1	
	B(ww)		0.2							1.2	
H/DF	S	1	1	1			1			1	
	A	1	11	7			3			2	
	B(ww)	22.3	1.1	46.9			0.3			0.6	

Table V.20 (continued).

TROPHIC GROUPS		STATIONS								
		S125	S126	S127	S128	S129	S130	S131	S132	S133
FF	S		2	2						1
	A		3	6						17
	B(ww)		364.6	30.2						19133.0
FF/SDF	S	1		1	3	4	2		2	5
	A	2		1	3	174	40		4	26
	B(ww)	3.0		1.7	56.4	681.3	29.0		2.8	77.3
SDF	S	1	1	1	5	3	4	3	2	
	A	56	1	1	19	54	97	37	27	
	B(ww)	1242.4	9.6	1.9	309.4	703.8	378.3	260.5	131.2	
SSDF	S	2	1	5	2	4	4	4	5	2
	A	2	8	33	35	57	74	49	28	7
	B(ww)	1994.3	689.4	105.7	364.1	390.9	168.7	377.0	44.2	14.9
C	S		1	3	2			2	1	2
	A		2	18	3			7	3	7
	B(ww)		260.0	528.8	85.7			63.1	4.5	1983.7
C/DF	S									2
	A									20
	B(ww)									14
H	S							1	1	
	A							8	2	
	B(ww)							175.1	287.4	
H/DF	S			3	1				2	
	A			18	1				22	
	B(ww)			4.7	2.8				163.8	

Table V.20 (continued).

The spatial distribution of the dominant trophic group at each of the sampling stations, in terms of number of species, abundance and biomass, is shown in figure 5.43. The clearest pattern is seen in the trophic groups based on species richness where SDF is the most frequent group. This spatial distribution clearly distinguishes the northern channel, in which surface deposit feeders dominate almost exclusively from the rest of the estuary. The entrance, the southern channel and the upper region of the estuary show more diverse local dominance, while the entrance to the inner estuary, is characterised by the dominance of sub-surface deposit feeders and filter/surface deposit feeders.

The distinction between the northern and the southern channel is not so obviously shown by the spatial distribution of the trophic groups based on the abundance (figure 5.43). In the northern channel, some of the locations closer to the margins are dominated by sub-surface and filter/surface deposit feeders and carnivores. Also, sub-surface deposit feeders are more frequently dominant in terms of abundance, namely in the upper region of the estuary, Marateca and the Alcácer channel. Herbivores, filter feeders and carnivores/deposit feeders are exclusively dominant in stations located between the entrance and the beginning of the sand banks.

Dominance in terms of wet-weight biomass (figure 5.43), still shows the surface deposit feeders as the most frequently dominant group in the estuary, but mainly in the northern channel. As before, some of the stations nearest to the north margin are dominated by other groups namely carnivores/deposit feeders, by carnivores and occasionally by filter feeders.

Sub-surface deposit feeders dominate mainly in the southern channel, Marateca and Alcácer channel while herbivores and herbivores/deposit feeders rarely dominate, and only in stations located near the estuarine entrance and in the southern channel. As expected, filter feeders dominate in a relative important number of sampling location, namely near the entrance and in the southern margin of the estuary and the intertidal sandbanks.

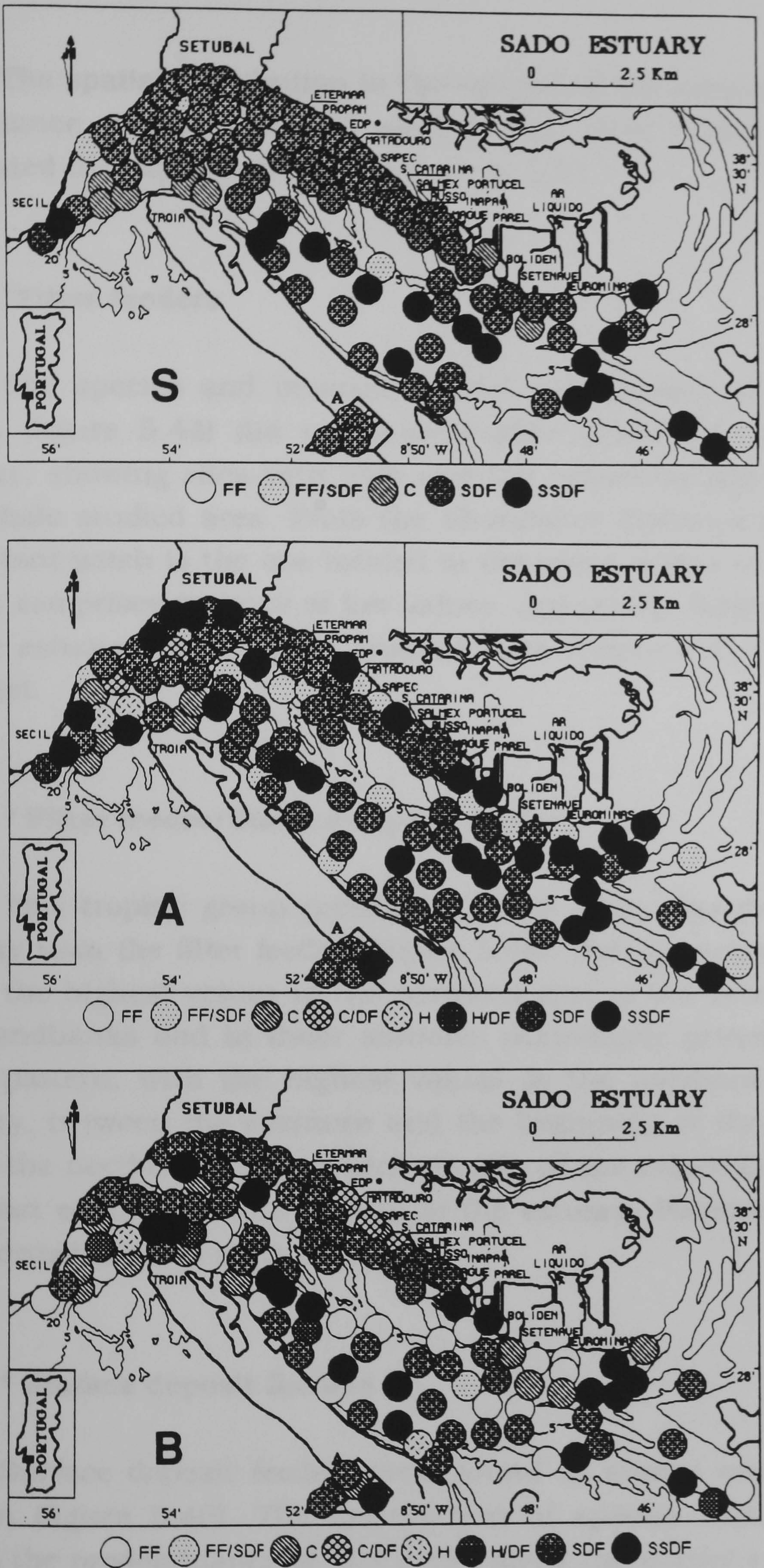


Figure 5.43 - Sado Estuary. Dominant trophic group per sampling station in terms of species richness (S), abundance (A) and wet-weigth biomass (B). The stations not marked have different trophic groups with the same percentage. FF - filter feeders, FF/SDF - filter/surface deposit feeders, SDF - surface deposit feeders, SSDF - sub-surface deposit feeders, C - carnivores, C/DF - carnivores/deposit feeders, H - herbivores, H/DF - herbivores/deposit feeders.

The spatial distribution in the estuary of the number of species, abundance and biomass of each of the eight trophic groups is presented in respectively figures 5.44 to 5.51.

*Filter feeders

The species and biomass spatial distribution of this trophic group (figure 5.44) did not individualise particular areas in the estuary, showing sites with high and low values equally scattered in the whole studied area. From the abundance distribution, the most important patch is the one located in the upper region of the estuary, which comprises stations of low values. Apparently distributed in the whole estuary, this trophic group is less frequent in the northern channel.

* Filter feeder/Surface deposit feeders

This trophic group presents a much wider distribution in the estuary than the filter feeders (figure 5.45). Species richness tends to show the highest values in the northern part of the estuary, around the sandbanks and in inner stations. Abundance presents a rather clear pattern, with the highest values in the northern part of the estuary, between the entrance and the beginning of the sandbanks, along the northern and southern margin of the intertidal sandbanks and part of the southern margin of the estuary. Biomass presents a close distribution to abundance.

* Surface deposit feeders

Surface deposit feeders were found in almost every sampling station (figure 5.46). The distribution of species richness clearly shows the predominance of this group along the northern channel.

The highest values were found along the northern margin from Comenda inwards, occupying almost all the north channel until Mague. In the south channel only few sites, mostly located close to the margin, present similar high values. The lowest values, extend from the estuarine entrance towards the southern channel until the Instalações Navais, showing another patch in front of Eurominas and in the innermost stations of Alcácer channel. Most of these locations show coarse instable sand.

The highest abundance and biomass distribution don't exactly correspond to the region with higher species richness. In fact, this group presented the lowest values of abundance in general along the northern margin, in stations 24 and 26 (urban sewage) and from Etermar inwards. Also, in the upper region of the estuary (in front of Boliden, Setenave and Eurominas), in Marateca and Alcácer channel and from the southern part of the estuarine entrance extending along most of the southern channel.

In general the areas with lowest biomass values are more or less the same as the ones with low abundance.

* Sub-surface deposit feeders

This widely distributed trophic group also distinguishes the northern and the southern part of the estuary. This distinction is mainly shown by the distribution of the number of species, abundance and of the biomass per sampling locations (figure 5.47). In opposition to the surface deposit feeders, this trophic group is more important in the southern than in the northern channel, particulary in respect to species richness.

The location in the estuary of the most important areas with high abundance is almost the same as the one found for the species number. However, there is a patch of high abundance values in the northern channel, close to the sandbanks, and it is along the northern margin that are located the 3 stations with the highest abundance values: stations 26, 39 and 93 (urban and pulp mill effluents).

Biomass distribution isolates the regions with the lowest values, namely the entrance and most of all the sampling station closer to the industrial belt along the northern margin. It shows clearly the difference between the stations closest to the margins in the southern and northern channel, the former with higher values than the latter.

*** Carnivores**

Carnivores were present in every part of the estuary (figure 5.48). The species distribution of this trophic group distinguishes 3 main patches of high values: one in the estuarine entrance, other at the beginning of southern channel (near Caldeira de Tróia) and another one inwards occupying the upper region of the estuary and the end of the southern channel.

Abundance distribution however showed in general that the main region with high values correspond to the area from the entrance up to the beginning of the sandbanks, while biomass presents patches of high values equally near the entrance, the upper region of the estuary and the northern channel.

*** Carnivores/Deposit feeders**

This trophic group is not so spread in the estuary as the strict carnivores (figure 5.49). It is almost absent in the inner part of the southern channel, the upper region and the inner estuary. In the northern channel, the group is more frequent close to the margins. The higher abundances were found mainly closer to the entrance, between Comenda and Setúbal harbour. Biomass, on the contrary, showed the highest values essentially in the inner part of the northern channel, along the margin inwards of the thermal power plant (EDP).

*** Herbivores**

Strict herbivores tend to occupy almost only the entrance region and the beginning of the southern channel. They are very rare in the northern channel, while in the inner part of the southern channel, in the upper region and in the inner estuary, this group is almost exclusively found closer to the southern margin (figure 5.50).

*** Herbivores/Deposit feeders**

This trophic group clearly presents a much wider distribution than strict herbivores, extending namely throughout the whole northern channel (figure 5.51). Species richest locations however, tend to concentrate closer to the entrance and in the southern channel. On the contrary, abundance and particularly biomass, tend to present the highest values mostly in the northern channel, inwards of Etermar.

In the next chapter, the distribution of the species number, abundances and biomass of these trophic groups will be analysed in relation to environmental data namely: fines, sand and total organic matter content of the sediment, sheer stress, residual flow and residual current velocity of the water column.

Figure 5.44 - Sado Estuary. Spatial distribution of species richness (S), abundance (A) and wet-weight biomass (B) of filter feeders per $0.1m^2$ considering the top ten species of each sampling station. Biomass in mg.

Figure 5.45- Sado Estuary. Spatial distribution of species richness (S), abundance (A) and wet-weight biomass (B) of filter/surface deposit feeders per 0.1m^2 considering the top ten species of each sampling station. Biomass in mg.

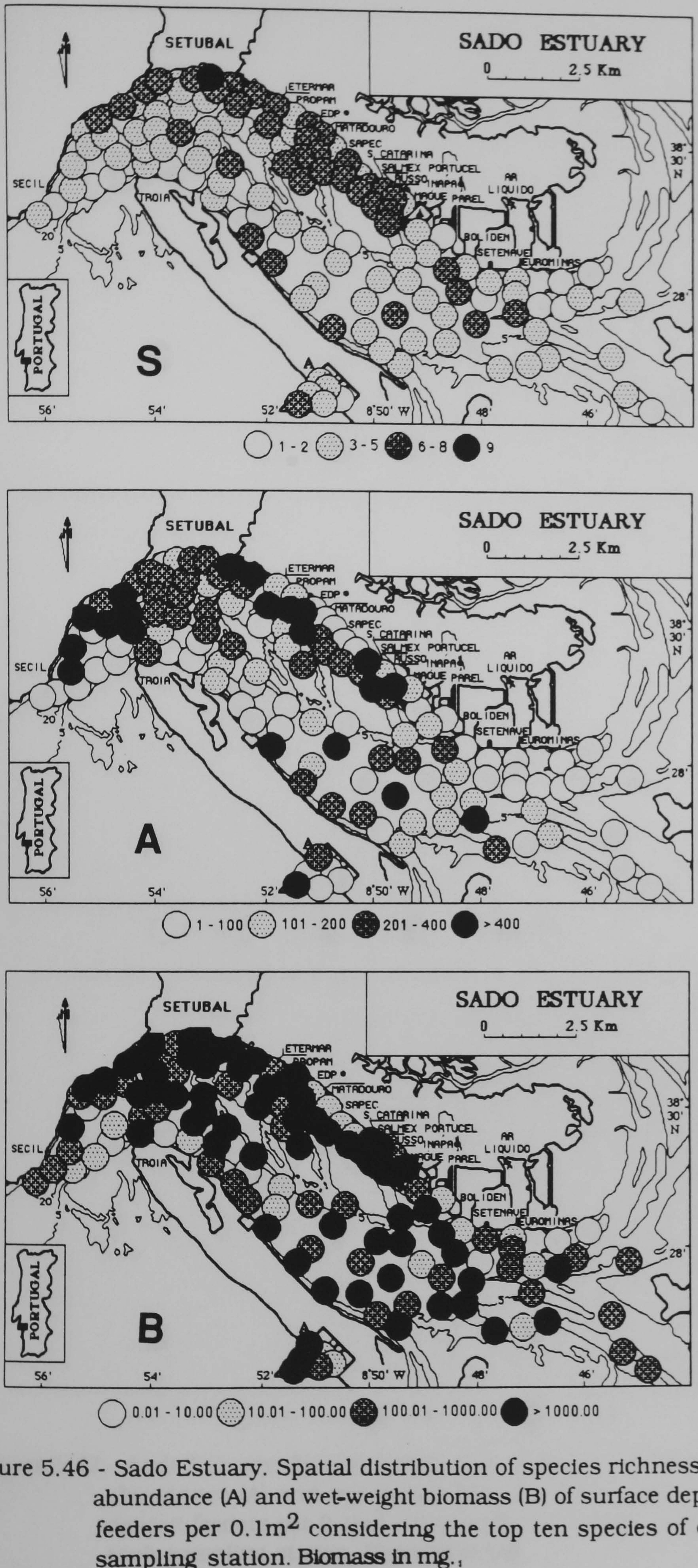


Figure 5.46 - Sado Estuary. Spatial distribution of species richness (S), abundance (A) and wet-weight biomass (B) of surface deposit feeders per 0.1m^2 considering the top ten species of each sampling station. Biomass in mg.,

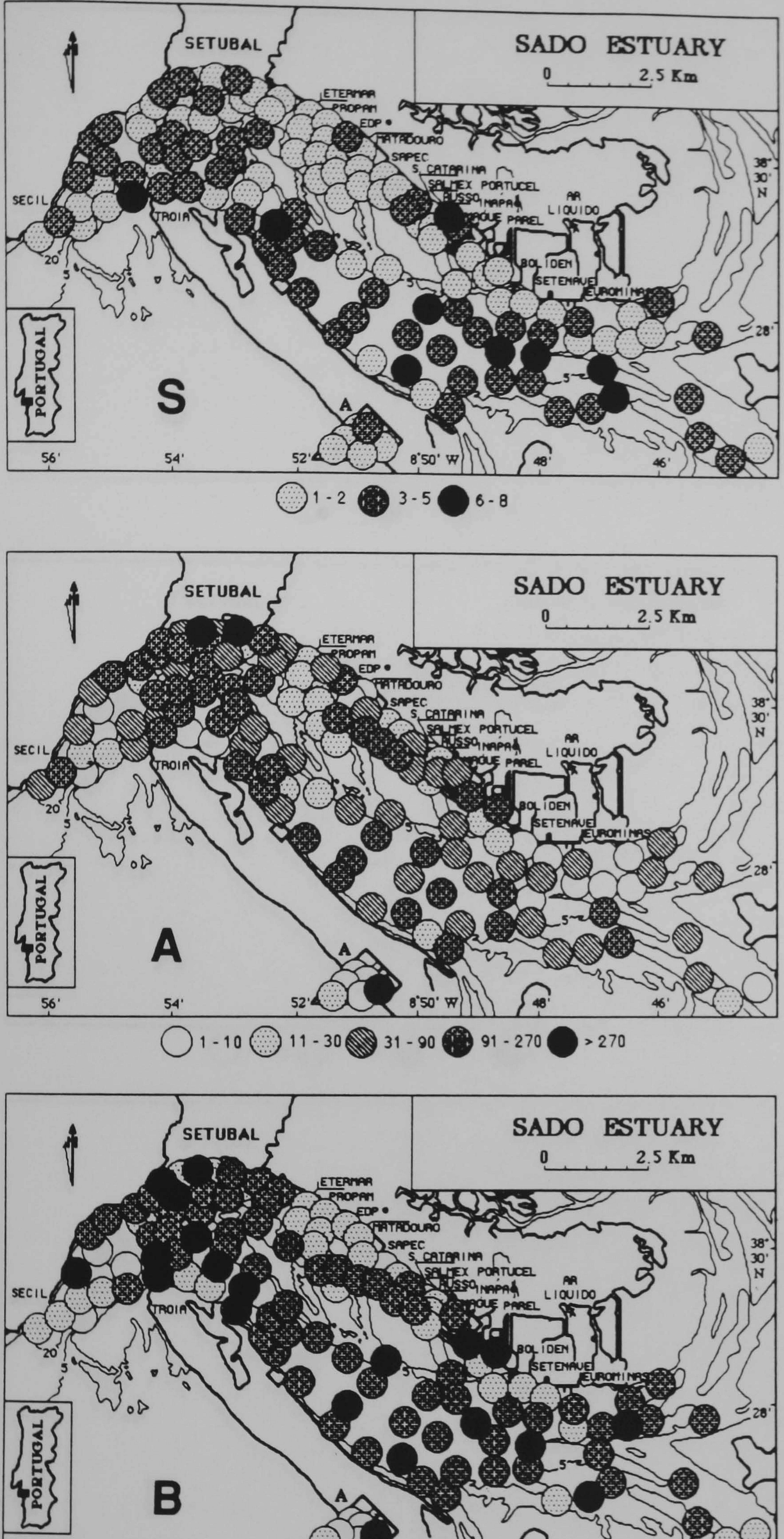


Figure 5.47 - Sado Estuary. Spatial distribution of species richness (S), abundance (A) and wet-weight biomass (B) of sub-surface deposit feeders per 0.1m^2 considering the top ten species of each sampling station. Biomass in mg.

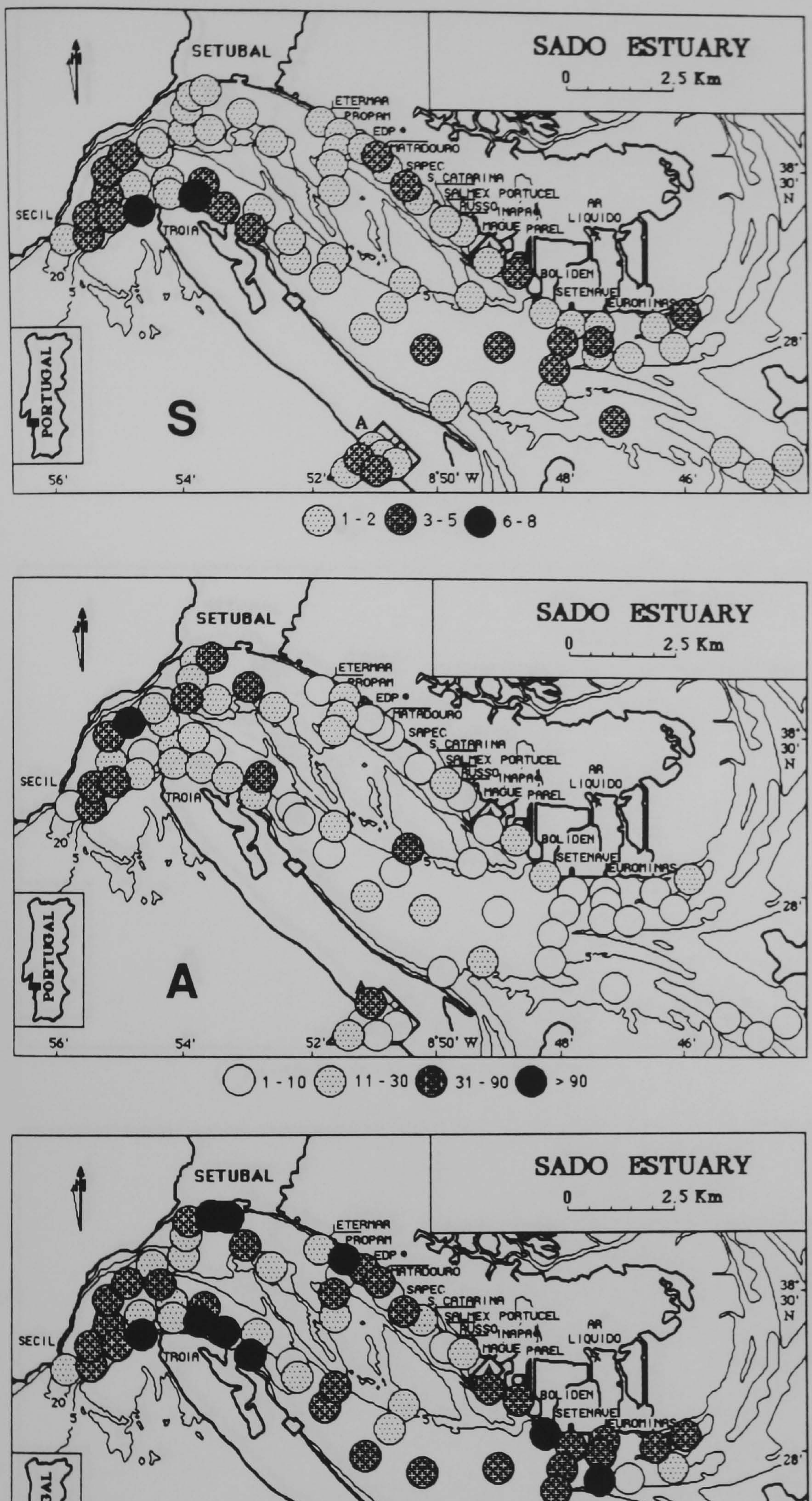


Figure 5.48 - Sado Estuary. Spatial distribution of species richness (S), abundance (A) and wet-weight biomass (B) of carnivores per $0.1m^2$ considering the top ten species of each sampling station. Biomass in mg.

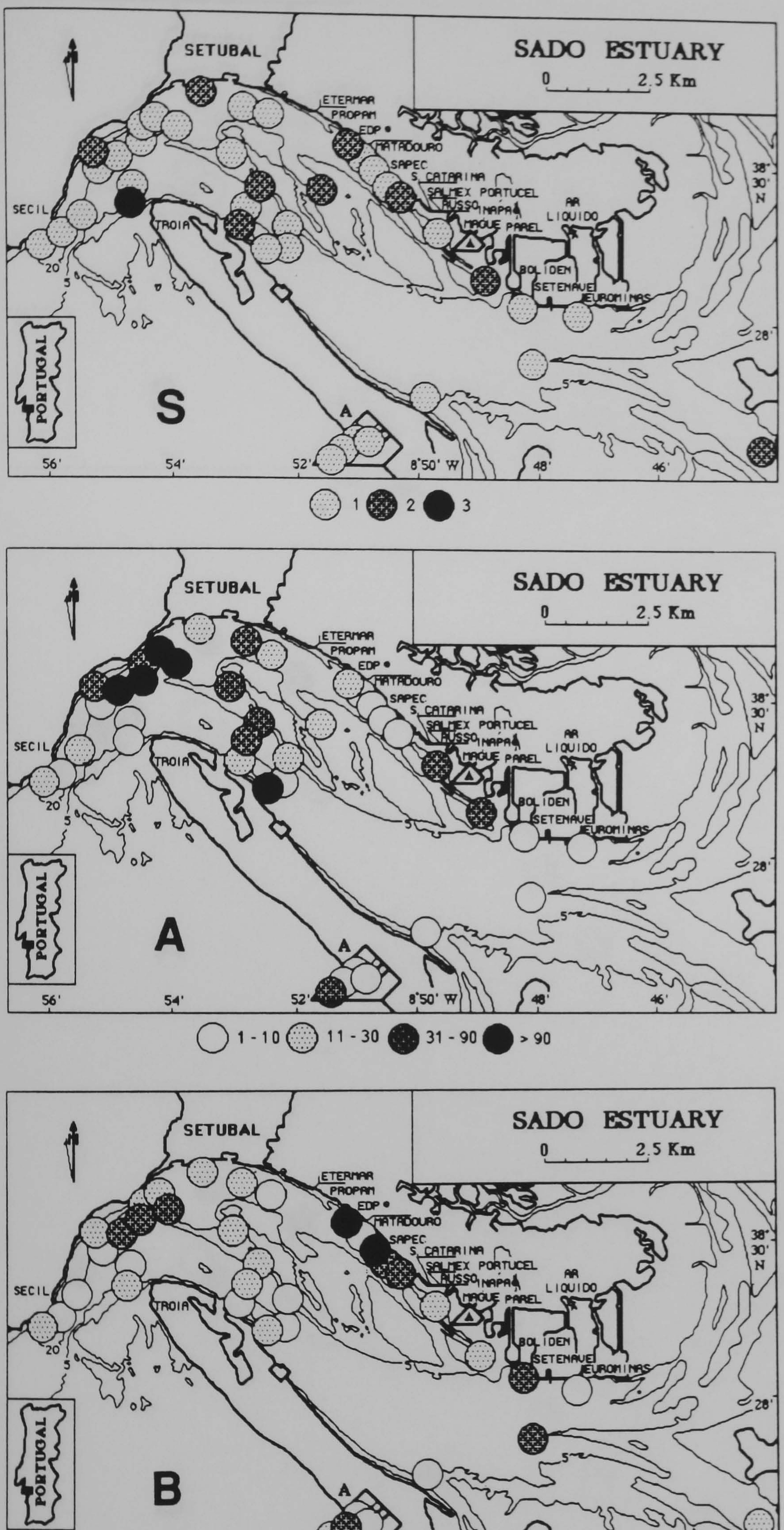


Figure 5.49 - Sado Estuary. Spatial distribution of species richness (S), abundance (A) and wet-weight biomass (B) of carnivores/deposit feeders per $0.1 m^2$ considering the top ten species of each sampling station. Biomass in mg.

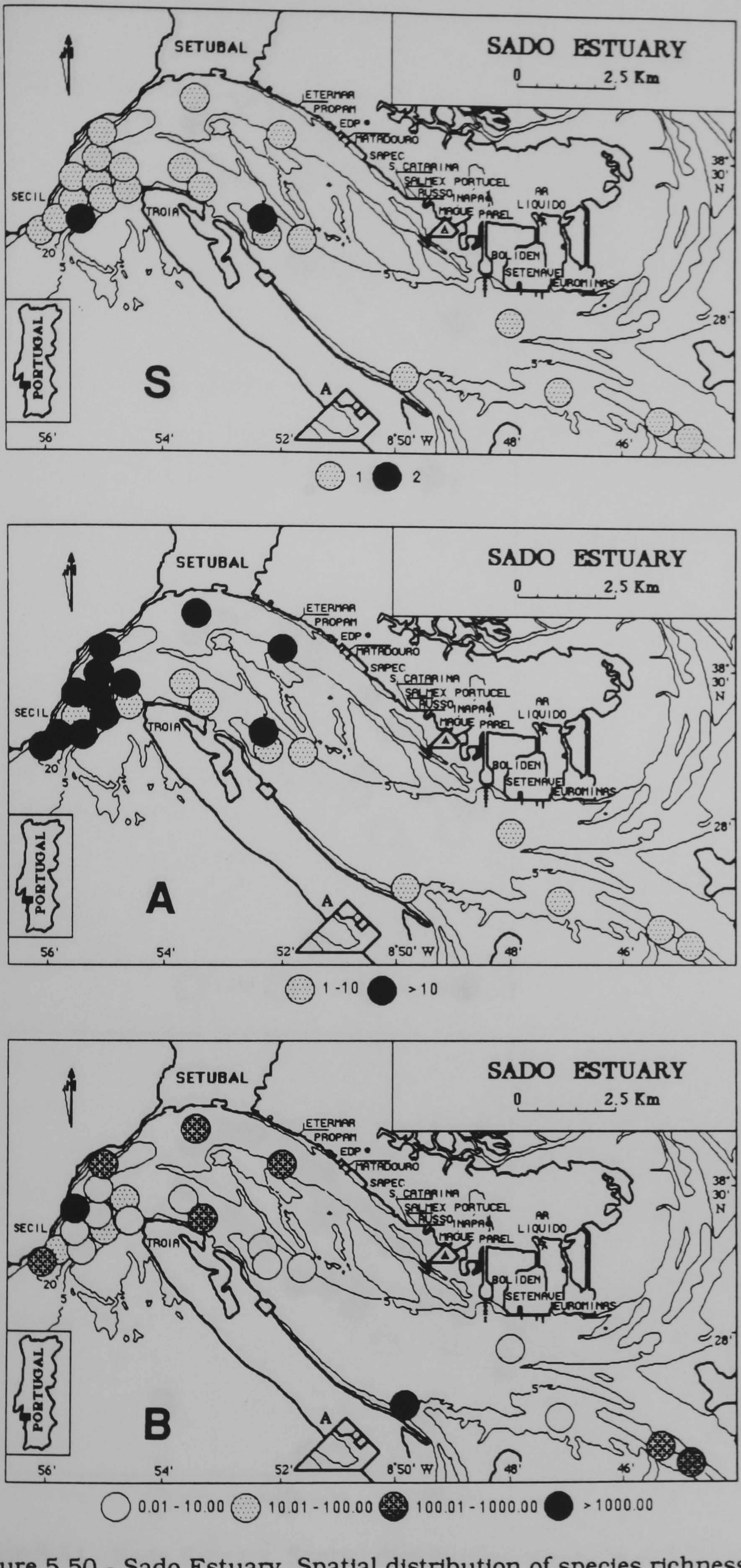


Figure 5.50 - Sado Estuary. Spatial distribution of species richness (S), abundance (A) and wet-weight biomass (B) of herbivores per $0.1m^2$ considering the top ten species of each sampling station. Biomass in mg.

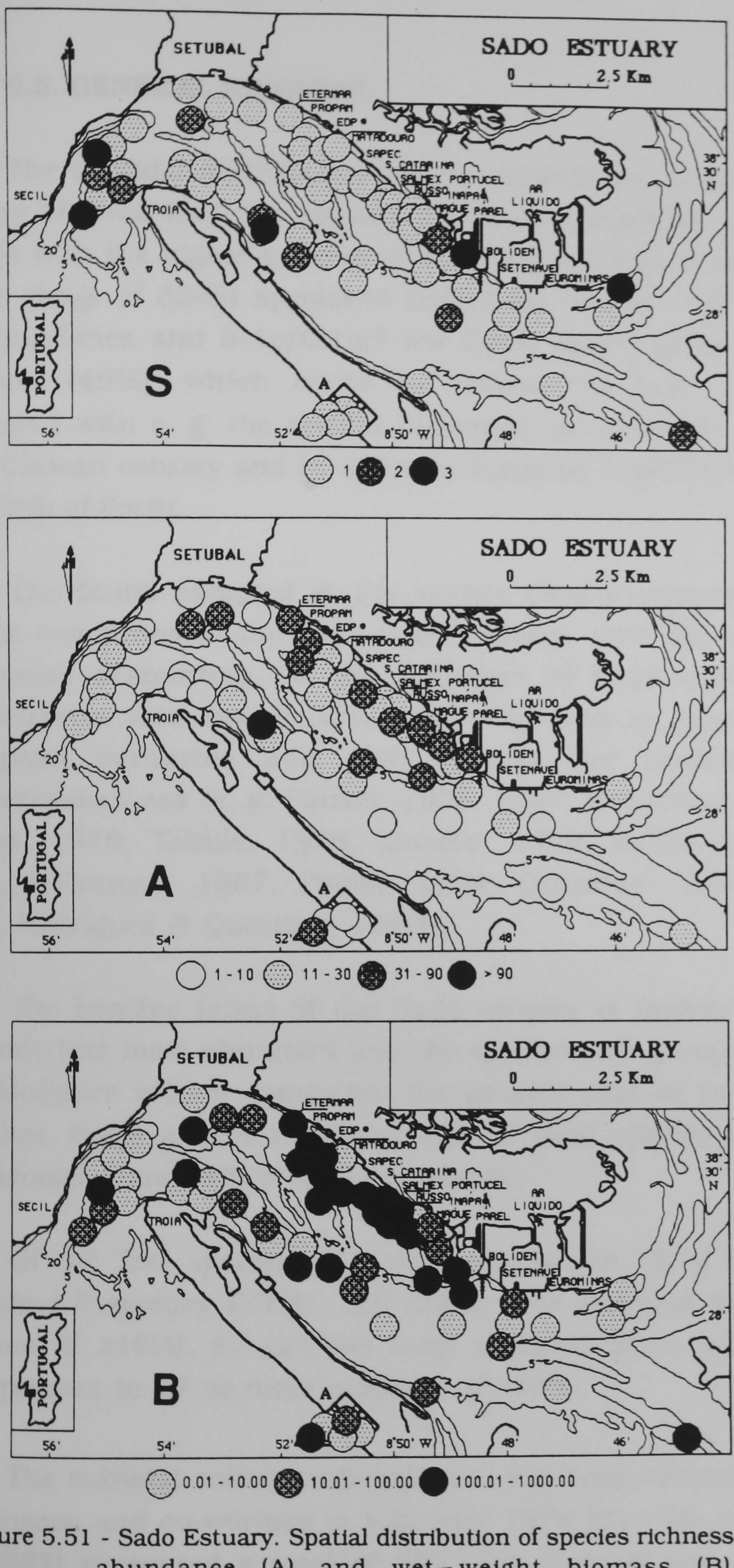


Figure 5.51 - Sado Estuary. Spatial distribution of species richness (S), abundance (A) and wet-weight biomass (B) of herbivores/deposit feeders per 0.1m^2 considering the top ten species of each sampling station. Biomass in mg.

5.5. GENERAL REMARKS

The subtidal macrofaunal survey undertaken in the Sado outer estuary showed that the species richness, abundance and biomass classes with the higher number of sampling stations in the Sado were in the range of 33-64 species/0.1m^2 (50%), 0-200 ind/0.1m^2 (31%) for abundance and 0-4g/0.1m^2 ww (28%) and 0-1g/0.1m^2 afdw for biomass (49%), which could be considered high values when compared with e. g. the results presented by Jaramillo *et al.* (1984) for a Chilean estuary and by Elliott & Kingston (1987) for the Estuary and Firth of Forth.

The fauna sampled in the survey clearly suggests prevailing marine conditions in the Sado outer estuary, with few contributions of species accounting for the influence of freshwater conditions (oligochaetes and insect larvae, namely) and is characteristic of European estuaries and also reflects the proximity of the Mediterranean sea (e. g. Fauvel, 1923, 1927, Katzmann *et al.*, 1974, Ramos, 1976, Tebble, 1976, Lincoln, 1979, Bellan-Santini *et al.* 1982, O'Connor, 1987, Pleijel, 1988, Quintino, 1988, Marques, 1989, Rodrigues & Quintino, 1991b).

The benthic fauna of the Sado estuary is mainly made up of Annelids (the most abundant and the species rich group), Arthropods and Molluscs (which comprises the greater part of total biomass). Together, these groups represent 93% of total species richness and total biomass, and 98% of total abundance.

Of the 362 species, 229 were present in 10 or less stations (sampling frequency F≤7%), 120 (33%) were sampled in 13 or more stations (F ≥10%), 87 (24.0%) were sampled once, and 15 (4.1%) were present in 67 or more stations (F>50%).

The subtidal survey undertaken in the Sado estuary by Cancela da Fonseca and co-workers in February 1979 (Cancela da Fonseca *et al.*, 1987) presented a total of 250 taxa (considering not only the taxonomic groups of the present work but also Foraminifera, Porifera, Cephalopada, Cirripedia, Diptera, Bryozoa), from which Annelids, Arthropods and Molluscs comprise 83% of the total number of species (Table V.21).

According to their data, only 30 species (12%) were present in 7 or more stations (F≥10%), with the most frequent species being present in 21 sampling stations (F=30%) (*Melinna palmata* and *Sphaeroma monodi*). On the other hand almost 57% of the species, 142, were present once (*cf.* table V.21). These results like the ones obtained in the present study, also indicate the predominance in the estuary of Annelids, Arthropods and Molluscs but they suggest not only a poorer fauna but also much more heterogeneous samples which could be the result of a major flood and stormy winter, in 1978/79, just before their sampling period.

Most of the species were present in few stations, for example of the 74 Arthropod species mentioned by the authors, 47 were sampled once and 10 twice, comprising 77% of the group total species, while in the present study from the 123 Arthropod species collected, 26 were sampled once and 14 twice representing together only 24% of the total.

The high number of low frequency species and the relative low sampling frequency of the most frequent species in Cancela da Fonseca's *et al.* (1987) made it difficult to globally characterize the Sado subtidal macrofauna. The authors don't present quantitative data (abundance and biomass), making it impossible to compare ours with their results.

	Number of species			Frequency		Sp. present once
	Ann.	Arthr.	Moll.	F≥10%	F>50%	
Present study	134 (37%)	123 (34%)	81 (22%)	120 (33%)	15 (4%)	87 (24%)
Cancela da Fonseca et al.	93 (37%)	74 (30%)	40 (16%)	30 (12%)	0	142 (57%)

Table V.21 - Comparison of some results obtained in the present study and the ones presented by Cancela da Fonseca *et al.*, (1987).

In the present study, the majority of species were represented by few animals: 179 species (almost 50%) were represented by a maximum of 10 individuals, comprising 686 specimens, less than 1%

of the total abundance. On the other hand 17 species were collected with more than 1000 specimens and they comprise almost 70% of the total abundance. The most frequent and abundant species belong mainly to the polychaets cirratulids: *Caulleriella sp.*, *Tharyx sp.* and *Cirriformia sp.*

From the 133 sampling stations only two appear defaunated. Annelids were present in all the remaining locations, Arthropods in 128 locals and Molluscs in 123. The stations without Annelids and Molluscs were mainly located close to the northern margin within the area of the industrial complex.

Biomass values were very unevenly distributed by the different species, with 38 taxa (considering wet-weight biomass values) represented by more than 10.0 g, and representing globally 91.3 % of total biomass. Molluscs dominate, either attending to wet weight, dry weight or ash-free dry weight measurements.

Some regions in the estuary presented, in general, low values for each the three biological variables: the estuarine entrance, the region near to the urban sewage outfall, the region closest to the margin in the northern channel corresponding to the industrial belt (from Etermar inwards), the upper region of the estuary (in front of Boliden/Setenave and Eurominas) and the innermost region of Alcácer channel. Generally, in these areas 50% or more of the total location abundance is attained by 1 or 2 species. This suggests that these areas present disturbance characteristics.

In fact, Elliott (1983) mentioned that in a clean, coastal sublittoral area at which the community is not stressed, the top ten species (by abundance) account for approx. 50-60% of the total. This number could be greatly reduced in an estuary (naturally stressed) or in a polluted area (stressed unnaturally). Despite this fact the author found in his study of the Forth estuary between 1 to 8 numerically dominant species, while only 1 or 2 in the stations located in areas disturbed by industrial wastes (Skinflats, Kinneil Bay, Bo'ness). These regions also presented the lowest values for species richness, abundance, biomass and diversity (H').

In the Sado estuary the region which presented the highest values for the three primary biological variables was found between the estuarine entrance and the beginning of the intertidal sandbanks.

For the species richness and abundance a longitudinal gradient could be defined (more clear, nevertheless, for species richness) with increasing values from the estuarine entrance towards the beginning of the sand banks and then decreasing landward in the direction of the upper and inner regions. In the northern channel, from Etermar inwards, transverse gradients are also noticeable with increasing species richness from the margin towards the sand banks. Biomass values are more scattered in the estuary and depended mainly on the presence of Molluscs and the high densities of particular species, namely opportunistic polychaetes.

The transverse gradients obtained in the Sado estuary show different characteristics: in the south channel they may be due to an impoverishment in the deeper regions most probably related to an increasing sediment instability, while in the northern channel the decreasing of the species richness, abundance and biomass towards the margins seems to indicate a disturbance induced by the industrial outfalls. Examples of biological variables gradients as a result of anthropogenic inputs are numerous in the benthic literature (e. g. Leppäkoski, 1975, Landner *et al.*, 1977, Pearson & Rosenberg, 1978, McLusky, 1982, Elliott & Kingston, 1987).

The general longitudinal and transverse gradients found in Sado estuary, were also defined in other systems of the Portuguese coast, namely in the lagoons of Obidos and Albufeira and Santo André (western coast) (Quintino, 1988, Quintino *et al.*, 1989, Cancela da Fonseca, 1989), Mira estuary (Andrade, 1986) and the Ria de Alvor (southern coast) (Quintino & Rodrigues, 1989). These gradients are commonly known from estuarine systems, where a mixture of freshwater and marine conditions tends to result in more or less clear horizontal gradients (McLusky, 1989) eventually shaped by other driving environmental conditions, able to induce local gradients (e. g. Pearson & Rosenberg, 1978).

The macrofauna species sampled in the Sado showed individual distribution areas and local densities more or less specific to a particular region of the estuary and only very rarely tend to be ubiquitous. Most of the species clearly avoid the region along the northern margin, inwards of the industrial belt and the one in front of Boliden/Setenave/Eurominas.

Species diversity values calculated with the abundances were in the range of 0.15 to 4.98 bits/ind., with 44% of the sampling stations showing values between 3.5 and 4.5. This range of values is somewhat lower but close to the ones found in the Firth of Forth, ranging from 0.71 to 5.24 bits/ind. (Elliott & Kingston, 1987).

In general, this variable shows spatial gradients similar to the ones defined with the primary variables: it decreases along the longitudinal axis seawards-inwards and transversely in the northern channel, from the sandbanks towards the margins, and in the southern channel, from the sandbanks and the margins towards the deeper regions. The lowest value areas (<2.5bits/ind.) are essentially concentrated in the upper region and also scattered along the northern margin. The highest values appeared in stations between the entrance and the beginning of the intertidal sandbanks, and extending to the most seaward region of the southern channel.

Diversity calculated on the basis of wet-weight biomass was in general lower but the global gradients were similar.

Eveness did not present a clear spatial pattern. Nevertheless, the values obtained with the biomass data separate well the northern from the southern channel, the last one with the highest values. Eveness based on the abundance data varied from 0.04 to 1.00, with the lowest values in the nearest stations to the urban sewage and the pulp mill outfalls, which also presented the lowest diversity values.

Like the diversity based on the biomass data, eveness values were in general lower than the ones obtained with the abundance data. Together with the lower diversity values these results seem also to point that biomass would be more unevenly distributed than abundance.

The spatial variability shown by the primary variables S, A, and B and the abundance ratio and the size ratio, along sets of sampling stations located in increasing distance from possible organic enrichment sources, showed that only in two cases was the succession of these variables the same as suggested by the SAB model and the expected variation of the two ratios in a gradient of organic enrichment (Pearson & Rosenberg, 1978, Pearson *et al.*, 1982).

The gradients established, corresponding to a decrease of organic enrichment, had their source points near the urban sewage and pulp mill outfall and were directed in the former to the estuarine entrance and in the latter to the southern channel. The two situations identified correspond to the "hot spots" in the estuary and the potential sources are located in the extremities of the industrial belt. The difficulties in establishing clear gradients could be due to particular characteristics of the Sado estuary, namely complex hydrodynamics, heterogeneous sediments relatively close to each other, as well as a complex mixture of anthropogenic sources affecting the northern channel.

The production estimations in the Sado estuary presented values ranging from 218.15 g afdw/m2/year, in station 26 (urban effluent outfall) to 0.26 g afdw/m2/year, in local 115 (in the upper region). The production spatial pattern was shown to be very similar to the afdw biomass, the main differences concerning the locations in which macrofauna was mainly made up either of very small or very large specimens. Similarities between the spatial distribution of production estimates and biomass afdw were also found in the Forth estuary, where the production was calculated using the more elaborate method of Crisp (1984), for populations with recruitment and size classes separable (Elliott, 1983, Elliott & Kingston, 1987, Elliott & Taylor, 1989).

In the Sado estuary the higher production estimates were found in the region between the entrance and the beginning of the sandbanks, mainly close to the northern margin, while the lowest ones correspond to the estuarine entrance, the part of the northern margin accompanying the industrial complex, the region in front of Boliden/Setenave and Eurominas, the beginning of Alcácer channel and in some stations of the southern channel with coarse sediments.

Trophic group analysis shows that the Sado estuary is dominated by both surface and sub-surface deposit feeders, sampled in almost every location, either in terms of species richness, abundance or biomass.

The spatial distribution of these two trophic groups shows, both in terms of species richness and biomass (wet-weight), clear differences between the two channels, being the surface deposit feeders preferentially distributed in the northern and the sub-surface in the southern channel.

Finally, the analysis of the primary and the derived variables together with the individual species and trophic groups distribution suggests that the Sado outer estuary presents 4 distinct regions: 1) the entrance, 2) a region located between the entrance and the beginning of the intertidal sandbanks, 3) the northern channel, in which the distinction of the nearest stations to the margin along the area occupied by the industrial belt should be made, and finally 4) the southern channel with the upper region, this latter with a distinct group of stations located closer to Boliden/Setenave/Eurominas, in the northern margin.

A more detailed analysis of the regions and the underlying ecological gradients will be the objective of the next chapter, in which the biological and the environmental data will be treated together.

CHAPTER 6

MACROBENTHOS-ENVIRONMENT RELATIONSHIPS

6.1 - INTRODUCTION

Several numerical data treatment methods have been used to assess the relationship between global species data and environmental data, to define, characterize and chart the spatial distribution of the Sado estuary subtidal benthic communities, and to define their relationship with the prevailing hydrophysical and sedimentary aspects of the estuary. The state of disturbance of these communities was assessed through the analytical study of community structure properties.

Regression analysis techniques (linear and the second order polynomial) were used to obtain initial information on the relationship between both the trophic structure of the estuary and the total primary biological variables distribution, and the sedimentary and hydrodynamic data.

A classification method (TWINSPAN) was used to identify affinity groups among sampling locations, validated on the basis of their species constancy and fidelity. These groups were also characterized by means of the most abundant and frequent species, and on the basis of sedimentary and hydrodynamic characteristics of the sampling sites.

Canonical correspondence analysis was further used to estimate the relationship between the TWINSPAN groups and the environmental data, giving insight into the driving environmental parameters in the Sado estuary.

By changing the spatial scale of observation, and considering in a single set the biological data of the sampling locations of each affinity group of stations, the global structure and state of disturbance of Sado estuary subtidal benthic communities was assessed by means of K-dominance curves and ABC-curves, the SAB model and the rarefaction measure of diversity.

6.2 - REGRESSION ANALYSIS

Both the trophic groups data and the species data (richness, abundance and biomass per sampling location), were submitted to a regression analysis against several environmental variables (depth, hydrodynamic and sedimentary variables).

Given the marked asymmetry observed in the biological data, a logarithmic transformation was imposed, $y' = \ln(y+1)$ (see Chapter 3). In each case, both linear and polynomial regressions were used. The results obtained between each pair of biological and environmental variables is summarized in Tables VI.1 and VI.2.

In general, the sedimentary parameters, mainly fines, sand and total organic matter (TOM), account for a higher percentage of the variation in the biological data than do the hydrodynamic variables, the best fits being obtained through the polynomial regression.

In the case of the trophic groups analysis however, a caution should be exercised in accepting the results as they are, since, with the exception of the surface and the sub-surface deposit feeders, present in almost all sites, these analyses had to deal with many zeros. In these cases, a logit regression could be more appropriate (ter Braak & Looman, 1987), but the method was not available in our data treatment software.

The distribution of filter feeders, was best explained by the gravel content of the sediment through linear regression. The best fit concerns the abundances of the group, for which gravel explains 11.3% of the variation.

The group filter feeders/surface deposit feeders presented better fits with current velocities in a polynomial regression, showing higher values at intermediate current speeds. The highest R^2_{adj} value

Biological Variables		Environmental variables															
		Shear stress		Water flow		Velocity		Depth		Gravel		Sand		Fines		TOM	
		Linear	Polyn.	Linear	Polyn	Linear	Polyn.	Linear	Polyn	Linear	Polyn	Linear	Polyn	Linear	Polyn	Linear	Polyn
FF - S	R2adj.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0.039	*	0.091	*	n.s.	n.s.	n.s.	n.s.	0.053	*
	F test							6.233		14.073						8.306	
	Prob.							0.0138		0.0003						0.0046	
FF - A	R2adj.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0.043	*	0.113	*	n.s.	n.s.	n.s.	n.s.	0.034	n.s.
	F test							6.781		17.620						5.623	
	Prob.							0.0103		0.0001						0.0192	
FF - B	R2adj.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0.037	n.s.	0.080	*	n.s.	n.s.	n.s.	n.s.	0.028	n.s.
	F test							6.016		12.372						4.787	
	Prob.							0.0155		0.0006						0.0305	
FF/SDF - S	R2adj.	0.061	*	0.060	*	0.061	0.117	n.s.	0.057	n.s.	0.073	0.075	*	0.083	*	0.067	*
	F test	9.455		9.296		9.382	9.601		4.931		6.118	11.560		12.831		10.348	
	Prob.	0.0026		0.0028		0.0027	0.0001		0.0090		0.0029	0.0009		0.0005		0.0016	
	t test						3.037		2.880		3.197						
	Prob						0.0029		0.0047		0.0018						
FF/SDF - A	R2adj.	0.034	0.070	n.s.	n.s.	0.030	0.096	n.s.	0.041	n.s.	0.036	n.s.	0.047	n.s.	0.050	n.s.	0.076
	F test	5.640	5.876			4.981	7.903		3.776		3.430		4.213		4.393		6.339
	Prob.	0.0190	0.0036			0.0274	0.0006		0.0260		0.0354		0.0169		0.0143		0.0024
	t test		2.428				3.234		2.746		2.619		2.538		2.631		3.377
	Prob		0.0166				0.0016		0.0069		0.0099		0.0123		0.0096		0.0010
FF/SDF - B	R2adj.	n.s.	0.033	n.s.	n.s.	n.s.	0.069	n.s.	0.038	n.s.	0.053	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
	F test		3.233				5.821		3.584		4.605						
	Prob.		0.0427				0.0038		0.0306		0.0117						
	t test		2.309				3.187		2.653		2.978						
	Prob.		0.0226				0.0018		0.0090		0.0035						
SDF - S	R2adj.	0.148	0.193	0.096	*	0.113	0.164	0.042	*	0.026	n.s.	0.072	0.226	0.089	0.297	0.096	0.248
	F test	23.504	16.549	14.825		17.623	13.780	6.634		4.459		11.103	20.027	13.622	28.403	14.876	22.390
	Prob.	0.0001	0.0001	0.0002		0.0001	0.0001	0.0111		0.0367		0.0011	0.0001	0.0003	0.0001	0.0002	0.0001
	t test		2.876				2.978						5.171		6.257		5.188
	Prob.		0.0047				0.0035						0.0001		0.0001		0.0001
SDF - A	R2adj.	0.027	0.090	n.s.	n.s.	n.s.	0.057	n.s.	n.s.	n.s.	n.s.	n.s.	0.283	n.s.	0.314	n.s.	0.250
	F test	4.569	7.400				4.928						26.676		30.685		22.638
	Prob.	0.0344	0.0009				0.0087						0.0001		0.0001		0.0001
	t test		3.149				2.535						7.304		7.832		6.729
	Prob.		0.0020				0.0124						0.0001		0.0001		0.0001
SDF - B	R2adj.	0.053	0.126	0.041	*	0.044	0.100	n.s.	n.s.	n.s.	n.s.	n.s.	0.316	n.s.	0.352	n.s.	0.288
	F test	8.302	10.401	6.614		7.011	8.258						31.063		36.322		27.268
	Prob.	0.0046	0.0001	0.0113		0.0091	0.0004						0.0001		0.0001		0.0001
	t test		3.436				3.011						7.807		8.426		7.313
	Prob.		0.0008				0.0031						0.0001		0.0001		0.0001
SSDF - S	R2adj.	0.030	*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
	F test	4.956															
	Prob.	0.0277															
SSDF - A	R2adj.	- n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0.039	n.s.	0.044	n.s.	0.033
	F test												3.626		4.012		3.250
	Prob.												0.0294		0.0204		0.042
	t test												2.676		2.810		2.512
	Prob.												0.0084		0.0057		0.0132
SSDF - B	R2adj.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
	F test																
	Prob.																
C - S	R2adj.	n.s.	0.075	0.028	n.s.	n.s.	0.048	n.s.	n.s.	n.s.	n.s.	n.s.	0.249		0.269		0.203
	F test		6.275	4.809			4.272						22.507		24.897		17.524
	Prob.		0.0025	0.0301			0.0160						0.0001		0.0001		0.0001
	t test		3.478				2.839						6.675		7.024		5.875
	Prob.		0.0007				0.0053						0.0001		0.0001		0.0001
C - A	R2adj.	n.s.	0.047	0.073	*	n.s.	0.045	n.s.	n.s.	n.s.	n.s.	n.s.	0.159	n.s.	0.171	n.s.	0.128
	F test		4.235	11.224			4.034						13.264		14.370		10.534
	Prob.		0.0166	0.0011			0.0200						0.0001		0.0001		0.0001
	t test		2.609				2.480						4.759		4.959		4.330
	Prob.		0.0102				0.0144						0.0001		0.0001		0.0001
C - B	R2adj.	n.s.	0.051	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0.197	n.s.	0.209	n.s.	0.105
	F test		4.495										16.930		18.138		8.610
	Prob.		0.0130										0.0001		0.0001		0.0003
	t test		2.938										5.811		6.015		4.120
	Prob.		0.0039										0.0001		0.0001		0.0001
C/DF - S	R2adj.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0.066	n.s.	0.068	n.s.	0.049
	F test												5.599		5.749		4.329
	Prob.												0.0047		0.0041		0.0152
	t test												2.891		2.954		2.357
	Prob												0.0045		0.0037		0.0199
C/DF - A	R2adj.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0.065	*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
	F test							10.064									
	Prob.							0.0019									
C/DF - B	R2adj.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0.033	0.093	0.035	0.091	0.031	0.063
	F test											5.486	7.640	5.731	7.468	5.171	5.389
	Prob.											0.0207	0.0007	0.0181	0.0009	0.0246	0.0057
	t test												3.072		2.976		2.330
	Prob												0.0026		0.0035		0.0214
H - S	R2adj.	0.112	0.197	0.154	*	0.084	0.194	0.082	*	0.132	*	0.042	*	0.078	0.171	0.052	0.124
	F test	17.414	16.980	24.755		12.859	16.615	12.682		20.693		6.672		12.009	14.447	8.180	10.225
	Prob.	0.0001	0.0001	0.0001		0.0005	0.0001	0.0005		0.0001		0.0109		0.0007	0.0001	0.0049	0.0001
	t test		3.834				4.314								3.941		3.405
	Prob		0.0002				0.0001								0.0001		0.0009
H - A	R2adj.	0.073	0.150	0.139	*	0.042	0.169	0.134	*	0.295	*	0.024	*	0.075	0.130	0.048	0.093
	F test	11.196	12.460	22.072		6.714	14.204	21.175		55.501		4.197		11.567	10.743	7.531	7.656
	Prob.	0.0011	0.0001	0.0001		0.0107	0.0001	0.0001		0.0001		0.0425		0.0009	0.0001	0.0069	0.0007
	t test		3.565				4.546								3.031		2.722
	Prob.		0.0005				0.0001								0.003		0.0074
H - B	R2adj.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0.053	0.080	0.228	*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
	F test							8.283	6.672	39.331							
	Prob.							0.0047	0.0018	0.0001							
	t test								2.195								
	Prob.								0.0300								
H/DF - S	R2adj.	0.038	*	n.s.	n.s.	0.050	*	n.s.	n.s.	n.s.	n.s.	0.026	0.085	n.s.	0.050	n.s.	0.074
	F test	6.081				7.826						4.428	7.008		4.449		6.204
	Prob.	0.0150				0.0059						0.0373	0.0013		0.0136		0.0027
	t test												3.050		2.429		2.949
	Prob												0.0028		0.0165		0.0038
H/DF - A&B	R2adj.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
	F test																
	Prob.																

Table VI.1 - Sado estuary. Linear and polynomial regression coefficients and probability tests. FF-Filter feeders; SDF-Surface deposit feeders; SSDF-Subsurface deposit feeders; C-Carnivores; H-Herbivores; S-species richness; A-Abundance; B-Biomass; ns-non significant; R2adj. - adjusted coefficient of determination; * -The polynomial regression does not improve the fit over the straight line

Biological variables		Environmental variables															
		Shear stress		Water flow		Velocity		Depth		Gravel		Sand		Fines		TOM	
		Linear	Polyn.	Linear	Polyn.	Linear	Polyn.	Linear	Polyn.	Linear	Polyn.	Linear	Polyn.	Linear	Polyn.	Linear	Polyn.
Trophic richness	R2adj.							0.036					0.085		0.133		0.096
	F test							5.799					7.059		10.944		7.890
	Probab.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0.0174	n.s.	n.s.	n.s.	n.s.	0.0012	n.s.	0.0001	n.s.	0.0006
	t test												3.740		4.616		3.834
	Probab.												0.0003		0.0001		0.0002
Total S	R2adj.									0.023			0.206	0.027	0.179	0.024	0.133
	F test									4.058			17.837	4.657	15.206	4.241	10.966
	Probab.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0.0460	n.s.	n.s.	0.0001	0.0328	0.0001	0.0415	0.0001
	t test												5.630		4.989		4.142
	Probab.												0.0001		0.0001		0.0001
Total A	R2adj.												0.161		0.159		0.158
	F test												13.463		13.320		13.212
	Probab.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0.0001	n.s.	0.0001	n.s.	0.0001
	t test												5.143		5.089		5.099
	Probab.												0.0001		0.0001		0.0001
Total B	R2adj.	0.060	0.132	0.094		0.063	0.132						0.244		0.226		0.225
	F test	9.364	10.888	14.421		9.725	10.842						21.987		20.008		19.848
	Probab.	0.0027	0.0001	0.0002	*	0.0022	0.0001	n.s.	n.s.	n.s.	n.s.	n.s.	0.0001	n.s.	0.0001	n.s.	0.0001
	t test	3.060	3.412				3.345						6.574		6.296		6.294
	Probab.		0.0009				0.011						0.0001		0.0001		0.0001
Annelids - S	R2adj.											0.029	0.177	0.039	0.159	0.039	0.130
	F test											4.826	14.961	6.339	13.245	6.313	10.705
	Probab.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0.0298	0.0001	0.0130	0.0001	0.0132	0.0001
	t test												4.922		4.388		3.800
	Probab												0.0001		0.0001		0.0002
Annelids - A	R2adj.												0.174		0.189		0.181
	F test												14.685		16.165		15.351
	Probab.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0.0001	n.s.	0.0001	n.s.	0.0001
	t test												5.385		5.653		5.469
	Probab.												0.0001		0.0001		0.0001
Annelids - B	R2adj.	0.035	0.117	0.092		0.036	0.116	0.057					0.125		0.192		0.197
	F test	5.677	9.614	14.121		5.842	9.504	8.813					10.308		16.411		16.909
	Probab.	0.0186	0.0001	0.0003	*	0.0171	0.0001	0.0036	*	n.s.	n.s.	n.s.	0.0001	n.s.	0.0001	n.s.	0.0001
	t test		3.609				3.555						4.370		5.503		5.674
	Probab.		0.0004				0.0005						0.0001		0.0001		0.0001
Molluscs - S	R2adj.		0.106				0.057			0.025			0.255		0.225		0.150
	F test		8.686				4.965			4.396			23.270		19.861		12.513
	Probab.	n.s.	0.0003	n.s.	n.s.	n.s.	0.0084	n.s.	n.s.	0.0380	n.s.	n.s.	0.0001	n.s.	0.0001	n.s.	0.0001
	t test		3.939				2.829						6.632		5.975		4.644
	Probab.		0.0001				0.0054						0.0001		0.0001		0.0001
Molluscs - A	R2adj.	0.029	0.067			0.024	0.052						0.256		0.223		0.159
	F test	4.814	5.631			4.197	4.558						23.417		19.623		13.289
	Probab.	0.0300	0.0045	n.s.	n.s.	0.0425	0.0122	n.s.	n.s.	n.s.	n.s.	n.s.	0.0001	n.s.	0.0001	n.s.	0.0001
	t test		2.500				2.190						6.833		6.219		5.127
	Probab.		0.0137				0.0303						0.0001		0.0001		0.0001
Molluscs - B	R2adj.		0.121	0.045			0.106		0.031				0.231		0.223		0.154
	F test		9.983	7.109			8.719		3.088				20.515		19.660		12.854
	Probab.	n.s.	0.0001	0.0087	*	n.s.	0.0003	n.s.	0.0490	n.s.	n.s.	n.s.	0.0001	n.s.	0.0001	n.s.	0.0001
	t test		3.997				3.654		2.008				6.374		6.217		4.984
	Probab.		0.0001				0.0004		0.0468				0.0001		0.0001		0.0001
Arthropods - S	R2adj.												0.122		0.103		0.079
	F test												10.030		8.466		6.579
	Probab.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0.0001	n.s.	0.0004	n.s.	0.0019
	t test												4.403		3.987		3.507
	Probab.												0.0001		0.0001		0.0006
Arthropods - A	R2adj.								0.038				0.073		0.063		0.104
	F test								3.564				6.126		5.371		8.530
	Probab.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0.0312	n.s.	n.s.	n.s.	0.0029	n.s.	0.0058	n.s.	0.0003
	t test								2.355				3.458		3.192		4.044
	Probab.								0.0200				0.0007		0.0018		0.0001
Arthropods - B	R2adj.		0.041										0.150		0.137		0.131
	F test		3.746										12.430		11.306		10.826
	Probab.	n.s.	0.0262	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0.0001	n.s.	0.0001	n.s.	0.0001
	t test		2.251										4.724		4.419		4.170
	Probab		0.0261										0.0001		0.0001		0.0001

Table VI.2 - Sado estuary. Linear and polynomial regression coefficients and probability tests. S-Species richness; A-Abundance; B-Biomass; ns- non significant; R2adj. - adjusted coefficient of determination; *-the polynomial regression does not improve the fit over the straight line.

(0.117) was obtained with the number of species of the group per site.

Surface deposit feeders distribution is better explained by fines, TOM and sand. This group had the highest values of species number, abundance and biomass, at values close to 35% of fines, 4 to 5% of TOM and 40 to 45% of sand, in a second order polynomial regression. The species richness and the biomass of this group are also significantly related to shear stress and current velocities, with maximum values at intermediate values of the explanatory variables.

On the contrary, sub-surface deposit feeders had little relation to the environmental data. In the case of species richness, the only significantly related parameter was shear stress, explaining 3% (linear regression) of the groups distribution in the estuary. Abundance showed a significative relation in a polynomial regression mainly with fines and sand, both explaining 4% of its variation. The biomass showed no significant relation with the environmental parameters.

The global results obtained with the deposit feeders show clearly a stronger influence of fines and TOM in the surface deposit feeders distribution than in the sub-surface deposit feeders. The former strongly dominate in the northern channel where the two environmental variables present their highest values. The latter are predominantly distributed along the southern channel, where the hydrodynamic parameters are more important.

Carnivores and carnivore/deposit feeders showed better fits through polynomial regression, mainly with fines and sand. In this case however, both groups showed minimum values with intermediate values of the explanatory variables. These results are not in disagreement with the distribution of those trophic groups (*cf.* figures 5.48 and 5.49 in Chapter 5), which in fact occur predominantly in stations where sediments show either the lowest or the highest silt and sand content. Nevertheless an analysis of the graphics generated by the regressions, suggests that the fits obtained could be mostly the result of many zeros in the data (see e.g. figure 6.1).

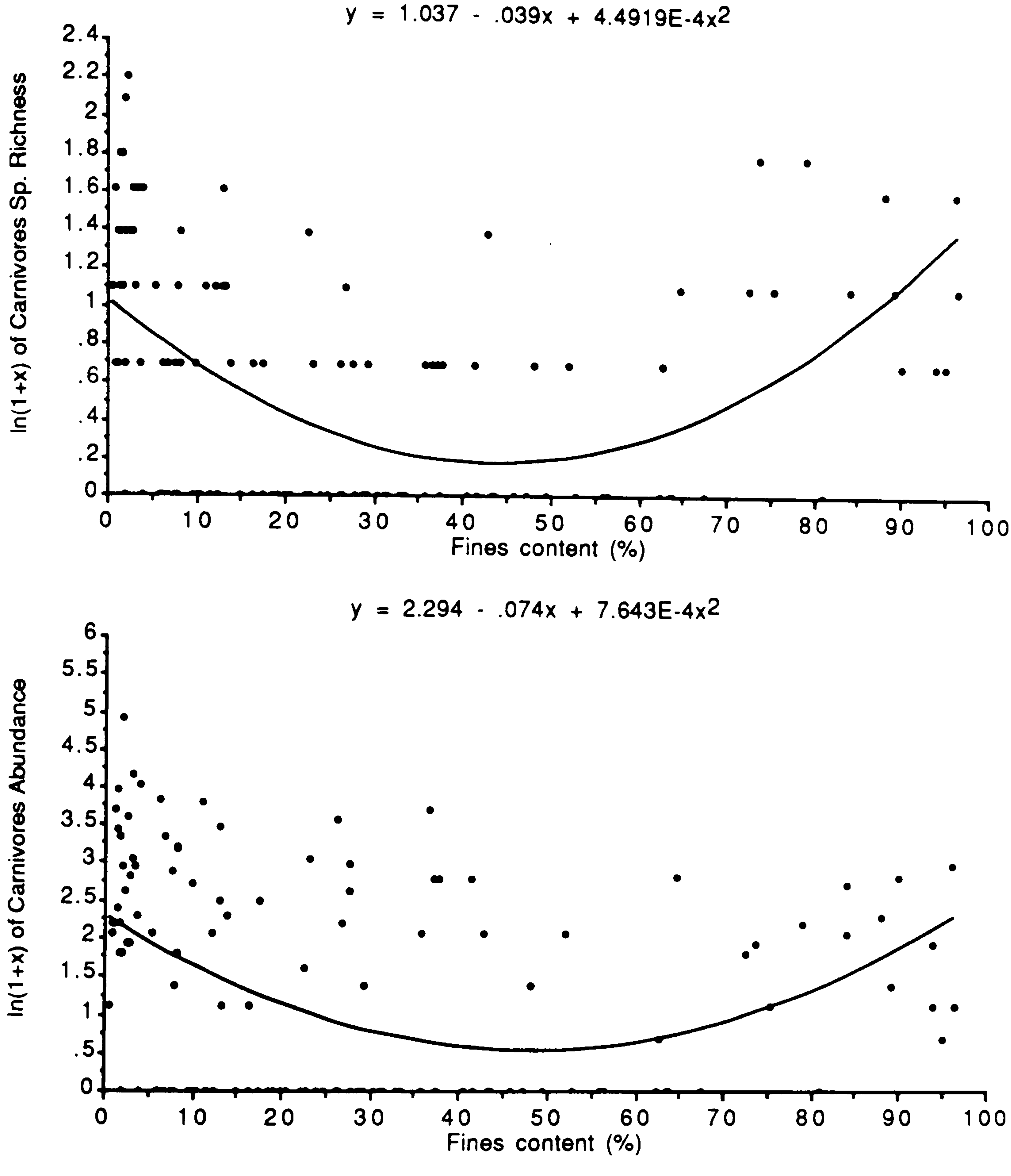


Figure 6.1 - Polynomial regression (degree 2) showing the fit between the species richness and abundance of carnivores and the fines content of the sediment.

Herbivore species richness and abundance are better explained (31% and 26%) by maximum values of shear stress in a polynomial regression, while the biomass variation is more related to the gravel content of the sediment, in a linear regression (23%). The results of this group also suggest a strong influence of the zeros in the data.

Finally the species richness distribution of the herbivores/deposit feeders appears to be related mainly to sand and TOM, which explain respectively 8% and 7% of the biological data variation. The abundance and the biomass didn't show any significant relation with the environmental variables.

Regression analysis was also used to assess the relationship between the number of trophic groups in each station and the environmental variables, and also between both the total and the individual taxonomic groups species richness, abundance and biomass, and the environmental data (Table VI.2).

With few exceptions the second order polynomial regression gave better fits and the strongest explanatory environmental variables were the fines in the case of trophic richness, and the fines, sand and TOM content of sediments for total species richness, abundance and biomass (*cf.* table VI.2). Total species richness and abundance didn't show significant relations with the hydrodynamical parameters, but biomass appeared significantly related with current velocity, shear stress and flow.

Sediment fines content explains 13% of the variation of the distribution of trophic richness in the estuary. The fitted parabola suggests that this biological variable tends to present minimum values with intermediate values of the fines content.

Sand, fines and total organic matter explain respectively 21%, 18% and 13% of the variation in total species richness distribution in the estuary. The same variables account for 16% of the variation of total abundance and 24%, 23% and 22%, respectively, of the variation of total biomass. The fitted parabola suggests that the biological parameters tend to show the highest values at more or less 30 to 40% of fines, 4 to 5% of TOM and 50 to 60%, of sand (e.g. figures 6.2 and 6.3).

Total biomass distribution is also significantly related to the hydrodynamic variables. Current velocities and shear stress account for 13% of the variation of this variable and flow for 9%. Higher biomass values are found at intermediate values of these variables.

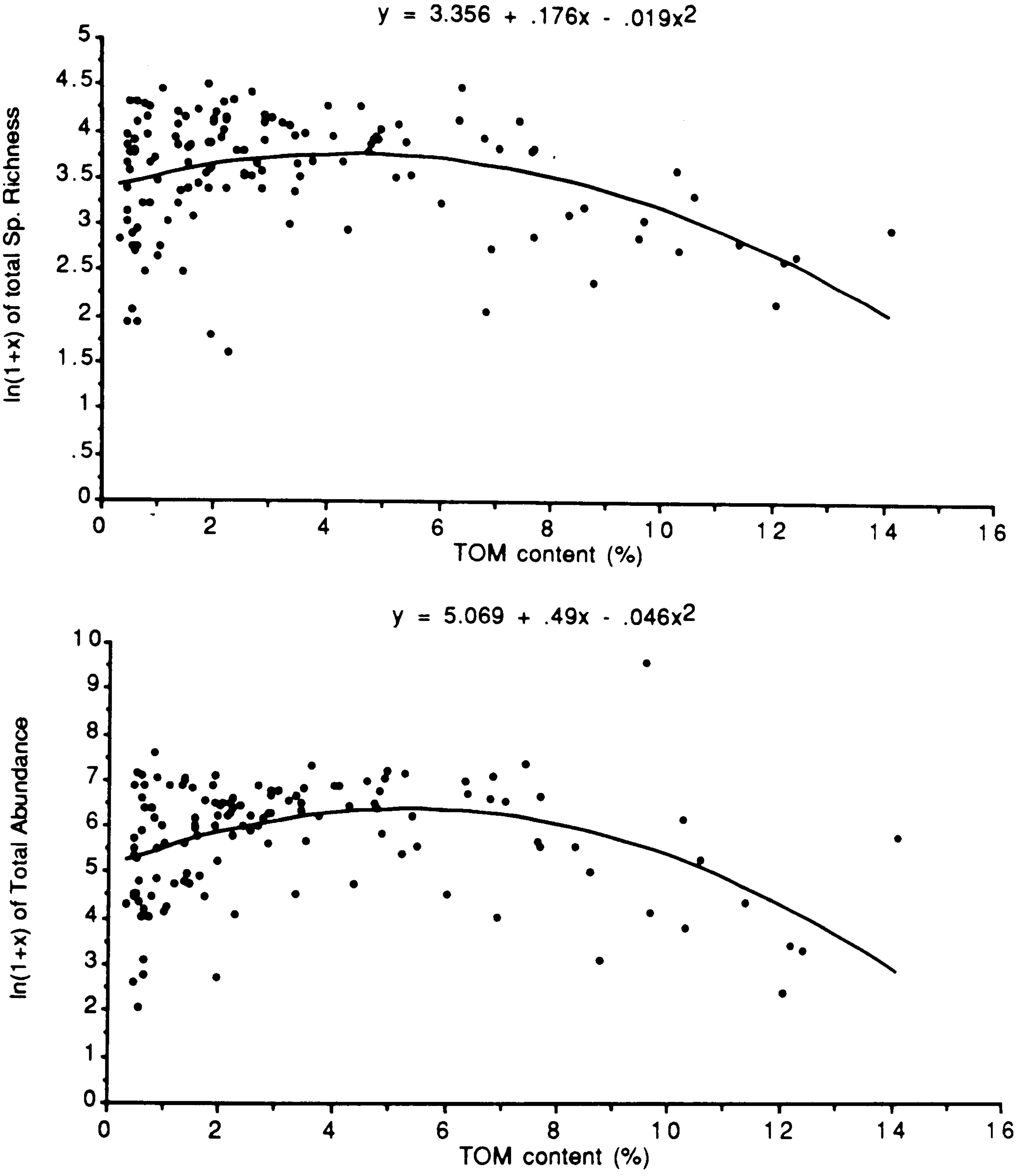


Figure 6.2 - Polynomial regression (degree 2) showing the variation of the biological variables, total species richness and total abundance, in relation to the total organic content of the sediment.

The individual taxonomic groups data has more significant relation to the hydrodynamic environmental variables, than the global macrofauna data. However, these relationships are always weaker than those obtained with the sedimentary parameters (Table VI.2). The highest values concern Annelid biomass, and Mollusc species richness and biomass, with shear stress and current velocities, through the second order polynomial regression.

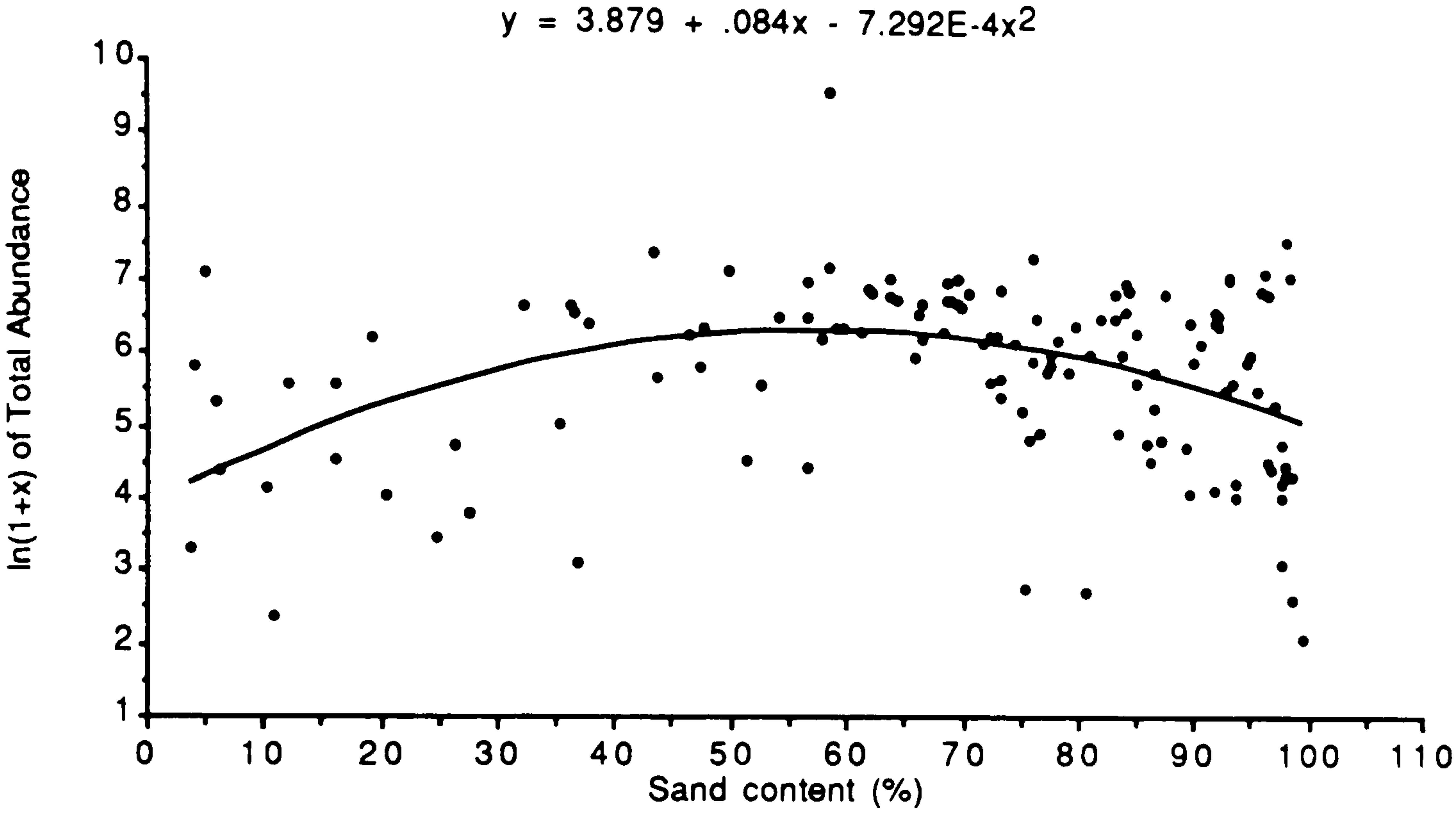


Figure 6.3 - Polynomial regression (degree 2) showing the variation of the total abundance, in relation to the sand content of the sediment.

The exploratory results obtained through regression analysis clearly point out predominant non-linear and non-monotonic relationships between the biological and the environmental data. Ordination analysis was thus based on methods which assume unimodal rather than linear response models (see ter Braak & Prentice, 1988), namely correspondence and canonical correspondence analysis.

6.3 - CLUSTER ANALYSIS

6.3.1 - TWINSPAN classification

The classification method TWINSPAN (Hill, 1979, see Chapter 3, Methodology), was used to search for affinity groups among the sampling locations, and to define, characterize and chart the Sado estuary subtidal benthic communities. The affinity groups obtained were further validated using species constancy and fidelity criteria, according to the scale proposed by Retière, 1979 (see Chapter 3).

The divisions emphasized by TWINSPAN, and considered in this work, are indicated in figure 6.4.

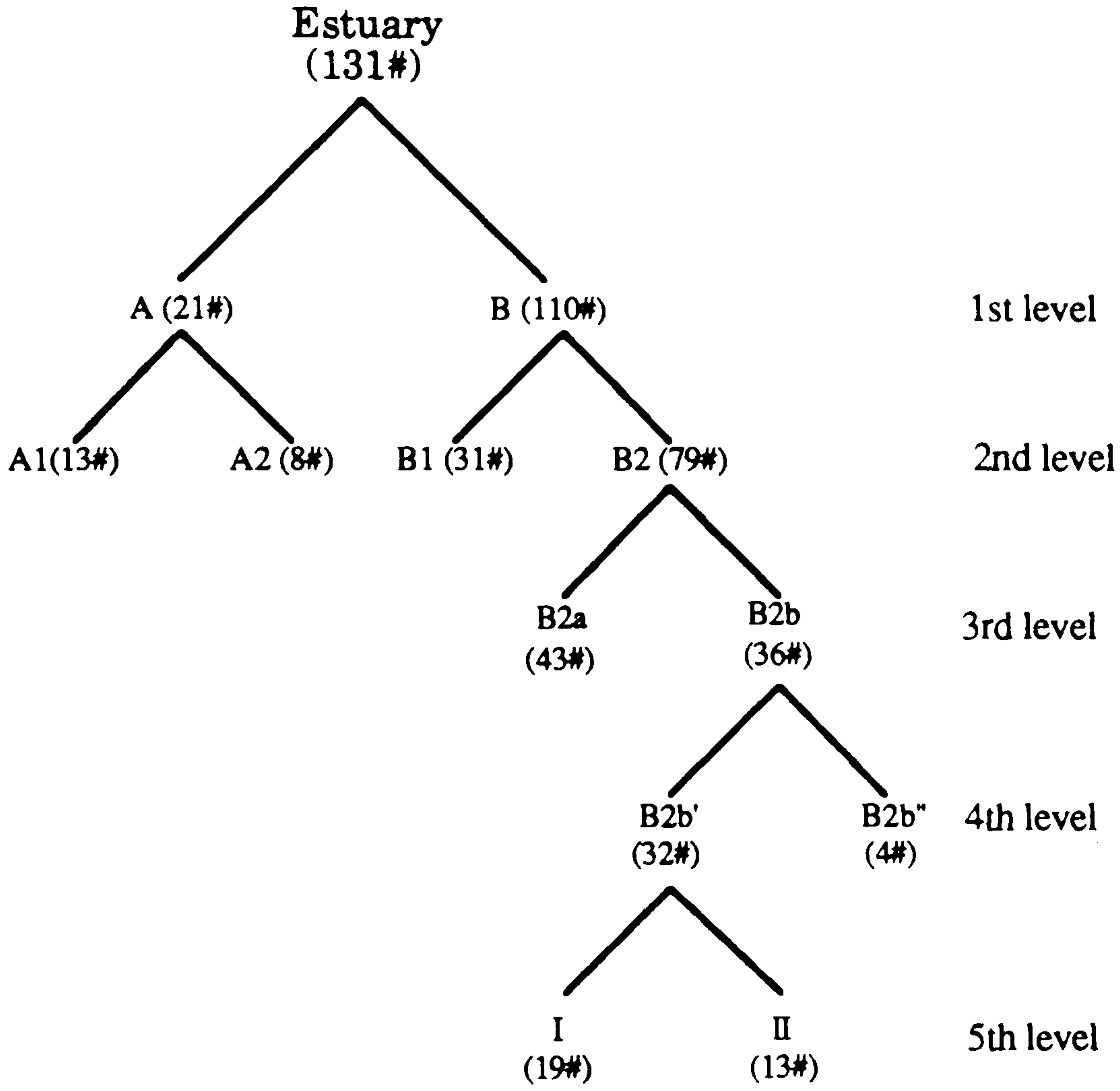


Figure 6.4 - Sado estuary. TWINSPAN affinity groups among the sampling locations (see text for explanation).

1st level division

The first level division separates a group of 21 stations (group A) from the remaining 110 (group B), clearly distinguishing the mouth of the estuary together with some locations of the southern channel (group A), from the rest of the estuary (group B) (figure 6.5).

The group A of sites comprise 174 species of which 25 were present only here (exclusive species). Eighty one species were present once and 10 were found in 50% or more of the stations.

These latter species are presented in Table VI.3. The representation of their sampling frequencies in group A (R value, see Chapter 3), indicates as the most important species the annelids *S. papillocercus*, exclusive, and *P. remota*, which shows 82% of its presence in this group.

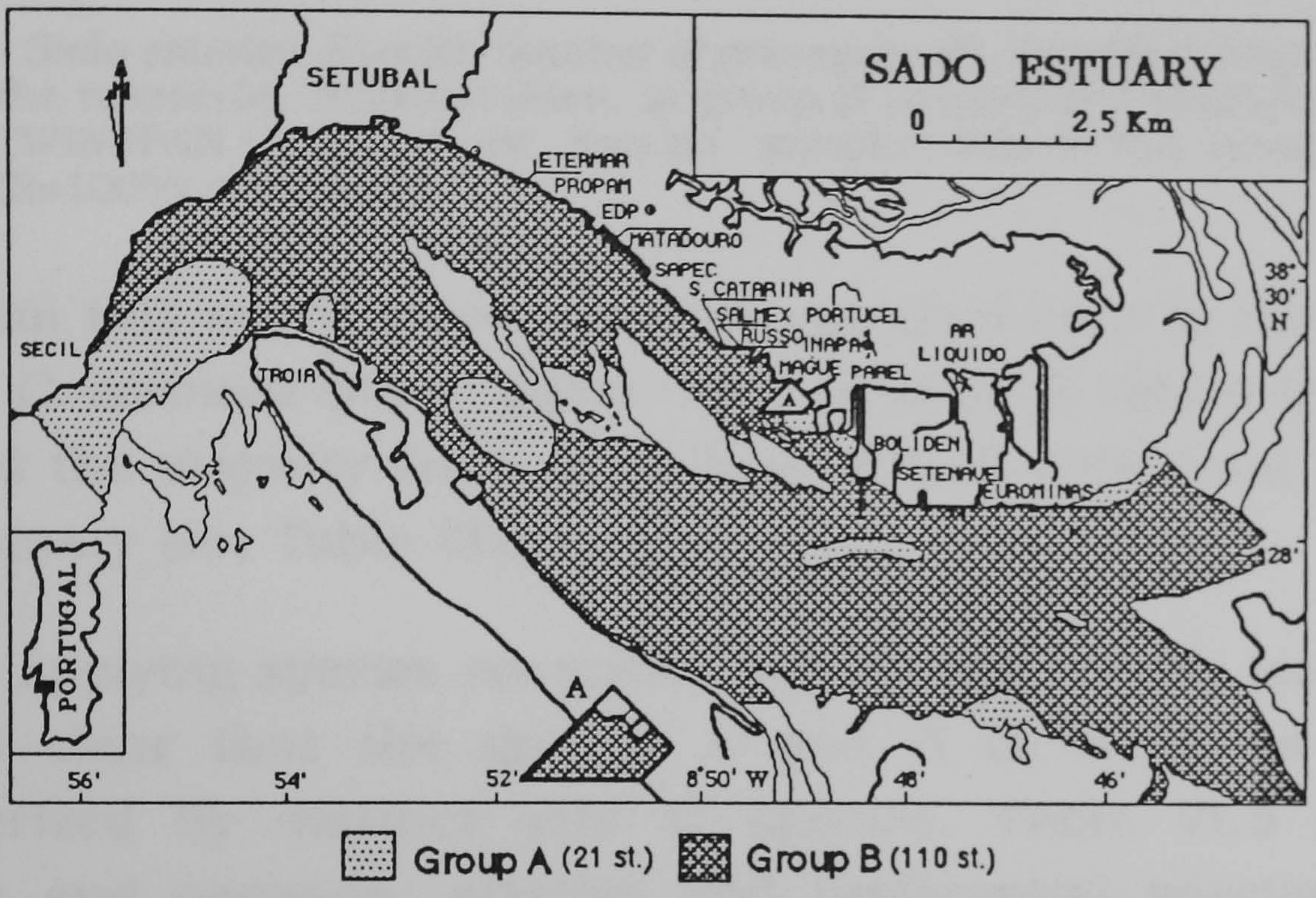


Figure 6.5 - Localisation of the affinity groups among sampling stations emphasized by TWINSPAN at the first level division.

	P	F(%)	R(%)		P	F(%)	R(%)
P. elegans	**18**	**85.7**	**62.1**	*P. kefersteini*	13	61.9	41.9
N. cirrosa	18	85.7	45.0	***S. papillocercus***	**11**	**52.4**	**100.0**
G. galaica	**16**	**76.2**	**50.0**	*P. longipes*	11	52.4	25.0
P. remota	**14**	**66.7**	**82.4**	**Oligochaet spA**	**11**	**52.4**	**68.8**
G. spinifer	**14**	**66.7**	**56.0**	*G. trydactyla*	11	52.4	13.8

Table VI.3 - Sado estuary. Species number of presences (P), sampling frequency (F) and the respective representation, in group A sampling locations defined by TWINSPAN (21 stations). Species with R values ≥ 50% are in bold.

Group B, which comprises the majority of the studied area, presented a total of 337 species, of which 189 were exclusive, and 86 present in only one of the stations. The most frequent species, present in 50% or more of the stations are shown in Table VI.4.

	P	F(%)	R(%)		P	F(%)	R(%)
Caulleriella sp.	95	86.4	92.2	*G. trydactyla*	69	62.7	86.2
Cirriformia sp.	94	85.5	94.0	*P. caeca*	68	61.8	90.7
Tharyx sp.	88	80.0	97.8	*N. latericeus*	68	61.8	87.2
A. oxycephala	87	79.1	95.6	***M. palmata***	**66**	**60.0**	**100.0**
S. costarum	84	76.4	94.4	*A. mucosa*	66	60.0	93.0
C. annulatum	84	76.4	95.4	*L. latreilli*	64	58.2	98.5
I. tenella	80	72.7	95.2	*M. capensis*	63	57.3	87.5
A. alba	75	68.2	97.4	***C. carinata***	**63**	**57.3**	**100.0**
A. tenuicornis	72	65.5	97.3	***C. gibba***	**60**	**54.5**	**100.0**
Nemertean spB	70	63.6	98.6	*H. filiformis*	57	51.8	98.3

Table VI.4 - Sado estuary. Species number of presences (P), sampling frequency (F) and the respective representation, in group B of sampling locations defined by TWINSPAN (110 stations). Species sampled only in this group of stations (R=100%) are in bold.

From this set of species, 3 were captured only in this area, *M. palmata, C. carinata and C. gibba.* They all show R values higher than 50%, and the majority have more than 90% of their total presences in the estuary (see Table VI.4).

By applying species constancy and fidelity criteria (see Chapter 3), it is clear that the groups A and B of locations are well characterized by distinct sets of species. Table VI.5 gives the constant and common, elective and preferential species of both groups.

	Species			
	Constant		**Common**	
	elective	**preferential**	**elective**	**preferential**
A	***S. papillocercus***	***P. elegans***	*U. grimaldi*	*G. capitata*
	Oligochaete spA	***N. cirrosa***	*P. appendiculatus*	*T. tenuis*
	P. remota	***G. galaica***		*S. monodi*
	G. spinifer			*Cirolanidae sp.*
	P. kefersteini			
B	***M. palmata***	***Caulleriella sp.***	*P. cristata*	*M.versiculatus*
	C. carinata	***Cirriformia sp.***	*S. inflatum*	*V. mirabilis*
	C. gibba	***Tharyx sp.***	*L. conchilega*	*P. antennata*
	H. filiformis	***A. oxycephala***	*A. talpa*	*N. hombergi*
	L. latreilli	***S. costarum***	*H. pectinata*	*C. sundevalli*
	***Nemertea* spB**	***C. annulatum***	*C. angulata*	*C. chinensis*
		I. tenella	*H. nitidum*	*L. pectinatus*
		A. alba	*C. paucicostatum*	*H. impar*
		A. tenuicornis	*E. palermitana*	*N. nucleus*
		A. mucosa	*S. boa*	*C. sextonae*
			C. runcicorne	
			N. incrassatus	
			L. murata	
			Ostracoda spB	
			A. remora	

Table VI.5 - Sado estuary. Constant and common, elective and preferential species, to the A and B groups of stations defined by TWINSPAN.

The set of species of each group shows clearly the predominance in group A of interstitial annelids, usually found in clean coarse or medium sand and of polychaetes and crustaceans with preferences for sandy sediments. Most of these species are commonly found in the exposed Portuguese coastal region or at the mouth of lagoon or estuarine areas, influenced by marine conditions namely wave energy or strong tidal currents (Rodrigues & Dauvin, 1987, Rodrigues & Quintino, 1986, 1988, Quintino & Gentil, 1987; Quintino, 1988).

Group B is mainly characterized by species showing more estuarine requirements, namely finer and siltier sediments (*cf.* namely Thorson, 1957, Muus, 1967, Cabioch, 1968, Wolff, 1973). Most of them are common in Portuguese estuaries and lagoons in more confined areas (*cf.* Rodrigues & Quintino, 1986). Some of the species are widely mentioned as indicators of organic enrichment of sediments (Pearson & Rosenberg, 1978).

In terms of species abundances, group B clearly presents much higher densities. Group A showed a total of 3898 specimens (≈ 186 ind/0.1m^2) and group B a total of 76320 individuals (≈ 694 ind/0.1m^2). The most abundant species in groups A and B, comprising 1% or more of the total abundance, are presented in Tables VI.6 and VI.7.

	A	**F**(%)	**R**(%)		**A**	**F**(%)	**R**(%)
P.longipes	636	16.3	26.3	*P. kefersteini*	71	1.8	40.6
S. armiger	603	15.5	46.2	***N. cirrosa***	**71**	**1.8**	**52.2**
P. remota	**196**	**5.0**	**95.2**	*Capitella*	67	1.7	0.4
P. elegans	**194**	**5.0**	**87.4**	*P. lyra*	66	1.7	28.7
G. galaica	**144**	**3.7**	**62.9**	*A. vedlomensis*	58	1.5	47.5
G. maculatus	138	3.5	34.3	Serpulids spp	55	1.4	22.5
P. appendiculatus	**105**	**2.7**	**91.3**	***S. papillocercus***	**55**	**1.4**	**100.0**
C. chinensis	86	2.2	24.9	*N. latericeus*	51	1.3	4.8
G. spinifer	**80**	**2.1**	**84.2**	*Caulleriella sp.*	46	1.2	1.6
Oligochaete spA	**77**	**2.0**	**76.2**	*C. sextonae*	39	1.0	4.2

Table VI.6 - Sado estuary. Species total abundance (A), abundance frequency (F) and the respective representation, in group A of sampling locations defined by TWINSPAN (21 stations). Species with R values ≥ 50% are in bold.

	A	F(%)	R(%)		A	F(%)	R(%)
Capitella	15653	20.5	99.6	*I. tenella*	1330	1.7	99.6
S. costarum	7180	9.4	99.9	*A. tenuicornis*	1321	1.7	99.8
Tharyx sp.	4793	6.3	99.9	*A. latreilli*	1276	1.7	99.5
Cirriformia sp.	3658	4.8	99.6	*N. latericeus*	1015	1.3	95.2
Caulleriella sp.	2737	3.6	98.4	*P. caeca*	983	1.3	98.4
C. annulatum	2601	3.4	99.6	***H. nitidum***	**971**	**1.3**	**100.0**
M. palmata	**2221**	**2.9**	**100.0**	*C. sextonae*	886	1.2	95.8
A. oxycephala	2061	2.7	99.8	*T. benedeni*	865	1.1	99.0
P. typicus	1985	2.6	98.6	***C. carinata***	**846**	**1.1**	**100.0**
P. longipes	1781	2.3	73.7	***A. talpa***	**805**	**1.1**	**100.0**
A. alba	1650	2.2	99.9	*P. antennata*	776	1.0	99.7
M. capensis	1636	2.1	97.8				

Table VI.7 - Sado estuary. Species total abundance (A), abundance frequency (F) and the respective representation, in group B of sampling locations defined by TWINSPAN (110 stations). Species sampled only in this group of stations (R=100%) are in bold.

In group A, the species which are important in terms of presence are also important in terms of abundances (only *G. trydactyla* is not included in the group of species representing 1% or more of the total abundances). From this set of species *S. papillocercus*, *P. remota* and *P. appendiculatus*, present more than 90% of their total abundance in group A of locations, while 5 others show R values higher than 50%.

Group B is characterized by an important group of species, all with R values higher than 50%, and the majority with more than 95% of their total abundance in this group.

2nd level division

The second level division of TWINSPAN separated groups A and B into groups A1, A2, B1 and B2, with respectively 13, 8, 31 and 79 locations (figures 6.4 and 6.6).

The division of group A separates a core of sites located at the estuarine entrance and a few others at the beginning of the southern channel (group A1), from the innermost stations, scattered on the coarse sediments in the upper part of the estuary (group A2).

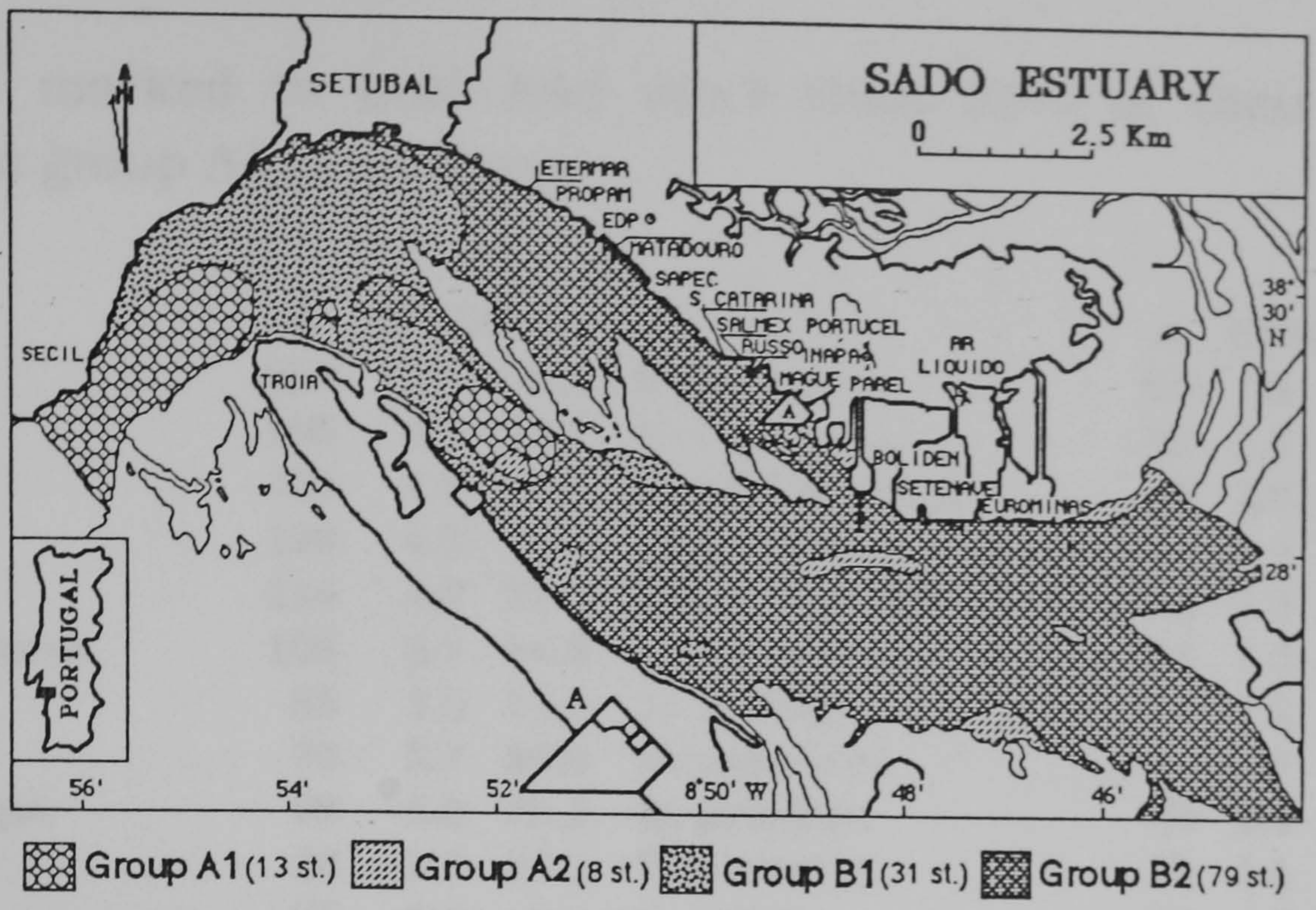


Figure 6.6 - Localisation of the affinity groups among sampling stations emphasized by TWINSPAN at the second level division.

Group A1 comprises 149 species, of which 101 do not exist in group A2. From the global set of species, 71 were present at only one station and 16 in at least 50% of the stations (Table VI.8).

	P	F(%)	R(%)		P	F(%)	R(%)
P. remota	**13**	**100**	**76.5**	*N. latericeus*	9	69	11.5
P. elegans	12	92	41.4	*G. galaica*	9	69	34.6
N. cirrosa	11	85	27.5	*S. hyalina*	8	62	16.3
G. spinifer	11	85	44.0	Nemertean spA	8	62	22.9
P. kefersteini	10	77	32.3	*G. capitata*	8	62	42.0
Oligochaete spA	**10**	**77**	**62.5**	*S. monodi*	7	54	46.7
S. papillocercus	**9**	**69**	**81.8**	*P. marina*	7	54	11.7
P. longipes	9	69	20.4	*M. capensis*	7	54	9.7

Table VI.8 - Sado estuary. Species number of presences (P), sampling frequency (F) and the respective representation, in group A1 of sampling locations (13 stations). Species with R values ≥ 50% are in bold.

From these species, *G. capitata, Nemertea* spA and *S. monodi,* do not exist in the stations of group A2.

Group A1 included a total of 2835 individuals (≈ 218ind/0.1m^2), *Photis longipes* being the most abundant, with 604 individuals (≈ 21% of the total). The species which represent more than 1% of the total abundance of this group are shown in table VI.9.

The species marked in bold had more than 50% of their total abundance in group A1 of locations.

	A	F(%)	R(%)		A	F(%)	R(%)
P. longipes	604	21.3	25.0	Serpulids sp.	55	1.9	22.5
P. remota	**195**	**6.8**	**94.7**	*N. latericeus*	50	1.8	4.7
G. maculatus	138	4.9	34.3	***S. papillocercus***	**44**	**1.6**	**80.0**
G. galaica	**128**	**4.5**	**55.9**	*C. sextonae*	39	1.4	4.2
P. elegans	**114**	**4.0**	**51.4**	Nemertean spA	38	1.3	8.2
P. appendiculatus	**105**	**3.7**	**91.3**	*G. capitata*	38	1.3	44.7
C. chinensis	85	3.0	24.6	*N. cirrosa*	34	1.2	25.0
G. spinifer	**76**	**2.7**	**80.0**	*M. capensis*	34	1.2	2.0
Oligochaete spA	**73**	**2.6**	**72.3**	***M. gladiosa***	**32**	**1.1**	**68.0**
P. lyra	66	2.3	28.7	***E. castanea***	**31**	**1.1**	**75.6**
C. capitata	65	2.3	0.4	*S. solida*	29	1.0	28.2
P. kefersteini	64	2.6	36.6	*M. obtusata*	29	1.0	9.6
A. vedlomensis	58	2.0	47.5				

Table VI.9 - Sado estuary. Species total abundance (A), abundance frequency (F) and the respective representation, in group A1 of sampling locations (13 stations). Species with R values ≥ 50% are in bold.

Group A2 included a total of 73 species, 25 of which do not occur in A1. However, apart from *Ophelia neglecta* and *Parapionosyllis labronica* (with one presence in the whole estuary), the remaining species are also present in group B of locations. Forty eight species (66%), were present once in group A2, and the most frequent, present in 50% or more of the stations are given in Table VI.10. Of these species, only *Tellina tenuis* had an R value equal or superior to 50%.

In terms of abundances, group A2 included a total of 1063 individuals (≈133ind/0.1m^2), of which *S. armiger* comprised 55%. The species having 1% or more of the total abundance of this group are shown in Table VI.11, of which only *T. tenuis* had at least 50% of its total abundance in the group A2 locations.

	P	F(%)	R(%)		P	F(%)	R(%)
S. armiger	7	88	11.3	*G. trydactyla*	5	62	6.2
N. cirrosa	7	88	17.5	*Caulleriella sp*	5	62	4.8
G. galaica	7	88	21.9	*Cirriformia sp*	4	50	3.9
T. tenuis	**6**	**75**	**50.0**	*C. edulis*	4	50	12.9
P. elegans	6	75	20.7				

Table VI.10 - Sado estuary. Species number of presences (P), sampling frequency (F) and the respective representation, in group A2 of sampling locations (8 stations). Species with R values ≥ 50% are in bold.

	A	F(%)	R(%)		A	F(%)	R(%)
S. armiger	587	55.2	45.0	*C. edule*	23	2.2	22.3
P. elegans	80	7.5	36.0	*G. trydactyla*	20	1.9	7.5
Caullerlella sp	38	3.6	1.4	*G. galaica*	16	1.5	7.0
N. cirrosa	37	3.5	27.2	*Cirriformia sp*	13	1.2	0.4
P. longipes	32	3.0	23.5	*S. hyalina*	11	1.0	3.3
T. tenuis	**27**	**2.5**	**61.4**	*S. papillocercus*	11	1.0	20.0
L. pectinatus	24	2.3	8.5	Ostracod spA	11	1.0	14.3

Table VI.11- Sado estuary. Species total abundance (A), abundance frequency (F) and the respective representation, in group A2 of sampling locations (8 stations). Species with R values ≥ 50% are in bold.

Analysing both the listings of the most frequent and most abundant species of groups A1 and A2, it is clear that group A1 comprises the most characteristic species of group A, while group A2 includes a set of species related with group A but also with group B. These results and the spatial distribution of A2, scattered in the upper part of the estuary, suggests a clear impoverishment of the more typical marine assemblage represented by group A1 of locations.

The second level division of group B separates a region located between the mouth of the estuary, inwards of A1, and the beginning of the sand banks (group B1), from the remaining area of the estuary (group B2) (*cf.* figure 6.6, page 224).

Group B1 comprises 291 species from which 68 were only found in this group. If only the species present in groups B1 and B2 are considered, the number of species exclusive to group B1 increases to 97. Eight two species were present once in B1 and 41 were sampled in 50% or more of the stations of this group. Among these however, it should be noted that only 9 species had at least 50% of their presences in the estuary in the group B1 of locations (Table VI.12).

	P	F(%)	R(%)		P	F(%)	R(%)
Caulleriella sp	30	97	29.1	***Polycirrus spA***	**20**	**64**	**58.8**
N. latericeus	29	94	37.2	*P. longipes*	20	64	45.4
M. capensis	29	94	40.3	***E. palermitana***	**20**	**64**	**60.6**
A. oxycephala	29	94	31.9	*A. lineata*	20	64	42.6
C. annulatum	27	87	30.7	*S. hyalina*	19	61	38.8
A. alba	27	87	35.1	*S. armiger*	19	61	30.6
Nemertean spB	26	84	36.6	*P. typicus*	19	61	40.4
I. tenella	26	84	31.0	*M. versiculatus*	19	61	35.2
G. trydactyla	26	84	32.5	***V. pullastra***	**18**	**58**	**72.0**
Tharyx sp.	25	81	27.8	*S. inflatum*	18	58	35.3
P. caeca	25	81	33.3	*P. marina*	18	58	30.0
A. mucosa	25	81	35.2	***S. solida***	**17**	**55**	**65.4**
S. costarum	24	77	27.0	*M. palmata*	17	55	25.8
Lumbrinereis latreilli	24	77	36.9	*P. cristata*	16	52	29.1
Cirriformia sp.	24	77	24.0	***P. longimanus***	**16**	**52**	**57.1**
P. antennata	23	74	43.4	**Ostracod spB**	**16**	**52**	**55.2**
L. pectinatus	**23**	**74**	**56.1**	*N. cirrosa*	16	52	40.0
C. chinensis	**22**	**71**	**50.0**	*M. obtusata*	16	52	44.4
A. talpa	22	71	45.8	*H. impar*	16	52	47.1
A. tenuicornis	22	71	29.7	*C. gibba*	16	52	26.7
Nemertean spA	**21**	**68**	**60.0**				

Table VI.12 - Sado estuary. Species number of presences (P), sampling frequency (F) and the respective representation, in group B1 of sampling locations (31 stations). Species with R values ≥ 50% are in bold.

	A	F(%)	R(%)		A	F(%)	R(%)
C. annulatum	**2075**	**7.5**	**79.5**	***P. antennata***	**681**	**2.4**	**87.5**
P. typicus	**1902**	**6.8**	**94.4**	***N. latericeus***	**673**	**2.4**	**63.1**
P. longipes	**1754**	**6.3**	**72.6**	***P. caeca***	**639**	**2.3**	**64.0**
Tharyx sp	1680	6.0	35.0	*A. oxycephala*	606	2.2	29.3
M. capensis	**1328**	**4.8**	**79.4**	***A. talpa***	**489**	**1.8**	**60.8**
Caulleriella sp	1281	4.6	46.0	*I. tenella*	471	1.7	35.3
A. latreilli	**1268**	**4.6**	**98.9**	***E. palermitana***	**421**	**1.5**	**78.5**
S. costarum	844	3.0	11.7	**Nemertean spA**	**410**	**1.5**	**88.4**
Abra alba	776	2.8	47.0	*Cirriformia sp*	392	1.4	10.7
C. sextonae	**767**	**2.8**	**82.9**	***C. runcicorne***	**360**	**1.3**	**54.3**

Table VI.13 - Sado estuary. Species total abundance (A), abundance frequency (F) and the respective representation, in group B1of sampling locations (31 stations). Species with R values ≥ 50% are in bold.

Group B1 comprised a total of 27816 specimens (≈ 897 ind./0.1m^2), with 20 species representing at least 1% of the group's total abundance. None of these species is particulary dominant in the group, but 13 of them had here more than 50% of their total abundance in the estuary, of which 7 belong to the crustaceans (Table VI.13).

Group B2 included a total of 239 species, 55 of which were not present in group B1, while 39 are exclusive to group B2. Fifty two species were present in only one station and 19 had a sampling frequency of at least 50%. They all show R values higher than 50%, and 7 species had a minimum of 70% of their total occurrences in group B2 (Table VI.14).

	P	**F**(%)	**R**(%)		**P**	**F**(%)	**R**(%)
Cirriformia sp	**70**	**88.6**	**70.0**	***C. carinata***	**48**	**60.8**	**76.2**
Caulleriella sp	65	82.3	63.1	*A. alba*	48	60.8	62.3
Tharyx sp	**63**	**79.7**	**70.0**	Nemertean spB	44	55.7	62.0
S. costarum	60	75.9	67.4	***C. gibba***	**44**	**55.7**	**73.3**
A. oxycephala	58	73.4	63.7	*P. caeca*	43	54.4	57.3
C. annulatum	57	72.2	64.8	*G. trydactyla*	43	54.4	53.8
I. tenella	54	68.4	64.3	***V. mirabilis***	**42**	**53.2**	**79.2**
H. filiformis	**50**	**63.3**	**86.2**	*A. mucosa*	41	51.9	57.8
A. tenuicornis	50	63.3	67.6	*L. latreilli*	40	50.6	61.5
M. palmata	**49**	**62.0**	**74.2**				

Table VI.14 - Sado estuary. Species number of presences (P), sampling frequency (F) and the respective representation, in group B2 of sampling locations (79 stations). Species with R values ≥ 50% are in bold.

With the exception of *H. filiformis*, *C. carinata* and *V. mirabilis*, all the species listed for group B2 are also among the most common of group B1, however with much lower R values (*cf.* Table VI.12).

	A	**F**(%)	**R**(%)		**A**	**F**(%)	**R**(%)
C. capitata	**15629**	**32.2**	**99.4**	***H. nitidum***	**921**	**1.9**	**94.8**
S. costarum	**6336**	**13.1**	**88.2**	***A. alba***	**874**	**1.8**	**52.9**
Cirriformia sp.	**3266**	**6.7**	**88.9**	***I. tenella***	**859**	**1.8**	**64.3**
Tharyx sp.	**3113**	**6.4**	**64.9**	***T. benedeni***	**823**	**1.7**	**94.2**
M. palmata	**1995**	**4.1**	**89.8**	***C. carinata***	**749**	**1.5**	**88.5**
Caulleriella sp.	**1456**	**3.0**	**52.3**	*S. armiger*	526	1.1	40.3
A. oxycephala	**1455**	**3.0**	**70.4**	*C. annulatum*	526	1.1	20.1
A. tenuicornis	**1053**	**2.2**	**79.6**	***S. inflatum***	**501**	**1.0**	**75.9**

Table VI.15 - Sado estuary. Species total abundance (A), abundance frequency (F) and the respective representation, in group B2 of sampling locations (79 stations). Species with R values ≥ 50% are in bold.

More than 48500 specimens were captured in group B2 (≈614 ind/0.1m^2), of which almost 33% belong to *Capitella*. Sixteen species contribute at least 1% of the group's total abundance, the majority of which are also represented by more than 50% of the species total number of individuals (Table VI.15).

Groups A1, A2, B1 and B2 emphasized by TWINSPAN at the second level, were also analysed according to the constancy and fidelity concepts. The main results are presented in Table VI.16.

	Species			
	Constant		Common	
	elective	preferential	elective	preferential
A1		***P. remota*** ***G. spinifer*** **Oligochaete spA** ***S.papillocercus*** ***S. monodi***	*U. grimaldi* *P. phasma*	*P.appendiculatus* *Cirolanidae sp.*
A2	***T. tenuis***	***C. edule***	*P. labronica* *A. foetida*	*C. crangon*
B1		***P.antennata*** ***L. pectinatus*** ***C. chinensis*** ***A. talpa*** ***Polycirrus sp.*** ***E. palermitana*** ***A. lineata*** ***V. pullastra*** ***P. longimanus*** **Ostracod spB** ***H. impar***	*A. squamata** Ostracod spC	*Phoronis sp.* *N. unicornis* *N.reticulatus* *M. pectinatus* *A. vedlomensis** *Nemertea spC* *C. acanthifera** *L. lutraria* *P. cirrifera** *S. decoratus** *P. serpens* *V. striatulus* *L. picta** *H. bilineata** *A.undeci tatus** *E. vitatta* Sipunculid sp. *P. aperta* *O. fusiformis* *E. sanguinea*
B2		***H. filiformis***	*U. typica*	*H. nitidum* *C. paucicostatum*

* preferential species in relation to group A

Table VI.16 - Sado estuary. Constant and common, elective and preferential species, to the groups A1, A2, B1 and B2 of stations defined by TWINSPAN.

A comparison between the results of the constancy and fidelity of species in groups A and B (*cf.* Table VI.5, page 221), and in groups A1, A2, B1 and B2, shows that the latter are less well characterized. Only group A2 presents a constant and elective species, and only group B1 shows a considerable number of constant preferential, and common elective and preferential species.

These results suggest that only groups A and B could be considered as two distinct benthic communities, A comprises a set of species indicative of prevailing marine conditions, where the interstitial polychaets *Saccocirrus papillocercus* and *Pisione remota* are important species, and B includes a set of species more typical of the estuarine environment, characterized mainly by *Melinna palmata, Cyathura carinata, Corbula gibba, Heteromastus filiformis*, and a nemertean species.

The division of group A separates the richest and more characteristic marine affinity group of sites, located at the estuarine entrance, group A1, from the impoverished areas settled in a few upper locations of the outer estuary, group A2.

The division of group B suggests important differences in the benthic community structure of groups B1 and B2.

Group B1 contains a larger group of preferential species, constant or common, either in relation to group A or to group B2. Apart from these species, this group also includes taxa which have their maximum abundance either in the seaward group A (*Ervilia castanea, G. spinifer, M. gladiosa, N. cirrosa, Oligochaete spA, P. elegans, P. remota, P. appendiculatus, U. brevicornis, U. grimaldi*), or in the landward group B2 (*Ampelisca* species, *A. mucosa, A. oxycephala, Cirratulid* species, *C. carinata, H. nitidum, H. filiformis, I. tenella, L. conchilega, M. palmata, S. inflatum, S. armiger, S. costarum, T. benedeni, V. mirabilis*).

This suggests that the area defined by the group B1 might correspond to a transition region between the typical marine and estuarine communities, including species from both but also species which find their preferential habitat in this area.

Group B2 shows a more uneven distribution of abundances, with a clear dominance of *Capitella capitata* and *Spiochaetopterus* *costarum*, comprising respectively more than 30% and 13% of the group's total abundance. It is also the estuarine region of preferential distribution of species commonly mentioned as indicating organic enrichment, (among others, *Capitella, Cirriformia, Caulleriella, Tharyx, Melinna, Tubificoides...*), thus presenting, in relation to group B1, a lower species richness but higher densities.

3rd level division

At the third level division, TWINSPAN splits group B2 into groups B2a and B2b, comprising respectively 43 and 36 sampling locations (*cf.* figure 6.4, page 219). B2a corresponds mainly to the southern channel and the upper region of the estuary, while B2b comprises almost all the northern channel and a few other locations close to the northern margin, either in the upper estuary or near the city of Setubal (the group also includes station 133, at the entrance of the Alcácer channel) (figure 6.7).

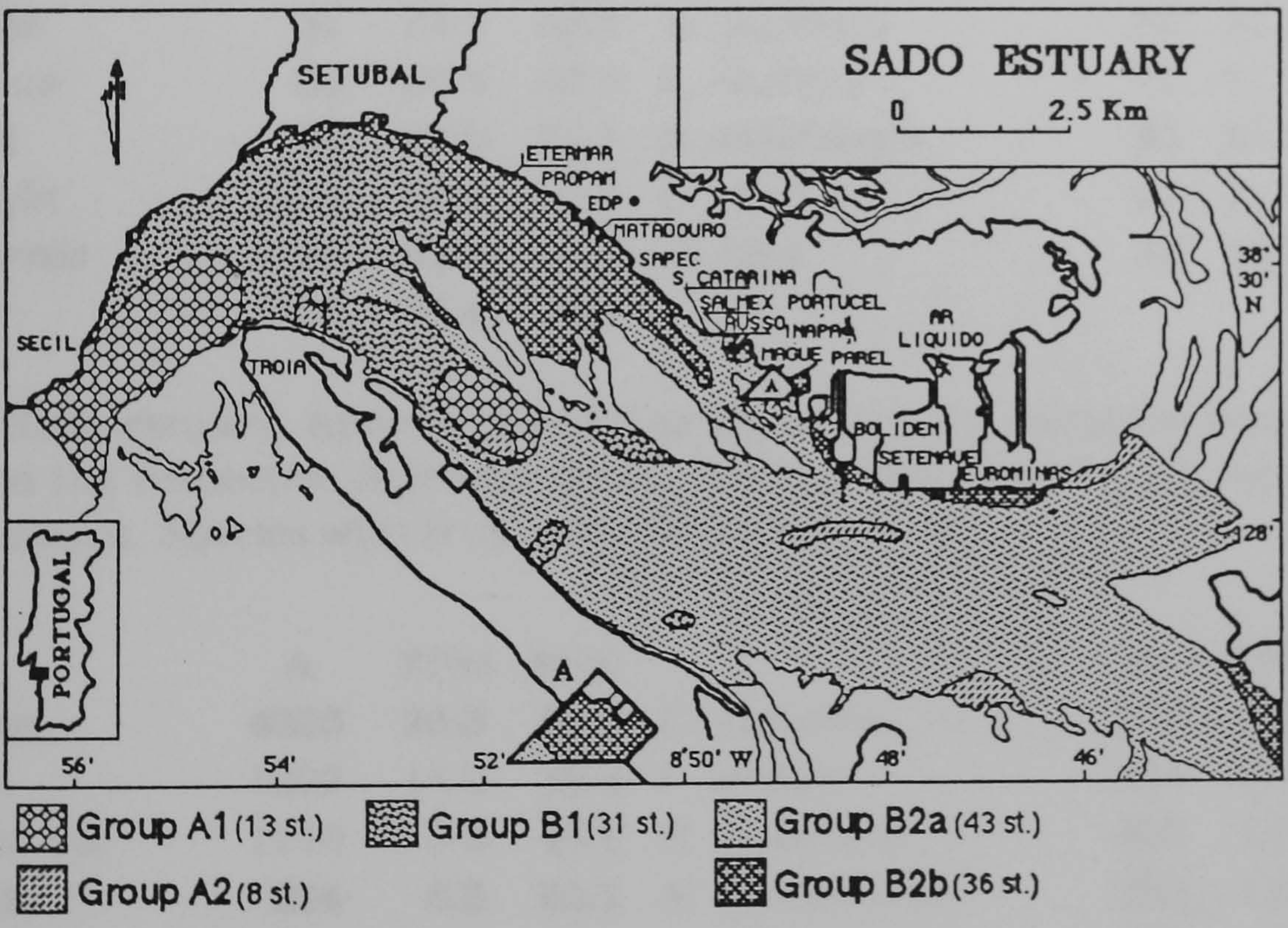


Figure 6.7 - Localisation of the affinity groups among sampling stations emphasized by TWINSPAN at the third level division.

These two groups contain almost the same total number of species, 199 and 195 respectively, of which, 40 were not present in group B2a and 44 in group B2b. They also include a very similar number of species sampled once, 58 in group B2a and 64 in group B2b. However, they differ strongly in terms of abundances, group B2a having a total of 17307 specimens (≈ 402ind/0.1m^2) and group B2b a total of 31197 (≈ 867ind/0.1m^2).

In group B2a, comprising the major part of the southern channel and the upper region of the estuary, 23 species showed a sampling frequency of at least 50%. These species, together with those which have more than 40% of their total presences in this group of locations, are marked in bold in Table VI.17. Table VI.18 gives the taxa comprising more than 1% of the group's total abundance with a special reference to species which present more than 50% of their abundance in group B2a.

	P	F(%)	R(%)		P	F(%)	R(%)
Cirriformia sp.	**41**	**95.3**	**41.0**	***H. filiformis***	**29**	**67.4**	**50.0**
A. oxycephala	**37**	**86.0**	**40.7**	***C. gibba***	**27**	**62.8**	**45.0**
Tharyx sp.	35	81.4	38.9	***S. inflatum***	**26**	**60.5**	**51.0**
S. costarum	35	81.4	39.3	*I. tenella*	26	60.5	31.0
Caullerlella sp.	35	81.4	34.0	Nemertean spB	24	55.8	33.8
C. annulatum	33	76.7	37.5	*P. caeca*	23	53.5	30.7
V. mirabilis	**31**	**72.1**	**58.5**	*M. palmata*	22	51.2	33.3
N. latericeus	30	69.8	38.5	*L. latreilli*	22	51.2	33.8
H. nitidum	**30**	**69.8**	**81.1**	***L. conchilega***	**22**	**51.2**	**44.0**
G. trydactyla	30	69.8	37.5	*C. carinata*	22	51.2	34.9
A. tenuicornis	**30**	**69.8**	**40.5**	*A. alba*	22	51.2	28.6
S. armiger	**29**	**67.4**	**46.8**				

Table VI.17 - Sado estuary. Species number of presences (P), sampling frequency (F) and the respective representation, in group B2a of sampling locations (43 stations). Species with R values ≥ 40% are in bold.

	A	F(%)	R(%)		A	F(%)	R(%)
S. costarum	**4236**	**24.5**	**58.9**	*C. carinata*	377	2.2	44.6
Tharyx sp.	1907	11.0	39.8	*I. tenella*	301	1.7	22.6
Cirriformia sp.	1710	9.9	46.6	*N. latericeus*	300	1.7	28.1
H. nitidum	**904**	**5.2**	**93.1**	*A. tenuicornis*	265	1.5	20.0
A. oxycephala	829	4.8	40.1	*C. runcicorne*	260	1.5	39.2
Caulleriella sp.	752	4.3	27.0	*C. annulatum*	252	1.5	9.6
S. armiger	519	3.0	39.8	***H. filiformis***	**226**	**1.3**	**60.4**
S. inflatum	**480**	**2.8**	**72.7**	***V. mirabilis***	**192**	**1.1**	**64.2**
M. palmata	442	2.6	19.9	***L. muratus***	**178**	**1.0**	**50.0**

Table VI.18 - Sado estuary. Species total abundance (A), abundance frequency (F) and the respective representation, in group B2a of sampling locations (43 stations). Species with R values ≥ 50% are in bold.

The most frequent species in group B2b (F ≥ 50%), which includes almost all the northern channel, are shown in Table VI.19. Four of these, *M. palmata, C. carinata, N. hombergi* and *C. paucicostatum* show R values higher than 40%. In terms of abundances, 12 species comprise 1% or more of the group's total abundance. *Capitella capitata* strongly dominates this group. This species, *T. benedeni, M. palmata* and *A. tenuicornis* show more than 50% of their total abundances in group B2b.

Neither *C. capitata* nor *T. benedeni* are included in the most abundant species of group B2a, where they are represented by respectively 2 and 19 individuals.

	P	F(%)	R(%)		P	F(%)	R(%)
Caulleriella sp.	30	83.3	29.1	***N. hombergi***	**21**	**58.3**	**42.9**
Cirriformia sp.	29	80.6	29.0	*H. filiformis*	21	58.3	36.2
Tharyx sp.	28	77.8	31.1	*A. oxycephala*	21	58.3	23.1
I. tenella	28	77.8	33.3	*P. caeca*	20	55.6	26.7
M. palmata	**27**	**75.0**	**40.9**	Nemertea n spB	20	55.6	28.2
C. carinata	**26**	**72.2**	**41.3**	*A. tenuicornis*	20	55.6	27.0
A. alba	26	72.2	33.8	*M. versiculatus*	19	52.8	35.2
S. costarum	25	69.4	28.1	***C. paucicostatum***	**19**	**52.8**	**54.3**
C. annulatum	24	66.7	27.3	*P. cristata*	18	50.0	32.7
A. mucosa	23	63.9	32.4	*L. latreilli*	18	50.0	27.7
P. marina	22	61.1	36.7	*A. talpa*	18	50.0	37.5

Table VI.19 - Sado estuary. Species number of presences (P), sampling frequency (F) and the respective representation, in group B2b of sampling locations (36 stations). Species with R values ≥ 40% are in bold.

	A	F(%)	R(%)		A	F(%)	R(%)
C. capitata	**15627**	**50.1**	**99.4**	***A. tenuicornis***	**788**	**2.5**	**59.6**
S. costarum	2100	6.7	29.2	*A. alba*	707	2.3	42.8
Cirriformia sp.	1556	5.0	42.4	*Caulleriella sp.*	704	2.3	25.3
M. palmata	**1553**	**5.0**	**69.9**	*A. oxycephala*	626	2.0	30.3
Tharyx sp	1206	3.9	25.2	*I. tenella*	558	1.8	41.8
T. benedeni	**804**	**2.6**	**92.0**	*C. carinata*	327	1.2	38.6

Table VI.20 - Sado estuary. Species total abundance (A), abundance frequency (F) and the respective representation, in group B2b of sampling locations (36 stations). Species with R values ≥ 50% are in bold.

4th level division

At the 4th level division of TWINSPAN, the northern channel group of locations (B2b) is divided into sub-groups B2b' and B2b", of respectively 32 and 4 sites (*cf.* fig. 6.4, page 219). The latter group corresponds to stations located near the northern margin, namely the sites 26, the urban outfall, 78, and 92 and 93, both at the pulp mill outfall (figure 6.8).

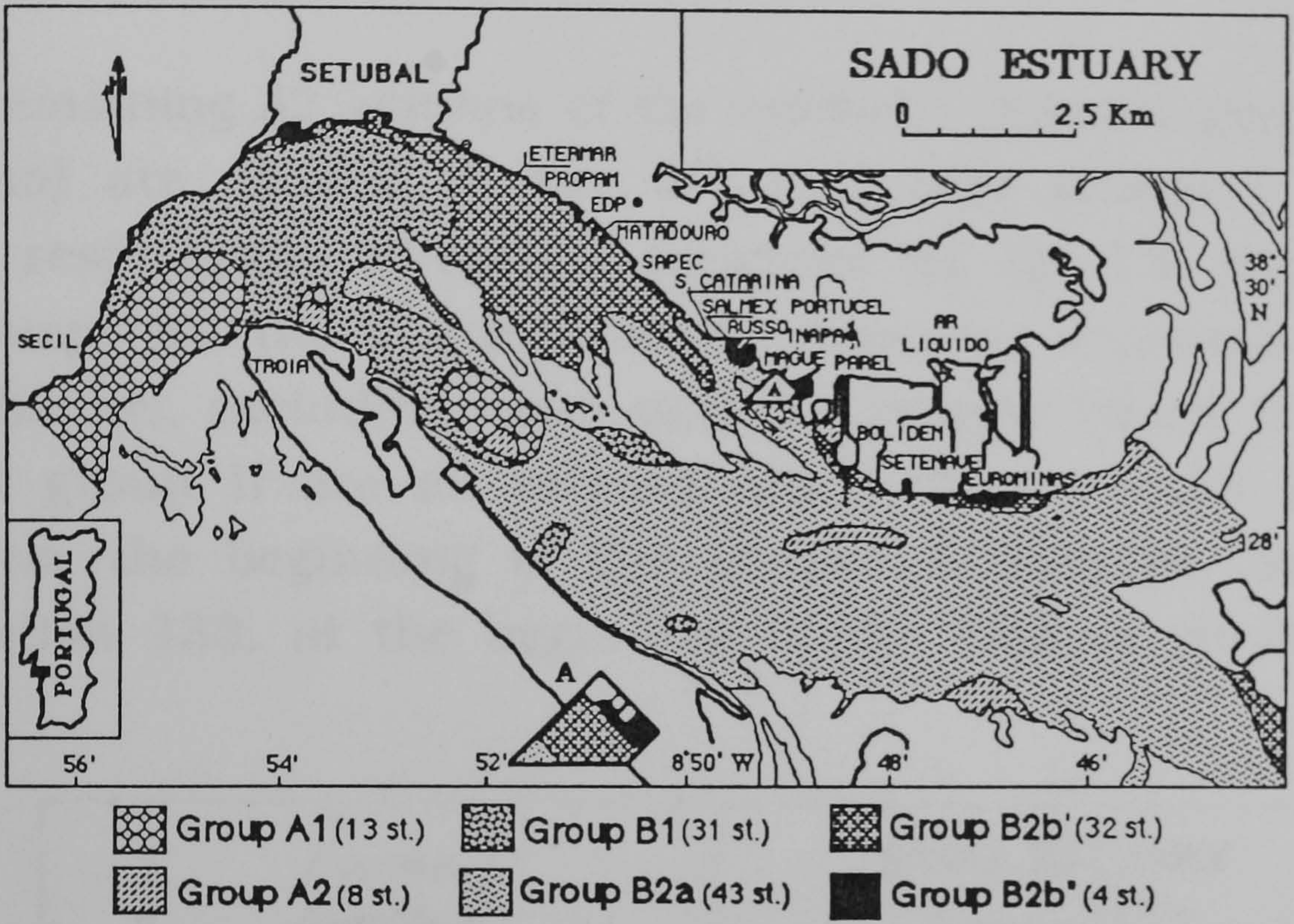


Figure 6.8 - Localisation of the affinity groups among sampling stations emphasized by TWINSPAN at the fourth level division.

These four sites show a very strong hierarchical structure, emphasized in the lists of their most frequent and abundant species (Table VI.21). The group comprises 32 species, of which 12 were sampled once and the remaining in 2 or more stations. Three species, the insect larvae, *N. caudata* and *Ophyotrocha sp.* are exclusive to this group.

In terms of abundance, this group included 16006 individuals, of which *C. capitata* and *M. fuliginosus* comprised 98.5%. These species were the only ones to represent 1% or more of the total abundance: *C. capitata* - 15602 (97.5%); *M. fuliginosus* - 163 (1.0%), which, in terms of their global densities in the estuary, represent respectively, 99.3% and 95.9%.

	P	F(%)	R(%)		P	F(%)	R(%)
M. fuliginosus	**4**	**100**	**80.0**	*Caulleriella sp*	3	75	2.9
Capitella	4	100	20.0	*P. marina*	2	50	3.3
Tharyx sp.	3	75	3.3	*N. hombergi*	2	50	4.1
S. costarum	3	75	3.4	*I. tenella*	2	50	2.4
Oligochaete spB	3	75	9.1	*H. filiformis*	2	50	3.4
C. carinata	3	75	4.8	*Cirriformia sp*	2	50	2.0

Table VI.21 - Sado estuary. Species number of presences (P), sampling frequency (F) and the respective representation, in group B2b" of sampling locations (4 stations). Species with the highest R value is in bold.

5th level division

The remaining 32 stations of the northern channel (group B2b' of Twinspan) are divided at the 5th level into groups I and II, comprising respectively 19 and 13 locations (*cf.* fig. 6.4, page 219). Group I comprises the majority of the sampling locations of the northern channel, excluding those near the margin (figure 6.9). The stations of group II are all located along the northern margin, inwards from the beginning of the industrial complex, and also include station 133, at the beginning of the Alcácer channel (*cf.* figure 6.9).

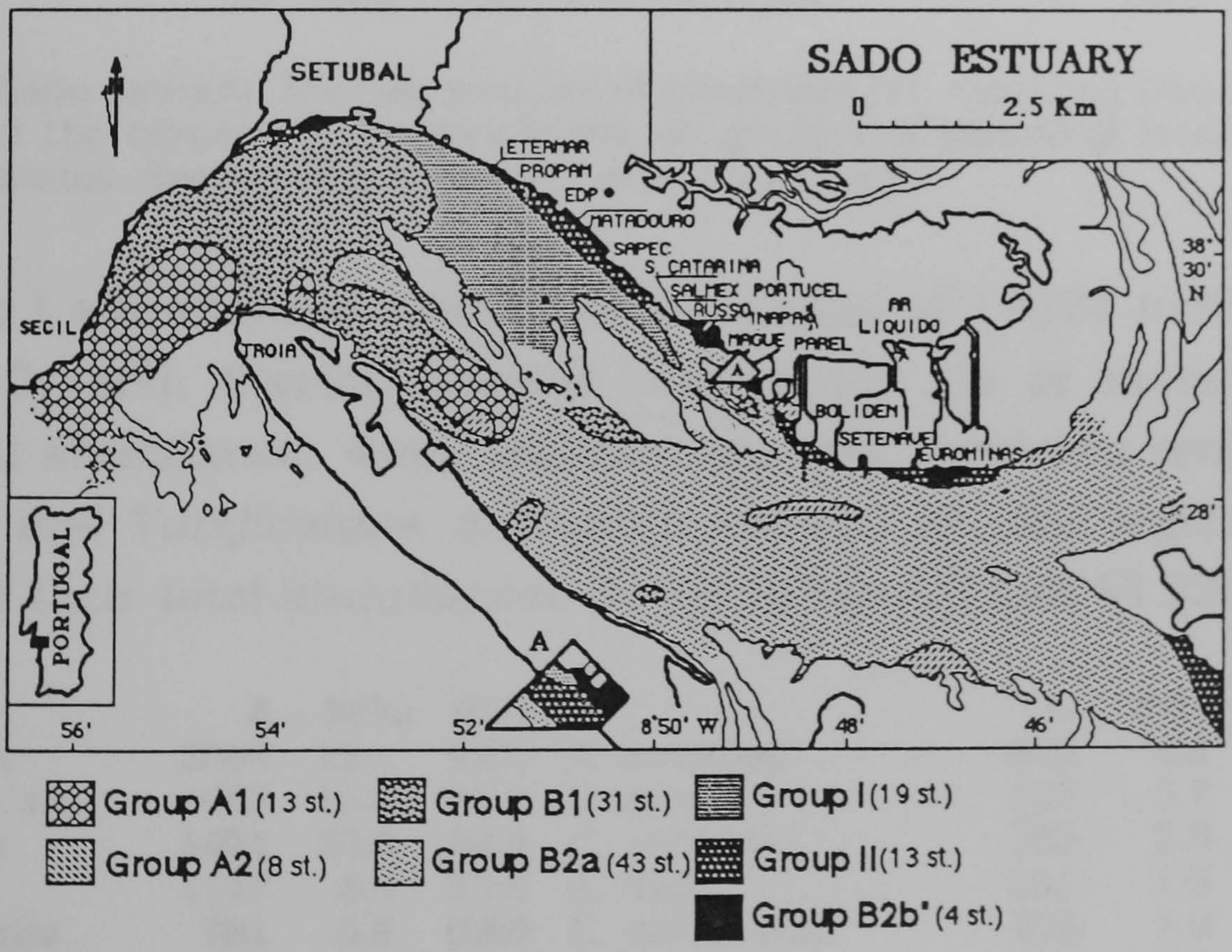


Figure 6.9 - Localisation of the affinity groups among sampling stations emphasized by TWINSPAN at the fifth level division.

The 19 sampling stations of group I comprise 177 species, 59 of which occured once. This group includes a large number of species with a sampling frequency in excess of 50%, of which $^1/_5$ were sampled at all of the locations. However, they showed low R values. Only *H. pectinata*, *C. paucicostatum*, *A. remora* and *A. diadema*, in this group show more than 40% of their total presences in the estuary (Table VI.22).

	P	F(%)	R(%)		P	F(%)	R(%)
Tharyx sp	19	100	21.1	*A. tenuicornis*	16	84.2	21.6
M. palmata	19	100	28.8	*P. cristata*	15	78.9	27.3
C. carinata	19	100	33.2	*P. marina*	15	78.9	25.0
Cirriformia	19	100	19.0	*C. gibba*	15	78.9	25.0
Caulleriella sp.	19	100	18.4	***C. paucicostatum***	**15**	**78.9**	**42.7**
A. oxycephala	19	100	20.9	*A. mucosa*	15	78.9	21.1
A. alba	19	100	24.7	***A. remora***	**13**	**68.4**	**46.4**
S. costarum	18	94.7	20.2	*S. boa*	12	63.2	37.5
I. tenella	18	94.7	21.4	*P. antennata*	12	63.2	16.0
C. annulatum	18	94.7	20.4	*C. angulata*	12	63.2	30.8
L. latreilli	17	89.5	26.2	*M. capensis*	11	57.9	15.3
P. caeca	16	84.2	21.3	*H. impar*	11	57.9	32.4
Nemertean spB	16	84.2	22.5	*C. sundevalli*	11	57.9	22.4
M. versiculatus	16	84.2	29.6	*A. lineata*	11	57.9	23.4
H. filiformis	16	84.2	27.6	***A. diadema***	**11**	**57.9**	**40.7**
H. pectinata	**16**	**84.2**	**41.0**	*N. nucleus*	10	52.6	29.4
A. talpa	16	84.2	33.3	*L. conchilega*	10	52.6	20.0

Table VI.22 - Sado estuary. Species number of presences (P), sampling frequency (F) and the respective representation, in group I of sampling locations (19 stations). Species with R values ≥ 40% are in bold.

Group I abundances correspond to a total of 13824 individuals (≈728 ind/$0.1m^2$). Sixteen species contributes 1% or more of the group's total abundance, while *Melinna palmata*, *Ampelica remora*, *A. tenuicornis* and *Tubificoides benedeni*, showed in this region more than 50% of their total abundances in the estuary (Table VI.23)

	A	F(%)	R(%)		A	F(%)	R(%)
S. costarum	2084	15.1	29.0	***T. benedeni***	**576**	**4.2**	**65.9**
Cirriformia sp	1463	10.6	39.8	*I. tenella*	505	3.7	37.8
M. palmata	**1421**	**10.3**	**64.0**	*C. carinata*	363	2.6	42.9
Tharyx sp	1147	8.3	23.9	*A. talpa*	261	1.9	32.4
A. tenuicornis	**781**	**5.6**	**59.0**	*C. annulatum*	259	1.9	9.9
Caulleriella sp.	639	4.6	23.0	***A. remora***	**217**	**1.6**	**74.3**
A. alba	631	4.6	38.2	*P. caeca*	206	1.5	20.6
A. oxycephala	623	4.5	30.2	*A. diadema*	190	1.4	14.4

Table VI.23 - Sado estuary. Species total abundance (A), abundance frequency (F) and the respective representation, in group I of sampling locations (19 stations). Species with R values ≥ 50% are in bold.

Group II, located almost exclusively close to the industrial outfalls and harbours along the northern margin, contained a total number of 93 species, of which 3 were exclusive, and almost 50% were sampled only once. Only 8 species were sampled in 50% or more of the locations, and none in this group attained 40% of their total presences in the estuary. The highest representative values of the sampling frequencies belong to two carnivorous polychates, *D. neapolitana* and *N. hombergii* (Table VI.24).

	P	F(%)	R(%)		P	F(%)	R(%)
N. hombergi	**10**	**76.9**	**20.4**	*Caullerlella sp*	8	61.5	7.8
I. tenella	8	61.5	9.5	*M. palmata*	7	53.8	10.6
D. neapolitana	**8**	**61.5**	**38.1**	*A. mucosa*	7	53.8	9.9
Cirriformia sp.	8	61.5	8.0	*A. alba*	7	53.8	9.1

Table VI.24 - Sado estuary. Species number of presences (P), sampling frequency (F) and the respective representation, in group II of sampling locations (13 stations). Species with the highest R values are in bold.

Eighteen species showed 1% or more of the total abundances of this group, of which *Ampelisca spinimana* and *Lopha stentina* showed high R values (Table VI.25). *L. stentina*, a small oyster species, was only sampled in the Alcacer channel location, the most inward of this group.

	A	F(%)	R(%)		A	F(%)	R(%)
A. spinimana	**243**	**17.8**	**90.0**	*P. marina*	36	2.6	7.9
T. benedeni	227	16.6	26.0	*C. capitata*	20	1.5	0.1
M. palmata	131	9.6	5.9	***L. stentina***	**17**	**1.2**	**87.0**
Cirriformia sp.	81	5.9	2.2	*E. puntatcus*	17	1.2	10.4
A. alba	76	5.6	4.6	*L. conchilega*	16	1.2	6.6
Caullerlella sp.	57	4.2	1.9	*A. mucosa*	16	1.2	4.1
N. hombergi	52	3.8	26.0	Oligochaete spA	15	1.1	14.8
I. tenella	47	3.4	3.5	*C. sextonae*	15	1.1	1.6
Tharyx sp.	45	3.3	0.9	*C. annulatum*	15	1.1	0.6

Table VI.25 - Sado estuary. Species total abundance (A), abundance frequency (F) and the respective representation, in group II of sampling locations (13 stations). Species with highest R values are in bold.

6.3.2 - Community characterization and spatial distribution

The affinity groups obtained through TWINSPAN and the most characteristic species of each, suggest the existence in the outer Sado estuary of two distinct benthic communities, marine and estuarine, separated by a transition region. The estuarine community however, shows several important and very coherent spatial subdivisions, designated as type, enriched, impoverished, highly disturbed and defaunated areas. The number of presences, abundances and biomasses (wet-weight) of each species, in these affinity groups are shown in annexes V, VI, and VII (for species codes see annex III).

The spatial pattern of these communities and their major subdivisions agrees well with the major sedimentary and hydrodynamic characteristics of the estuary, and suggests the effects of both natural and anthropogenic factors.

The type marine community together with the transition region ocupy the area of the seaward main velocity gyre, while the type estuarine community extends landwards, in the region of the other main vortice. The meeting point of these two vortices in the California region of the southern channel, corresponds well to the innermost extention of the type marine community and the transition region (*cf.* figs. 2.5, page 19 and 4.2, page 78).

The enrichment areas of the estuarine community in the northern channel also agrees with the gap between the two main residual vortices, where the hydrodynamic energy tends to be the lowest of all the studied area.

The impoverishment areas, the highly disturbed areas, and the defauned sites suggest the prevalence of anthropogenic factors over the natural conditions of the estuary, some clearly related to organic enrichment, while others point out stronger toxicity and inhibiting effects over the benthic community.

Marine Community

The marine affinity community, group A of Twinspan, is mainly located in the estuarine entrance and the southern channel, but also including a few scattered locations along the upper estuary (*cf.* fig. 6.5, page 220). The most characteristic species are small interstitial annelids, namely *Saccocirrus papillocercus, Pisione remota, Polygordius appendiculatus* and a non determined oligochaete. Other important species comprise the polychaetes *Parapionosillys elegans, Nephtys cirrosa* and *Goniadella galaica,* the crustaceans *Gastrosaccus spinifer* and *Melita gladiosa,* and the bivalve *Ervilia castanea.*

The type region of this community (group A1 of Twinspan) occurs in the estuarine entrance and along a few locations of the southern channel (stations: 1 to 4, 7 to 11, 31, 48, 49 and 67 - *cf.* fig.6.6, page 224), corresponding essentially to the clean coarse sands of the mouth of the estuary.

The impoverished areas of this community (group A2 of Twinspan) is found at several scattered sampling sites, mainly located in the upper estuary (stations: 32, 68, 96, 104, 106, 115, 123 and 127 - *cf.* fig. 6.6, page 224), and corresponds to a clear increase in fines and total organic matter, in relation to the type community. It is characterized by a strong hierarchical structure, being *Scoloplos armiger* the most abundant species, comprising 55% of the total abundance. *Tellina tenuis* is, however, the most important species both in relative frequency and abundance.

Both the type and the impoverished areas have a high number of species sampled only once, respectively 47.7% and 65.8%. However, mean species richness, abundance and wet-weight biomass per site, are much higher in the type community.

Transition region

The transition region, group B1 of Twinspan, extends, as with the marine community, further inside the estuary through the southern channel (stations: 5, 6, 12 to 22, 25, 27 to 30, 33, 36 to 38, 43, 45 to 47, 81, 83, 84, 97 and 101 - *cf.* fig. 6.6, page 224).

It is characterized by species of both the marine and the estuarine community, together with an important proportion of exclusive species sampled once in the whole estuary.

The transition region is the region of the estuary with the highest total species richness and the lowest proportion of species sampled once in each of the affinity groups (28.2%). It also contained the highest number of species with a sampling frequency higher than 50%, and the highest values of mean species richness and species diversity per site of the whole estuary, while showing the lowest relative abundance represented by the first ranked species.

The most characteristic species are the crustaceans, namely *Corophium sextonae, C. annulatum, C. runcicorne, Pariambus typicus, Photis longipes, Apseudes latreilli, A. talpa, Leptocheirus pectinatus, Perioculodes longimanus* and a non determined ostracod species. Also important are the annelids *Mediomastus capensis, Euclymene palermitana, Polycirrus sp. Pseudopolydora antennata, Polydora caeca* and *Notomastus latericeus*, the molluscs *Venerupis pullastra, Spisula solida* and *Calyptraea chinensis*, and also a non determined nemertean.

Estuarine Community

The estuarine community, group B2 of Twinspan, is located inwards of all the previous groups (*cf.* fig. 6.6, page 224). It is characterized by an important number of species with high representative values of both sampling frequency and abundance, in which annelids clearly predominate.

The most important species for the whole community are the annelid polychaetes *Heteromastus filiformis, Melinna palmata, Cirriformia sp., Tharyx sp., Caulleriella sp., Aonides oxycephala, Spiochaetopterus costarum, Scalibregma inflatum, Glycera tridactyla,* *Anaitides mucosa, Lumbrinereis latreilli* and *Capitela capitata*, the oligochaet *Tubificoides benedeni*, the molluscs *Abra alba, Hemilepton nitidum* and *Corbula gibba*, the crustaceans *Cyathura carinata, Iphinöe tenella* and *Ampelisca tenuicornis*, and the anthozoan *Virgularia mirabilis*.

This community contains several important subgroups, the spatial distribution of which suggest the influence of both natural environmental gradients and anthropogenic factors.

Type areas

The estuarine community type areas, group B2a of Twinspan, comprises the majority of the southern channel and the upper part of estuary (stations: 34, 35, 50, 66, 69 to 72, 74 to 76, 79, 82, 85 to 88, 91, 98 to 100, 102, 103, 105, 108 to 114, 116, 118, 119, 121, 122, 124, 125, 128 to 132 - *cf.* fig. 6.7, page 231). It occurs in the large extension of silty to very silty medium sand of the upper part of the estuary. The mean species richness, abundance and biomass are all lower than the observed in the transition region, but all higher than the obtained in the type marine community.

The most characteristic species of the type community are the annelid polychaets *Heteromastus filiformis, Scalibregma inflatum, Spiochaetopterus costarum, Lygdamis muratus, Lanice conchilega* and *Aonides oxycephala*, the molluscs *Hemilepton nitidum* and *Corbula gibba*, and the anthozoan *Virgularia mirabilis*.

Enrichment areas

Enrichment areas of the estuarine community, group I of Twinspan, are located in the northern channel (stations: 23, 39 to 42, 44, 51 to 56, 59, 60, 63, 64, 77, 80, 89 - *cf.* fig 6.9, page 235), mainly over very silty medium sand and the large extention of very silty fine sand which borders the northern margin of the intertidal sand-banks. The mean fines, sand, gravel and total organic matter content of this region clearly indicates an increasing fines and organic content in relation to the typical areas.

In relation to the type areas, this region showed a lower total species richness, but much higher mean values for species richness, abundance and biomass per sampling location. Also, it is the region of the estuary with the highest mean wet-weight biomass per site and the highest proportion of species with sampling frequency superior to 50% (19.2%). Within the estuarine community, it shows the higher species diversity.

Tharyx sp., Cirriformia sp., Caulleriella sp., Melinna palmata, Aonides oxycephala, Abra alba and *Cyathura carinata*, all important species to the whole estuarine community, are present in all the sampling stations of the enrichment areas. The most important species to these areas are, however, the annelids *Melinna palmata* and *Tubificoides benedeni*, the mollusc *Cardium paucicostatum*, and the crustaceans *Ampelisca remora, A. tenuicornis, A. diadema* and *Harpinia pectinata*.

Impoverishment areas

Impoverishment areas of the estuarine community, group II of Twinspan, are located close to the northern margin, in the vicinity of the industrial complex and the urban sewage outfall (stations: 24, 57, 58, 61, 62, 65, 73, 90, 94, 107, 117, 126, 133 - *cf.* fig. 6.9, page 235). The sampling sites of this region are characterized by a clear organic and fines enrichment in relation to the previous regions.

The 13 sites comprising this region showed the lowest mean abundance and biomass per sampling station within the estuarine community. Also, almost 50% of the species were only sampled once in the stations of this group.

The most important species were the carnivorous annelids *Nephtys hombergi* and *Diopatra neapolitana*, and the crustacean *Ampelisca spinimana*.

Highly disturbed areas

A total of four sampling stations (stations: 26, 78, 92 and 93) comprise the most disturbed areas of the estuarine community (group B2b" of Twinspan - *cf.* fig. 6.9,page 235). These sites are mainly located in the proximity of the sewage outfall and the pulp mill outfall. The mean fines, sand, gravel and total organic content indicate a strong organic enrichment.

The annelids *Malacoceros fuliginosus* and *Capitella capitata* are the only characteristic species of this region, with abundances of respectively 96% and over 99% of the species total abundances in the estuary.

Defaunated areas

Finally, two defaunated locations, stations 95 and 120, complete the total group of sites sampled in the estuary. These locations are positioned close to the northern margin (figure 6.10), in the vicinity of the most disturbed areas. They showed the highest mean total organic matter content in the estuary.

The spatial distribution of the Sado estuary subtidal benthic communities and their major subdivisions is presented in figure 6.10 and a summary of the biological and the environmental data of the major affinity groups is shown in table VI.26.

In the next section, these major gradients will be analysed through an ordination method in which the major pattern of variation of the biological variables is defined, *a priori*, as a function of the environmental variables.

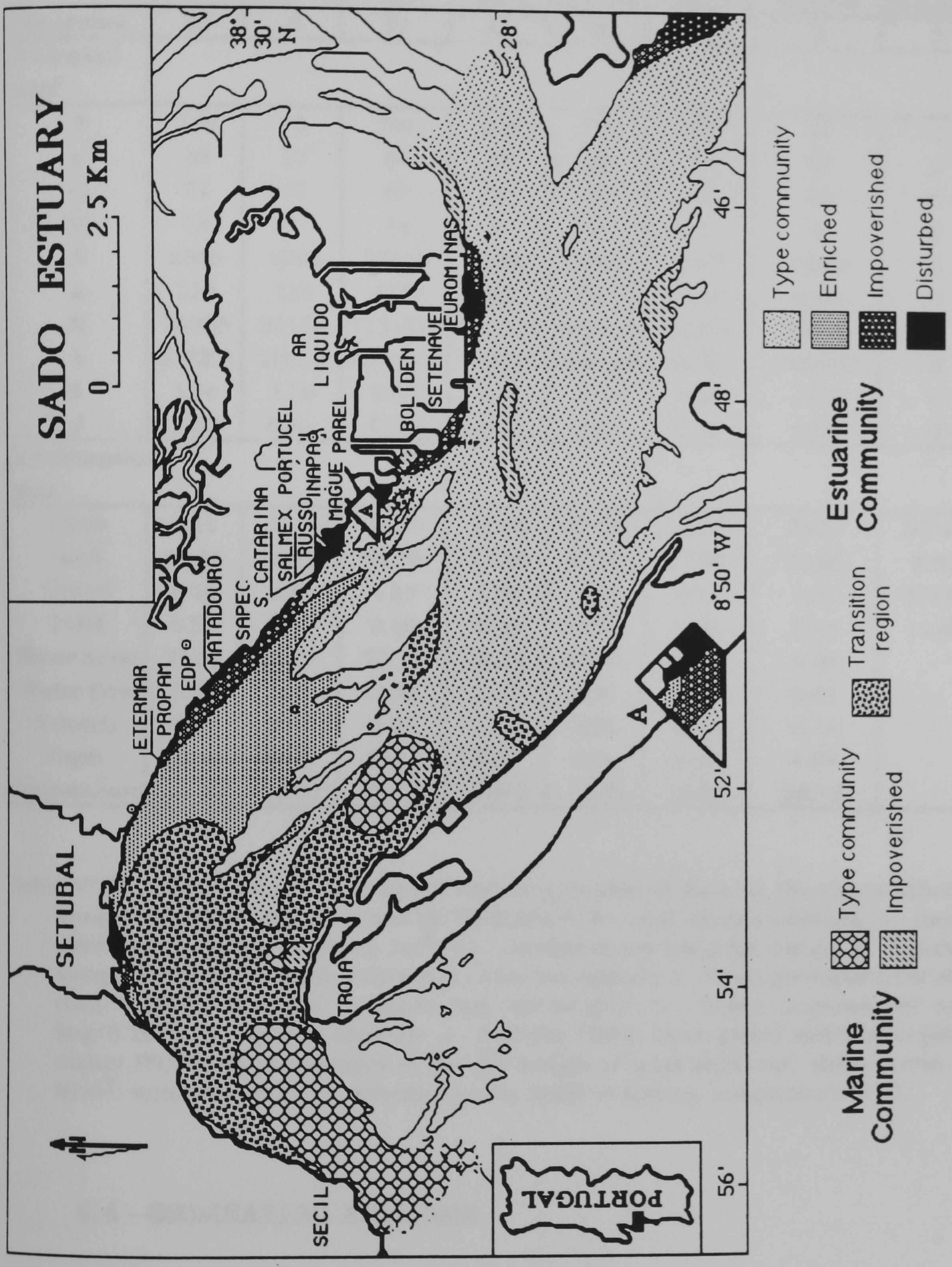


Figure 6.10 - Sado Estuary. Spatial distribution of the benthic faunal assemblages.

	Group A1 marine commun.	**Group A2** marine (impov.)	**Group B1** transition region	**Group B2a** estuarine (type)	**Group I** estuarine (enrich.)	**Group II** ind. north. margin	**Group B2b"** sewage, st.78 pulp mill	**Sites 95 and 120** (defaunated)
No. of sites	13	8	31	43	19	13	4	2
Biological data								
S	149	73	291	199	177	93	32	0
s	32	17	64	34	49	18	12	0
s1	71	48	82	58	59	45	20	0
S1	18	1	44	9	9	3	3	0
A	2385	1063	27816	17307	13824	1367	16006	0
a	218	133	897	402	728	105	4002	0
B	74393	25135	1131318	760418	699253	83534	78304	0
b	5722.6	3141.9	36494.0	17684.0	36803.0	6425.7	19576.0	0
H'	5.24	3.16	5.84	4.26	4.74	4.58	0.25	0
J	0.73	0.51	0.71	0.56	0.63	0.70	0.05	0
Environment data								
Fines	2.11	13.9	15.79	24.68	41.24	72.55	75.07	93.44
Sand	89.85	85.72	79.98	73.46	57.38	27.06	23.63	6.52
Gravel	8.04	0.38	4.23	1.86	1.38	0.39	1.31	0.003
TOM	0.51	2.39	2.15	2.55	5.09	7.60	9.78	11.46
Shear stress	45.04	22.61	23.11	27.72	15.36	11.11	4.58	-
Water flow	7.88	2.69	3.30	2.47	1.85	1.23	0.43	-
Velocity	0.41	0.27	0.27	0.30	0.22	0.18	0.13	-
Depth	13.43	5.85	10.87	6.57	6.34	5.73	4.28	-
Temperature	18.46	20.00	19.22	19.99	18.90	19.87	20.13	-

Table VI.26 - Sado estuary. Biological and environmental data in the major affinity groups among locations defined by TWINSPAN. S - total species richness; s - mean species richness per site (sp/0.1m^2); s1 - number of species present once; S1 - species sampled once in the whole estuary; A - total abundance; a - mean abundance per site (ind/0.1m^2); B - total biomass (mg wet-weight); b - mean biomass per site (mg/0.1m^2); H' - species diversity; J - eveness. Fines, sand, gravel and total organic matter (TOM), as percentages of the dry weight of total sediment; shear stress in N/m^2; water flow in m^2/s; velocity in m/s; depth in meters; temperature in °C.

6.4 - ORDINATION ANALYSIS

A direct gradient ordination method was used to analyse which pattern of variation of the biological data is best explained by the particular set of environmental variables available. The results obtained and the main conclusions were then compared with those obtained from the TWINSPAN analysis, which made use only of the abundance and species composition data.

The ordination method employed was canonical correspondence analysis (CCA), described in Chapter 3. Simple correspondence analysis (CA) was also used with the same data, to check if comparable results would be obtained without the imposed variability of the environmental data.

CA and CCA were performed with the program CANOCO, version 3.1 (see Chapter 3, Methodology), with the same abundance data file as used in TWINSPAN, but considering location 26 as a supplementary station, because of the distorting effect of its extremely high abundance. The [ln (y+1)] transformation was imposed on the biological data and nine environmental variables were considered (*cf.* data set in Chapter 4, Table IV.4, page 98): fines, sand, gravel, total organic matter, shear stress, water flow, current velocity, depth and sediment temperature.

CA and CCA were also run with the biomass data (wet-weight and ash-free dry weight), to check for major differences in relation to the abundance data. Several locations showed very high biomass values, essentially due to the bivalve *Venerupis pullastra*, which for that reason was introduced as a supplementary species.

Abundance data

CCA was first run considering all the nine environmental variables. The total variance, or total inertia, in the species data was 5.477, of which the nine environmental variables account for 0.837, i.e. 15.3%. Species composition data is often very noisy. With large data matrixes such as these, it is common that the first axes of CA (or CCA), will comprise what may seem to be a relative low proportion of the total variance, which however may be very informative (*cf.* Gauch, 1982).

CCA extractes first the canonical, or constrained, axes and only afterwards the unconstrained ones, which comprise the amount of variance unexplained by the environmental data. In this case, the 10th axis will be the first, and the strongest, unconstrained axis.

Table VI.27 summarizes the ordination results obtained. The two first canonical axes explain 7.9% of the total variation in the species data, and comprise 51.7% of the variance explained by the environmental variables, while the first four canonical axes account for 75.7% of that variance.

Axes		1	2	3	4	**Total inertia**
Eigenvalues	:	.291	.142	.122	.079	5.477
Species-environment correlations	:	.869	.833	.861	.765	
Cumulative percentage variance						
of species data	:	5.3	7.9	10.1	11.6	
of species-environment relation	:	34.8	51.7	66.3	75.7	
Sum of all unconstrained eigenvalues						4.640
Sum of all canonical eigenvalues						.837

Table VI.27 - Sado estuary. Ordination summary for the canonical correspondence analysis with the nine environmental variables.

The species-environment correlations, a measure of the strength of the relationship between species and environment for a given axis, are all higher than 0.76. It should be noticed however that the fourth canonical axis only adds 1.5% to the amount of total variance already explained by the three first axes, meaning that the eigenvalues, more than the species-environment correlations, should be used to check the discriminant power of a given axis (*cf.* ter Braak, 1987a).

The set of the environmental variables which best explain the species data was searched with the *"forward selection of environmental variables"*, an option allowed by this version of CANOCO. For this, the environmental variables were added one by one to the analysis and their statistical significance was tested, allowing the inclusion as passive variables of those which no longer add a significant part to the already explained variance in the biological data (see Chapter 3, Methodology).

The forward selection of environmental variables permited the exclusion from the analysis of total organic matter and sand. Total organic matter is very strongly related with fines, as shown in Chapter 4, and so both tend to explain the same global variability in the biological data. Sand content is complementary of fines and gravel, and for that reason the analysis suggests its introduction as a passive variable. The ordination summary of CCA with the seven retained environmental variables is presented in Table VI.28.

Axes		1	2	3	4	**Total inertia**
Eigenvalues	:	.291	.141	.122	.078	5.477
Species-environment correlations	:	.868	.833	.859	.775	
Cumulative percentage variance						
of species data	:	5.3	7.9	10.1	11.5	
of species-environment relation	:	36.6	54.4	69.7	79.5	
Sum of all unconstrained eigenvalues						4.683
Sum of all canonical eigenvalues						.794

Table VI.28 - Sado estuary. Ordination summary for the canonical correspondence analysis, after the forward selection of the (seven) environmental variables which best explain the biological data.

Compared to the first analysis, with all the environmental data, it may be seen that the first four canonical axes present almost the same 1) eigenvalues, 2) cumulative percentage variance of the species data, and 3) species-environment correlations (*cf.* Table VI.27), thus confirming the non-significance of the excluded variables.

The total variance explained by the canonical axes is now lower (0.794, = 14.5%), since total organic matter and sand are no longer active variables. The cumulative percentage variance of the species-environment relation of the first four axes tends to be higher simply because the canonical eigenvalues are almost the same, and the total canonical variance is lower than before (*cf.* Table VI.27).

Finally, the first unconstrained eigenvalue in both analyses was 0.30, indicating that the first and strongest non-environmental axis comprises the same amount of variance, with or without the two excluded environmental variables.

The interpretation of the ordination axes in CCA makes use of the intraset correlations (*cf.* ter Braak, 1986), obtained between the environmental variables and the canonical axes. These correlations are given in Table VI.29, and they indicate which variables are more strongly correlated to each axis.

Axes	**1**	**2**	**3**	**4**
Fines	-.6561	.4740	-.1550	.3820
Gravel	.6881	.5911	.3397	.0195
Shear stress	.4336	-.5121	.5338	.2732
Water flow	.6986	-.3325	-.0079	.1299
Current velocity	.3684	-.5541	.4215	.1130
Depth	.6889	.2573	-.0500	-.3709
Temperature	-.3831	-.1690	.7585	-.1244

Table VI.29 - Correlations between the environmental variables and the canonical axes.

Axis one is mainly defined by the opposition of depth, gravel and water flow, on the positive side, to fines content and temperature, on the negative side, and axis 2, by the opposition of gravel and fines on the positive side, to shear stress and current velocity on the negative side.

While axis 1 may be seen essentially as a mixture of hydrodynamic and sedimentary conditions, opposing seaward to landward conditions, axis 2 would represent a detailed granulometric partition between the more heterogeneous sediments (positive side), and the more strictly sandy sediments, determined by the higher values of shear stress and current velocity.

Temperature is the most important environmental variable for axis 3, in opposition to fines content, suggesting a detailed partition within the landward group defined by axis 1. Axis 4 presents the lowest correlation values with the environmental data, which agrees with the minor proportion of the total variance accounted for by this axis, as seen before. It opposes fines to depth.

The statistical significance of canonical axis 1, the strongest constrained axis, was confirmed using the Monte Carlo permutation test (see Chapter 3, Methodology). The real data F-ratio for axis 1 was 6.84, while the highest F-ratio obtained after 19 random permutations (P=0.05) was no higher than 2.63.

The representation of the sampling sites in plane 1-2 of CCA is given in figure 6.11, in which the locations are represented by symbols, according to the partitions established by TWINSPAN. The environmental variables are represented by vectors, and they are distributed in all the 4 quadrants defined by axes 1 and 2. Total organic matter and sand, introduced as passive variables, are represented by dashed lines.

The ordination diagram clearly represents the data presented in Table VI.29. Axis 1 opposes fines, TOM and temperature to the other environmental variables, while axis 2 opposes fines, TOM, gravel and depth to the remaining variables. Total organic matter and fines content are highly positively correlated, while negatively correlated with flow, shear stress, velocity and sand, which are all positively correlated with each other. Depth and temperature present a clear negative correlation. Temperature appears as the weakest environmental factor, judged by the length of the vector.

The distribution of the sampling stations in the ordination diagram of figure 6.11 clearly resembles the results obtained by TWINSPAN.

The positive side of axis 1 contains all the locations from the marine community and the majority of the locations from the transition region, while only very few from the type estuarine community appear on this side. The negative side of this axis contains all the locations from the enriched, the impoverished and the highly disturbed facies of the estuarine community, and almost all the locations from the estuarine type community. Axis 1 thus clearly

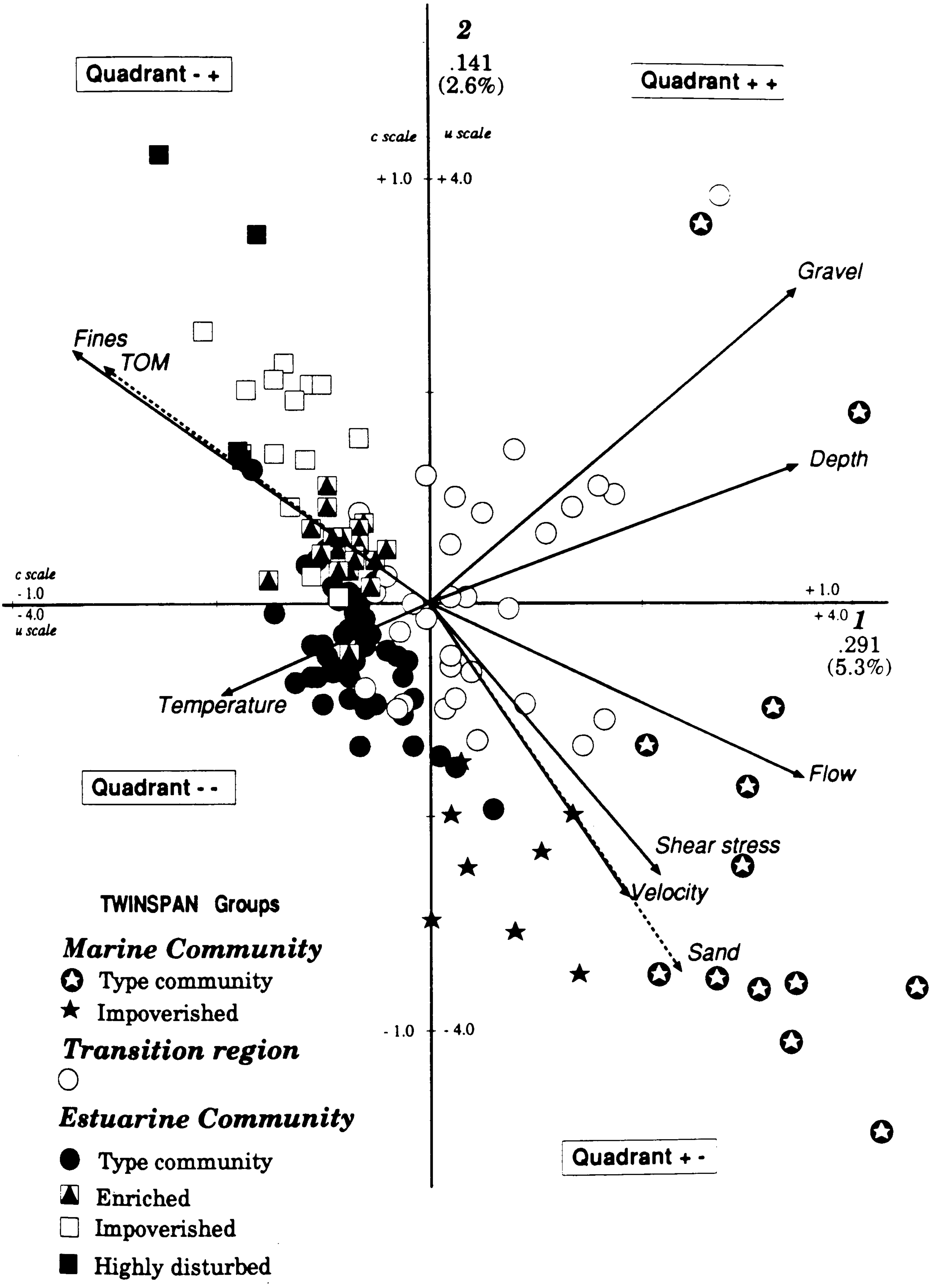


Figure 6.11 - Sado estuary. Point-stations in plane 1-2 of canonical correspondence analysis, representing the affinity groups defined by TWINSPAN. The dashed vectors represent passive environmental variables. u scale - locations; c scale - environment data

represents the opposition of marine, or seaward, to estuarine, or landward, conditions.

The relative distribution of the sampling sites in plane 1-2 of CCA also agrees with the detailed partitions established by TWINSPAN.

Along the gradients presented in fig. 6.11, the opposition of the locations from the type marine community (quadrant +–) to the highly disturbed areas of the estuarine community (quadrant – +) is clear. The first are essentially related to high values of flow, current velocity, shear stress and sand, while the second are very strongly related to organic matter content and fines.

The transition between both groups is quite comparable to the classification results. The impoverished areas of the marine community (quadrant +–) approaches the locations corresponding to the estuarine type community (quadrant – –), for which temperature appears to be the strongest environmental factor, which agrees with the spatial distribution of this descriptor (*cf.* fig 4.11, page 97).

A few locations of the type estuarine community make the transition to the first group of locations clearly aligned in the fines-organic content gradient (quadrant – +). These locations, closest to the centre of the representation, belong to the enriched areas of the estuarine community, corresponding to the northern channel core of sites.

With an increasing content of organic matter and fines, the locations corresponding to the impoverished areas of the estuarine community appear, located close to the northern industrial margin, and finally the highly disturbed areas, in which the two extreme points correspond to the sites located the closest to the urban sewage outfall and the pulp mill outfall.

In quadrant ++, determined by the highest values of gravel and depth, 3 sites are clearly distinguished, locations 1, 2 and 5, belonging to the type marine community and to the transition region.

These sites correspond either to the deepest sampling locations (sites 2 and 5) and/or to the highest gravel content (site 1).

The global and the detailed underlying gradients suggested by canonical correspondence analysis are thus very similar to those defined by the TWINSPAN results and its *a posteriori* interpretation.

The ordination diagram of the species scores shown by the location of the species code number on the figure 6.12, emphasizes these same gradients.

The species which appear isolated in quadrant ++ (*P. milliaris* - 296, *H. artica* - 142, *K. suborbicularis* - 156, *Protomystides sp.* - 295, *G. gracillis* - 126, *A. lactea* - 36, Amphipod spA - 24 and *O. massiliensis* - 243) are those most influenced by depth and are mainly abundant in the deepest stations 1, 2 and 5.

In quadrant + -, the species which are more positively related to sand content, water flow, shear stress and current velocity, while negatively related to fines and TOM, such as *P. phasma* (299) and *M. aberrans* (204), only appear in the stations of the type marine community, or are predominant in this group like the Nudibranch sp. (236), *P. appendiculatus* (280), *U. grimaldii* (356), *H. elongata* (138) and *P. remota* (273). Some of these species are also influenced by depth.

In quadrant - - the species which begin to be more related to temperature but are still influenced to some extent by sand content and shear stress appear, e. g. *O. laubieri* (239), *P. monolifer* (261) *A. brevicornis* (10) and *E. pusillus* (93). These are mainly abundant in the transition region and the southern channel. They make the transition to others predominantly present in areas of higher temperatures, such as *S. bocqueti* (319) *J. marmorata* (153), *A. langerhansi* (46) *M. lanata* (196), which are abundant in the impoverished part of the marine community (southern channel and upper estuary), the transition region and the enrichment areas of the northern channel. *Melita palmata* (202), only present in the type estuarine community, also appears in this quadrant. This species

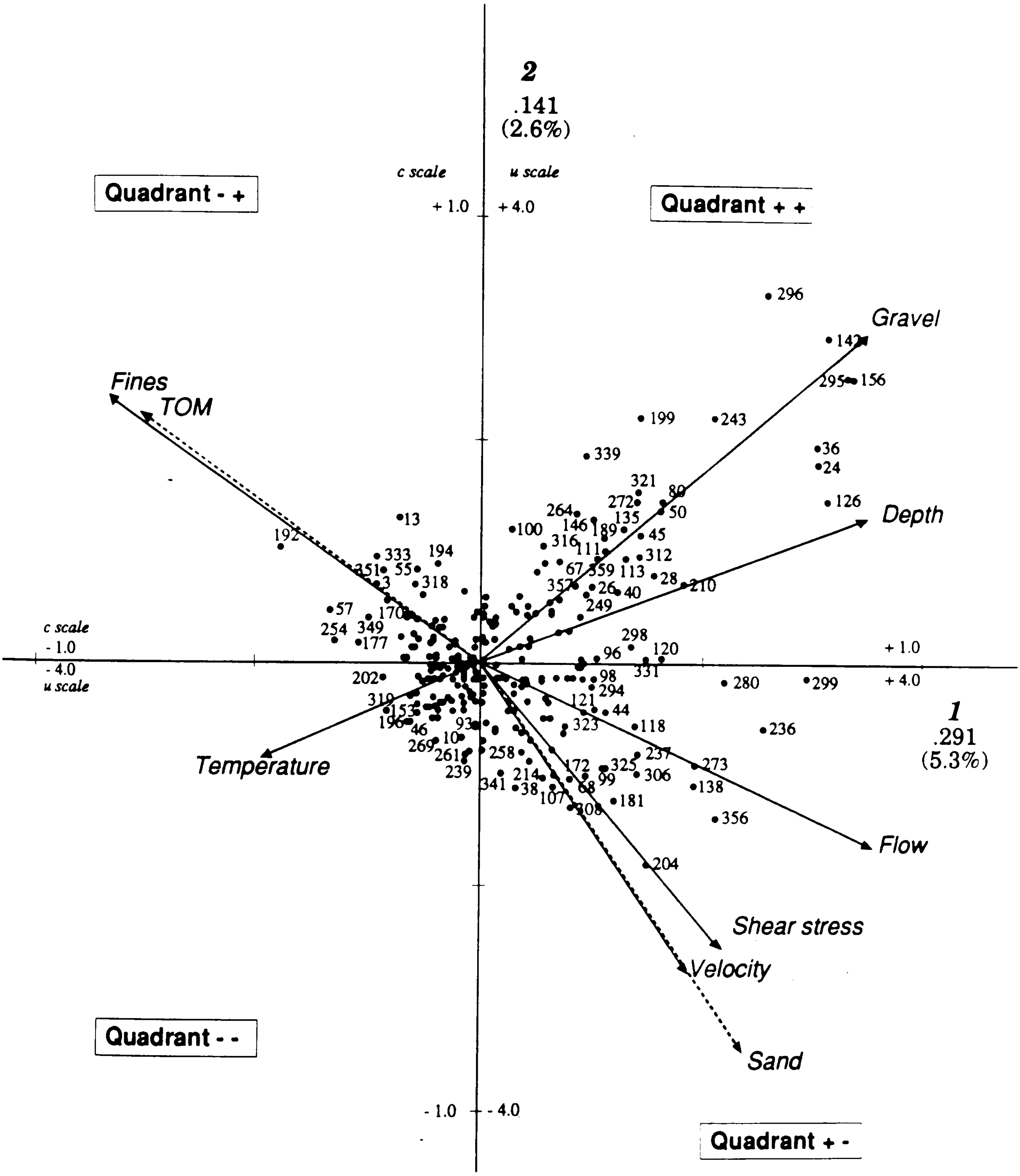


Figure 6.12 - Sado estuary. Point-species in plane 1-2 of canonical correspondence analysis. The dashed vectors represent passive environmental variables. u scale - species; c scale - environmental data. For species codes see annex III.

shows one of the highest correlations with temperature, stronger than its relation with fines and TOM (the reason why the species is located in this quadrant), but a low correlation with sand and shear stress.

The species which present the strongest correlation with fines and the total organic matter appear in quadrant - +, although some also show a high positive correlation with temperature. These species have their maximum abundances in the enrichment areas of the northern channel, the impoverished areas closest to the margin and the highly disturbed locations of the estuarine community, e. g. *M. fuliginosus* (192), *A. spinimana* (13), *T. benedeni* (351), *A. nitida* (3), *C. maenas* (57), *C. capitata* (55), *S. togata* (318), *L. arcuatus* (170) and *L. stentina* (177).

These results suggest a very close relation between the conclusions drawn from the analysis of the biological data alone and those from the imposed variability of the measured environmental variables.

The results obtained with a simple correspondence analysis, to which the environmental variables were added *a posteriori* as passive variables, suggest the same general conclusions, thus confirming the significance of the environmental data considered. Table VI.30 summarizes the ordination results from that analysis.

Axes		**1**	**2**	**3**	**4**	**Total inertia**
Eigenvalues	:	.443	.271	.227	.200	5.477
Species-environment correlations	:	.713	.627	.297	.547	
Cumulative percentage variance						
of species data	:	8.1	13.1	17.2	20.9	
of species-environment relation	:	28.4	41.8	44.3	51.9	
Sum of all unconstrained eigenvalues						5.477
Sum of all passive canonical eigenvalues						.794

Table VI.30 - Sado estuary. Ordination summary for the correspondence analysis, introducing as passive variables the seven environmental variables which best explain the biological data in the CCA.

The relative variance accounted for by the first two axes now corresponds to 13.1%, while in canonical correspondence analysis the value was lower, 7.9%. The species-environment correlations are lower than in CCA, as expected, since in a normal CA there is no imposed variability of the environmental data over the biological data. However, the values are also high, 0.71 and 0.63, respectively for the axes 1 and 2. For the same reason, the cumulative percentage variance of the species-environment relations is lower than in CCA. The first four axes now correspond to 51.9% of this variance, while in CCA, they accounted for 79.5% (*cf.* tables VI.28 and VI.30).

Table VI.31 presents the correlations between the environmental variables and the axes determined by CA. When comparing these results with those from CCA, given in table VI.29, we see that the correlations are similar to those obtained with the canonical analysis, especially when considering the results from axis 1. In fact, as in CCA, this analysis also establishes the difference between landward and seaward conditions as the strongest partition in the data.

Axes	**1**	**2**	**3**	**4**
Fines	-.6902	.2688	.5341	.0333
Gravel	.5475	-.8361	.0437	.5246
Shear stress	.5481	.1981	-.7071	.3865
Water flow	.7622	-.1922	-.4813	.1513
Velocity	.4767	.2196	-.7922	.3512
Depth	.6185	-.6433	-.4679	.3311
Temperature	-.3544	.4997	-.0460	.6074

Table VI.31 - Correlations between the environmental variables and the ordinations axes, obtained *a posteriori*.

This may be more clearly observed in figure 6.13, representing the distribution of the Twinspan groups in plane 1-2 of the correspondence analysis, to which the nine environmental variables were added *a posteriori*, as passive variables.

All the locations from the marine community are again in the positive side of axis 1, while almost all the locations from the estuarine community are in the negative side. The transition region is now less dispersed but is still the only group distributed in more

Figure 6.13 - Sado estuary. Point-stations in plane 1-2 of a simple correspondence analysis, representing the affinity groups defined by TWINSPAN. u scale - locations; c scale - environment data

than 2 quadrants. The sampling locations from the estuarine community are also less dispersed than in CCA, and are almost entirely located in the quadrant - +. In consequence, the environmental variables which are more closely related to these samples, i. e. fines, TOM and temperature, are now represented in a single quadrant (*cf.* figures 6.11 and 6.13).

The sites distribution in plane 1-2 of CA and the relation between the three major groups of locations, the marine community, the transition region and the estuarine community, are thus very similar to those presented by plane 1-2 of CCA. The major difference concerns the more detailed partitioning of the locations belonging to the estuarine community. These results confirm the validity of the environmental variables considered.

Biomass data

The biomass data was run with CCA and CA to check for major differences from the results obtained using the abundance data.

For both the wet-weight and the ash-free dry weight, the forward selection of environmental variables showed that besides total organic matter and sand, the shear stress should also be included as a passive variable, thus conducting the final analysis with six environmental variables. The ordination summary from this analysis with the wet-weight biomass data is presented in table VI.32.

Axes		1	2	3	4	**Total inertia**
Eigenvalues	:	.274	.146	.128	.076	6.202
Species-environment correlations	:	.877	.820	.842	.837	
Cumulative percentage variance						
of species data	:	4.4	6.8	8.8	10.0	
of species-environment relation	:	36.1	55.3	72.1	82.1	
Sum of all unconstrained eigenvalues						5.443
Sum of all canonical eigenvalues						.759

Table VI.32 - Sado estuary. Ordination summary for the canonical correspondence analysis, after the forward selection of the (six) environmental variables which best explain the wet-weight biomass data.

Total inertia in the species biomass data is 6.202, of which the significant environmental variables explain 0.759, i. e. 12.2%, which is slightly lower than the value obtained with the abundance data (cf. table VI.28, page 248). Also, the first four canonical axes account for 10.0% of the total variance in the species biomass data, while with the abundance data the first four axes accounted for 11.5%. The results obtained show that with the biomass data (wet-weight), the environmental data considered has slightly lower explanatory power than with the abundance data.

The correlations between the canonical axes and the environmental variables for this same analysis are presented in table VI.33.

Axes	**1**	**2**	**3**	**4**
Fines	-.6194	.6207	.1509	.0373
Gravel	.7244	.2117	.5691	.2669
Water flow	.6584	-.3141	-.1542	-.0102
Velocity	.2804	-.7001	.1121	.1202
Depth	.7425	.1628	.2155	-.5577
Temperature	-.3952	-.5499	.5314	-.1042

Table VI.33 - Correlations between the environmental variables and the canonical ordinations axes.

Axis 1 opposes fines and temperature (negative pole) to the other variables, while axis 2 opposes water flow, current velocity and temperature (negative pole), to fines, gravel and depth. These relations are exactly the same as those obtained with the abundance data (*cf.* table VI.29, page 249), suggesting that the analysis with both biological variables allows the same basic conclusions.

Finally, the wet-weight biomass data was also run with CA, to which the environmental variables were then added *a posteriori* as passive variables. The ordination summary from this analysis is given in table VI.34. As with the abundance data, the first four eigenvalues are stronger than those in the canonical analysis. The first two CA axes account for 11.4% of the total variance in the species biomass data (13.1% in the case of the abundance data, cf. table VI.30), while the two first CCA axes comprised 6.8% (cf. table VI.32). However, the species-environment relations are lower than in CCA, as expected, and as obtained with the abundance data.

Axes		1	2	3	4	**Total inertia**
Eigenvalues	:	.407	.298	.247	.210	6.202
Species-environment correlations	:	.705	.587	.354	.501	
Cumulative percentage variance						
of species data	:	6.6	11.4	15.4	18.8	
of species-environment relation	:	26.7	40.2	44.3	51.3	
Sum of all unconstrained eigenvalues						6.202
Sum of all canonical eigenvalues						.759

Table VI.34 - Sado estuary. Ordination summary for the correspondence analysis, introducing as passive variables the six environmental variables which best explain the wet-weight biomass data in the CCA.

The species-environment correlation obtained with axis 1 is, nevertheless, high, 0.705 (0.713 with the abundance data, cf. table VI.30, page 255).

As with the abundance data, CA and CCA run with the wet-weight biomass data also allow the same basic conclusions and establish the opposition of landward to seaward conditions, determined by axis 1 as the strongest partition in the data. This is shown in table VI.35, showing the correlation between the CA axes and the environmental variables.

Axes	**1**	**2**	**3**	**4**
Fines	-.7233	.0660	.4385	.0529
Gravel	.5920	-.7034	.0313	.5882
Water flow	.7473	-.1910	-.4299	.0875
Velocity	.4229	.3042	-.8603	.3145
Depth	.6756	-.6086	-.3366	.3460
Temperature	-.3347	.6733	-.2816	.5433

Table VI.35 - Correlations between the environmental variables and the CA ordinations axes, obtained *a posteriori*.

Axis 1 opposes precisely the same variables as they did with the CCA run (*cf.* table VI.33), while axis 2 opposes with the biomass data the same variables as the CA run with the abundance data (*cf.* table VI.31, page 256).

The results suggest that:

1) CA and CCA show the same basic pattern in the data, and

2) Abundance and wet-weight biomass data show precisely the same distinctions and similarities between the sampling sites.

Finally, the ash-free dry weight biomass data was also analysed. The results obtained are in every aspect similar to those obtained from the wet-weight biomass analysis. The results from the CCA run are given in tables VI.36 (ordination summary) and VI.37 (correlation between the canonical axes and the environmental data), while the results with the CA run including the environmental data as passive variables, are given in tables VI.38 and VI.39. In this case, the significant environmental variables account for 12.0% of the total variance in the species ash-free dry weight biomass data, while with the wet-weight biomass, the value was 12.2%.

Axes		**1**	**2**	**3**	**4**	**Total inertia**
Eigenvalues	:	.292	.171	.138	.087	7.067
Species-environment correlations	:	.883	.819	.823	.790	
Cumulative percentage variance						
of species data	:	4.1	6.6	8.5	9.7	
of species-environment relation	:	34.6	54.8	71.1	81.3	
Sum of all unconstrained eigenvalues						6.221
Sum of all canonical eigenvalues						.846

Table VI.36 - Sado estuary. Ordination summary for the canonical correspondence analysis, after the forward selection of the (six) environmental variables which best explain the ash-free dry weight biomass data.

Axes	**1**	**2**	**3**	**4**
Fines	-.6147	.6197	.2257	.3976
Gravel	.7287	.1798	.5496	-.2493
Water flow	.6531	-.2918	-.1436	.6531
Velocity	.2632	-.7044	.1292	.3512
Depth	.7701	.1580	.2451	.3338
Temperature	-.3427	-.5888	.4793	.1668

Table VI.37 - Correlations between the environmental variables and the CCA ordinations axes.

Axes		1	2	3	4	**Total inertia**
Eigenvalues	:	.435	.350	.318	.269	7.067
Species-environment correlations	:	.649	.621	.312	.308	
Cumulative percentage variance						
of species data	:	6.6	11.4	15.4	18.8	
of species-environment relation	:	26.7	40.2	44.3	51.3	
Sum of all unconstrained eigenvalues						7.067
Sum of all canonical eigenvalues						.846

Table VI.38 - Sado estuary. Ordination summary for the correspondence analysis, introducing as passive variables the six environmental variables which best explain the ash-free dry weight biomass data in the CCA.

Axes	**1**	**2**	**3**	**4**
Fines	-.7560	.1953	.5311	.8520
Gravel	.5558	-.7464	.2383	-.1725
Water flow	.7653	-.3196	-.3959	.1394
Velocity	.4579	.1758	-.7991	-.1373
Depth	.6649	-.6914	-.2106	.0100
Temperature	-.2277	.6277	-.0860	-.3139

Table VI.39 - Correlations between the environmental variables and the CA ordinations axes, obtained *a posteriori*.

6.5 - COMMUNITY DISTURBANCE

The global structure of the major benthic affinity groups established by Twinspan, was also analysed using the diversity rarefaction method (Sanders, 1968), the K-dominance curves method (Lambshead *et al.*, 1983) and the ABC curves method (Warwick, 1986). In addition changes in their species richness, abundance and biomass were analysed and compared with those suggested by the SAB model (Pearson & Rosenberg, 1978).

The abundance data and the wet-weight biomass data of the several sites in each of the groups was combined in a single sample, thus modifying the spatial scale of the analysis. Since this scale modification is based on a grouping method, it permits a more general assessment of the structure of each of the major benthic biotopes in the estuary, eliminating the variability between sites within a group.

6.5.1 - SAB model

Total species richness and the mean species richness per site, present their highest values in the transition region. Mean abundance per sampling location is also maximal in the transition region, excepting the highly disturbed spots of the estuarine community. Mean wet-weight biomass per site has its highest values both in the transition region and the enrichment areas of the estuarine community. Total species diversity and eveness present values above 5.0 and 0.7 respectively, only in the type marine community and the transition region.

Along the axis defined by type marine community (mouth of the estuary) -> transition region -> type estuarine community (southern channel and upper part of the estuary) -> enrichment areas (northern channel) -> impoverishment areas (industrial northern margin) -> high disturbance areas (sewage and pulp mill outfalls), and -> defaunated sampling sites, the mean fines and total organic matter content increase continually, while sand and flow decrease. Shear stress and velocity tend to show higher values in the type estuarine community than in the transition region, but thereafter decrease continually (*cf.* table VI.26, page 245).

Figure 6.14 presents the sucessive changes, within the estuarine community, of the mean species richness (S), abundance (A) and wet-weight biomass (B) per sampling location, along the gradients of decreasing organic content and increasing hydrodynamic energy.

Species richness increases continually from the defaunated stations until the enrichment areas of the northern channel core, where the maximum value is attained and decreasing thereafter in the type community. Abundance and biomass follow both the same pattern, with two maxima. However, while abundance clearly has its highest values in the disturbed locations close to the sewage and pulp mill outfalls, biomass shows the highest values in the enrichment areas of the northern channel, at lower levels of organic enrichment.

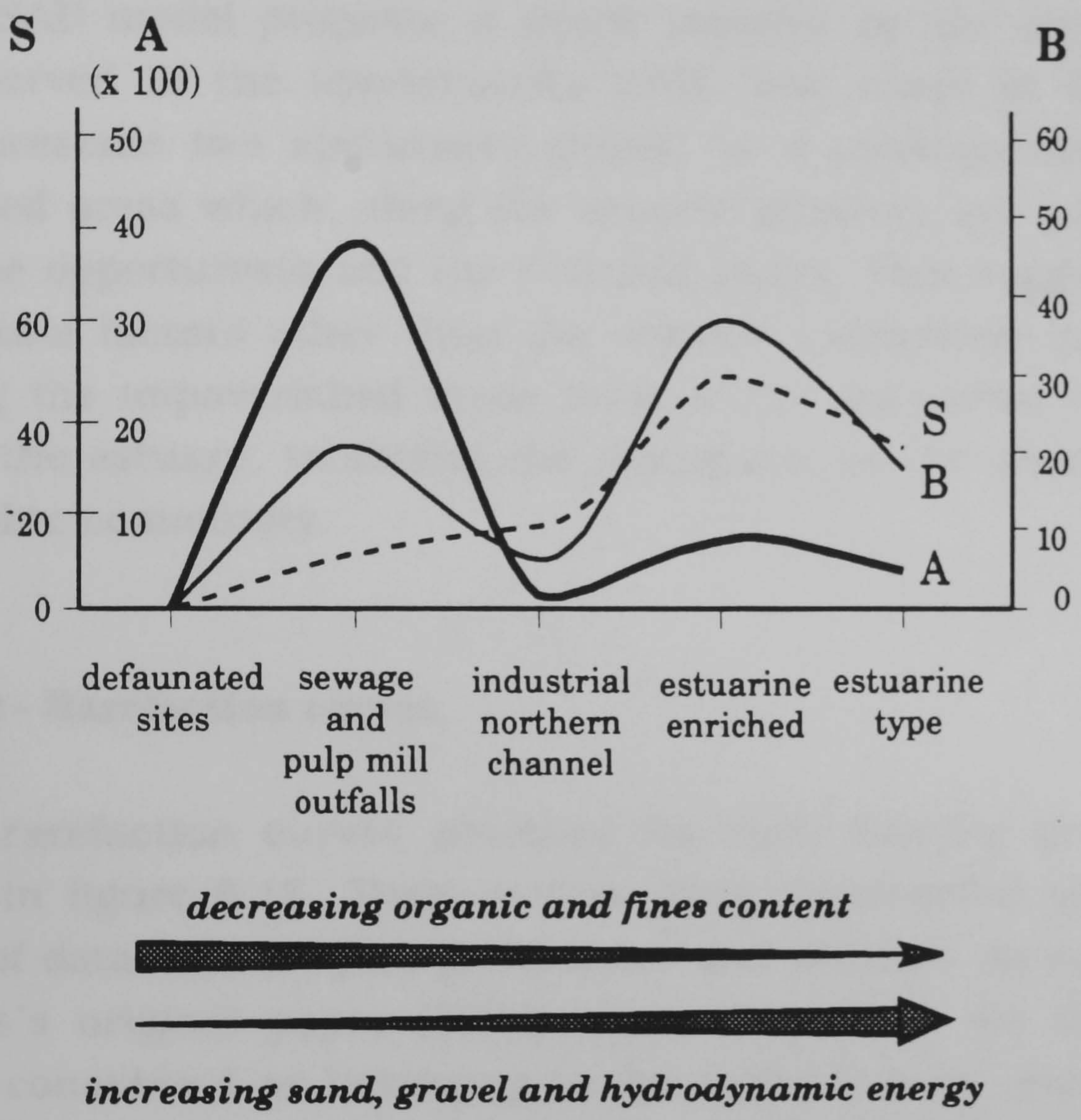


Figure 6.14 - Sado estuary. Spatial evolution of mean species richness (S - sp./0.1m^2), abundance (A - ind./0.1m^2) and wet-weight biomass (B - g/0.1m^2) per location, following the gradients of decreasing organic content and increasing hydrodynamic energy, within the estuarine benthic community.

This spatial gradient, as a whole aspect of the estuarine community, clearly resembles the evolution of the primary biological variables proposed in the SAB model of benthic changes following sedimentary enrichment (Pearson & Rosenberg, 1978). The defaunated stations, the highly disturbed locations, the enrichment areas and the type estuarine community would correspond respectively to the "grossly polluted areas", the "opportunists peak", the "ecotone" and the "normal" areas defined in the model. In terms of the disturbance sucession in the Sado induced by anthropogenic inputs, "normal" areas were those less affected and are considered our reference areas (southern channel).

The SAB model proposes a single maxima for the abundance curve, observed in the opportunists peak. The curve in fig. 6.14 however, presents two abundance peaks, as a consequence of the impoverished areas which, along the organic gradient, are positioned between the opportunists and the enriched zones. This suggests that anthropogenic factors other than the organic enrichment might be influencing the impoverished areas close to the industrial northern margin of the estuary, inhibiting the settlement or the development of the benthic community.

6.5.2 - Rarefaction curves

The rarefaction curves obtained for each benthic group are presented in figure 6.15. These curves were constructed using the entire set of data and not just polychaetes and bivalves, as suggested in Sanders's original paper (1968). Also, the whole set of curves cannot be considered as belonging to the same habitat, since some curves include groups of locations with a high sand content while others have high silt and clay contents. However, the two curves from the marine community assemblage may be regarded as a within-habitat comparison, the same being true for the set of curves generated for the estuarine community.

The transition region, or ecotone, located between the seaward marine community and the landward estuarine community, shows the rarefaction curve with the steepest slope, and also the highest species diversity (*cf.* Table VI.26, page 245). The highly disturbed estuarine areas show the lowest species diversity and the flatest rarefaction curve.

The rarefaction curves with the steepest slope belong to the type benthic biotopes identified in the Sado estuary, namely, the ecotone, the type marine community and the type estuarine community. Their relative position indicates a decreasing diversity in this same sense, which agrees not only with the global Shannon-Wiener diversity values obtained for each of these assemblages (*cf.* table VI.26, page 245), but also with the type spatial distribution and structure of benthic communities encountered in estuarine and lagoon coastal systems in the Portuguese coast (*cf.* Quintino & Rodrigues, 1989).

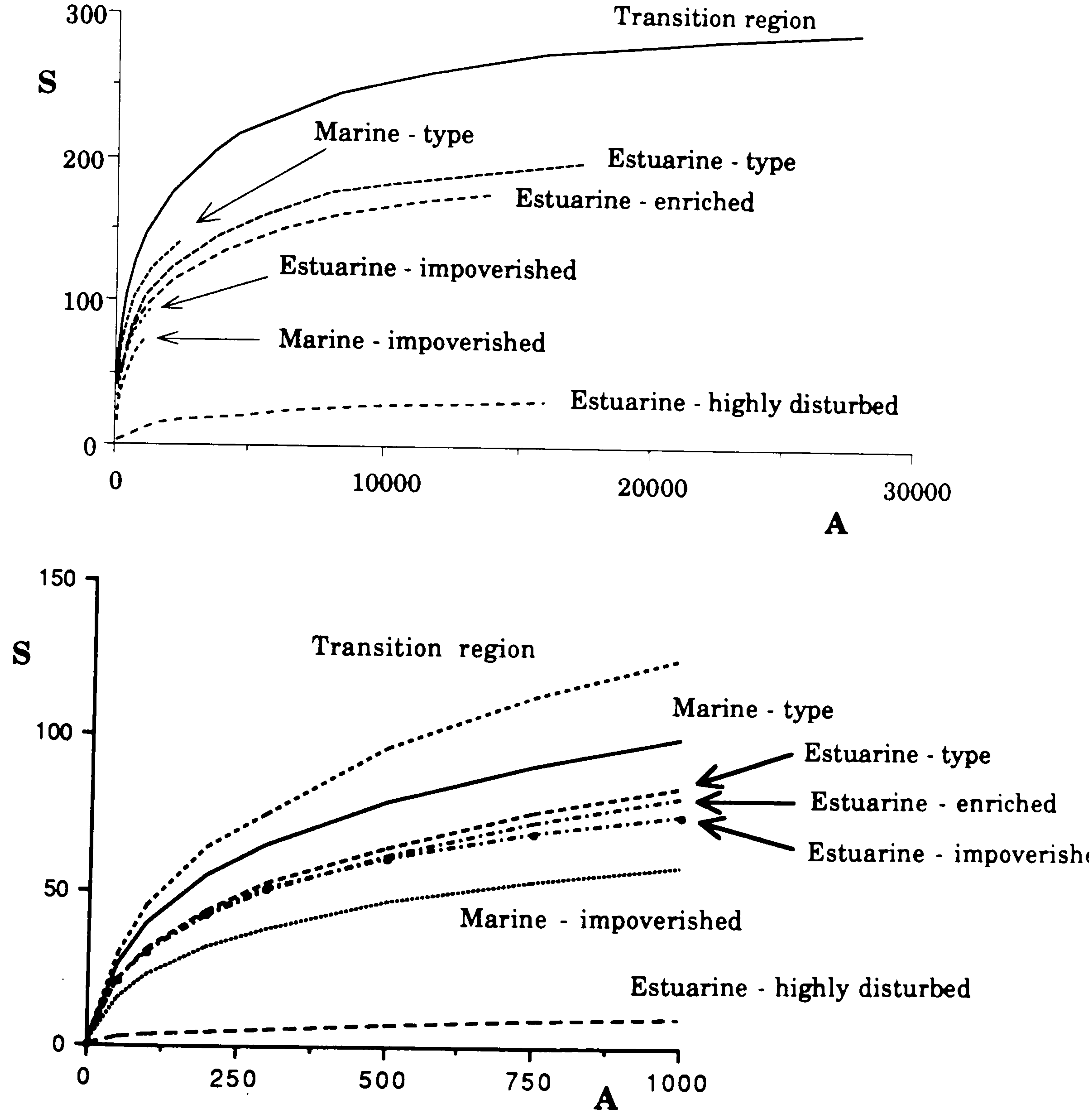


Figure 6.15 - Rarefaction diversity curves for the several benthic assemblages in the Sado estuary. The lower graph presents a detailed aspect of the initial part of the curves. S - species richness, A - Abundances.

The detailed divisions within both the marine and the estuarine communities also show very coherent results in terms of the rarefaction method of diversity analysis.

The rarefaction curve for the impoverished marine community is flatter than the curve for the type community, which agrees with its lower species diversity and stronger hierarchical structure, as described in the classification analysis section (section 6.3). Corresponding to a within-habitat comparison, the two curves from the marine community indicate the stronger disturbance in the impoverished areas, represented by several scattered locations inside the estuary.

Between the two curves from the marine community, appear the majority of the rarefaction curves belonging to the estuarine community, namely the type community, the enriched areas and the impoverished areas. Finally, the highly disturbed areas of the estuarine community correspond to the flattest rarefaction curve.

The within-habitat comparison of the four rarefaction curves belonging to the estuarine community suggests a decreasing diversity and increasing disturbance state of the benthic assemblage in the order type community -> enriched areas -> impoverished areas -> highly disturbed areas. These results agree with the increasing disturbance within the estuarine community as previously suggested by the spatial change in species richness, abundance and biomass, along an increasing gradient of organic enrichment and decreasing hydrodynamic energy level, following the concepts of the SAB model represented above in fig. 6.14.

However, it should be noticed that the global Shannon-Wiener diversity values for each of the benthic assemblages within the estuarine community, do not decrease along this same gradient. In fact, both the enriched and the impoverished areas show higher global diversity values and higher eveness values than the estuarine type community (*cf.* Table VI.26). It is possible that the organic enrichment in the northern channel of the estuary may be enhancing the initial phases of the response of benthic communities, resulting in an increase in diversity, as suggested by several authors (*cf.* Rees *et al.*, 1990).

This also indicates that care should be taken before assuming that higher species diversity results from higher levels of biological complexity, which may not be the case if the increased structural properties of the community (= species diversity) are not accompanied by increasing functioning complexity. This also suggests that these two synthethic descriptors of the structure of benthic communities should preferably be accompanied by analytical methods of diversity analysis, i. e. the rarefaction method or others, which may be more informative on the general structure of the community than are the values of the index itself.

6.5.3 - K- dominance curves

A similar approach based on the K-dominance curves method (Lambshead *et al.*, 1983), presents comparable results. Figure 6.16 shows the curves obtained for the type marine community, the transition region and the type estuarine community.

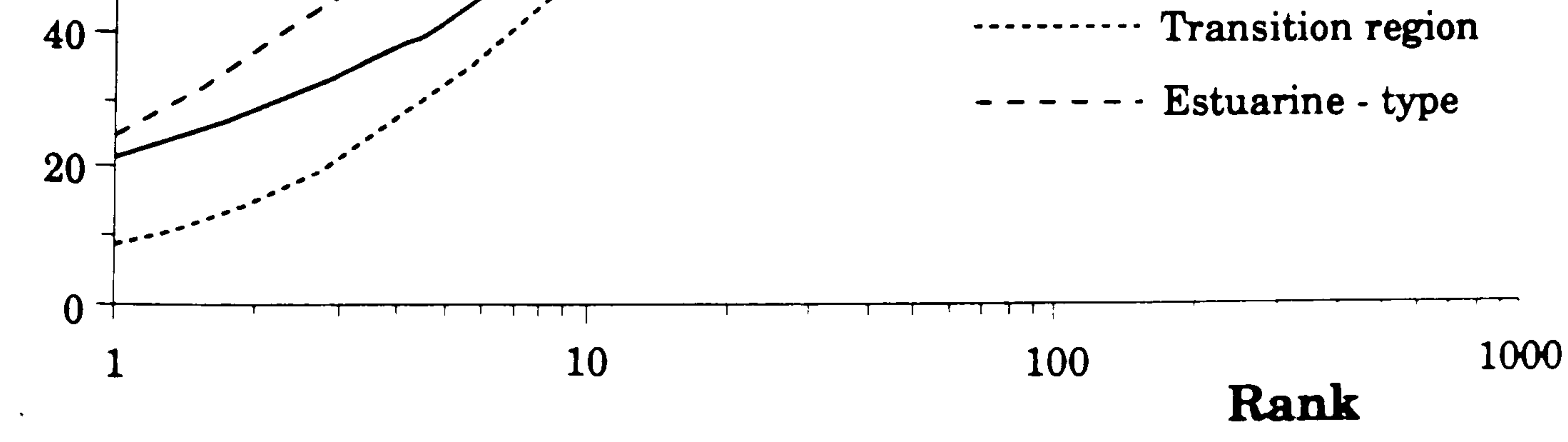


Figure 6.16 - Sado estuary. K-dominance curves for the type marine community, the transition region and the type estuarine community.

The starting points of the three curves are all below the 25% of the abundance frequency of the first rank species, and again, the type marine community curve lies between the transition region curve and the type estuarine community curve, suggesting the same conclusions as drawn from the rarefaction method above.

The full set of K-dominance curves is presented in figure 6.17. While the curves from the impoverished marine community and the estuarine highly disturbed areas suggest disturbance states of the benthic community, with the first rank species comprising more than 50% of the total abundance in each case (more than 95% for the highly disturbed areas of the estuarine community), the remaining curves, namely the enriched and the impoverished areas of the estuarine community, do not show a clear partition as in the previous analysis.

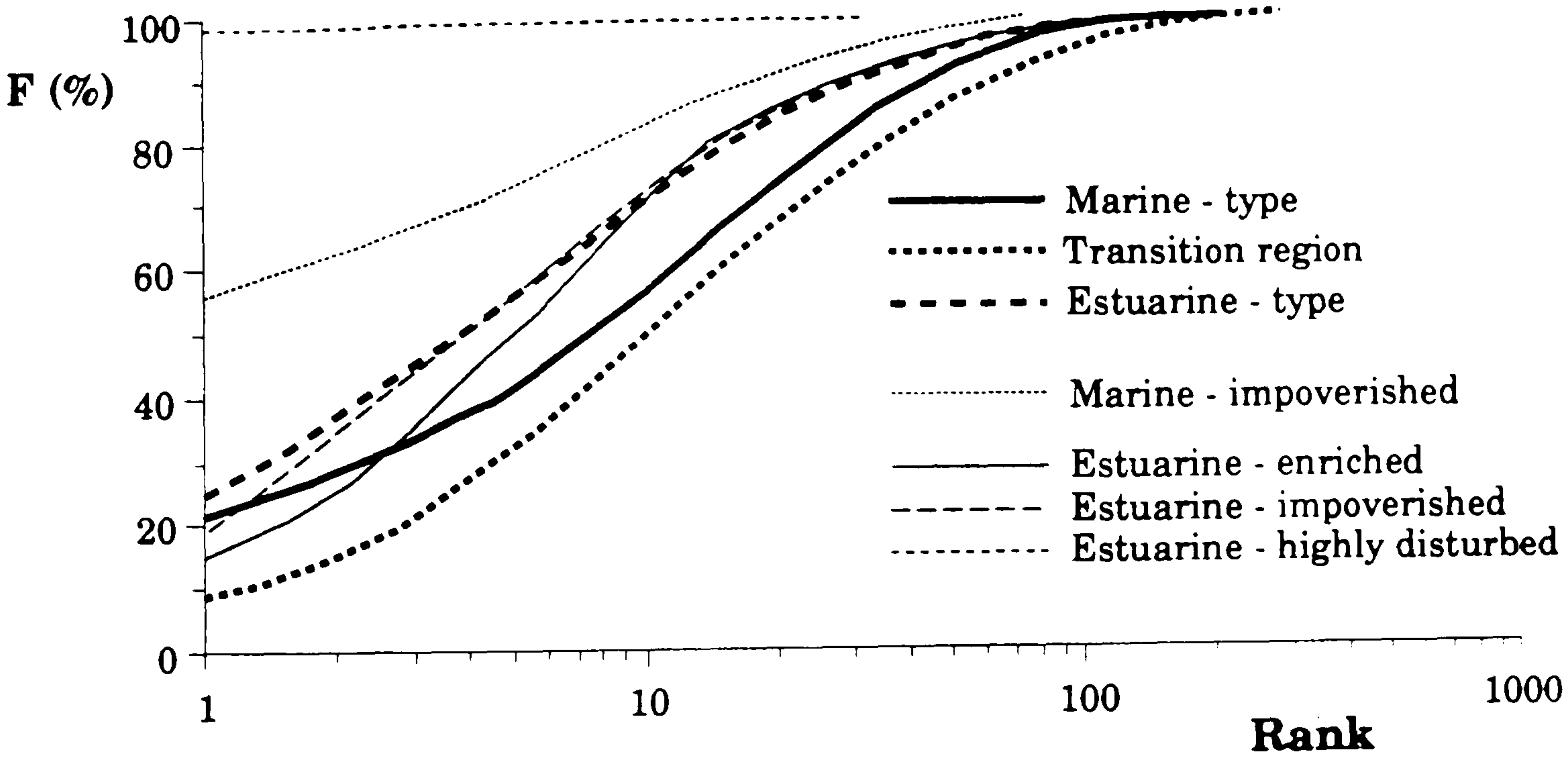


Figure 6.17 - K-dominance curves for the main benthic biotopes in the Sado estuary.

However, the majority of the curves lay above the type marine community curve and the transition region curve. Within the estuarine community, the three main regions have very similar curves, with the enrichment facies showing the most inner curve. Thus in assessing detailed aspects of the estuarine community, and apart from the almost monospecific type curve of the highly disturbed areas, the K-dominance method does not lead to as clear a discrimination as the rarefaction method of diversity analysis.

6.5.4 - Abundance and Biomass Comparison curves

Finally, the ABC curves method (Warwick, 1986), was also used to characterize the main benthic biotopes in the Sado estuary. Figures 6.18, 6.19 and 6.20 present the results obtained for, respectively, the type marine community, the transition region and the type estuarine community.

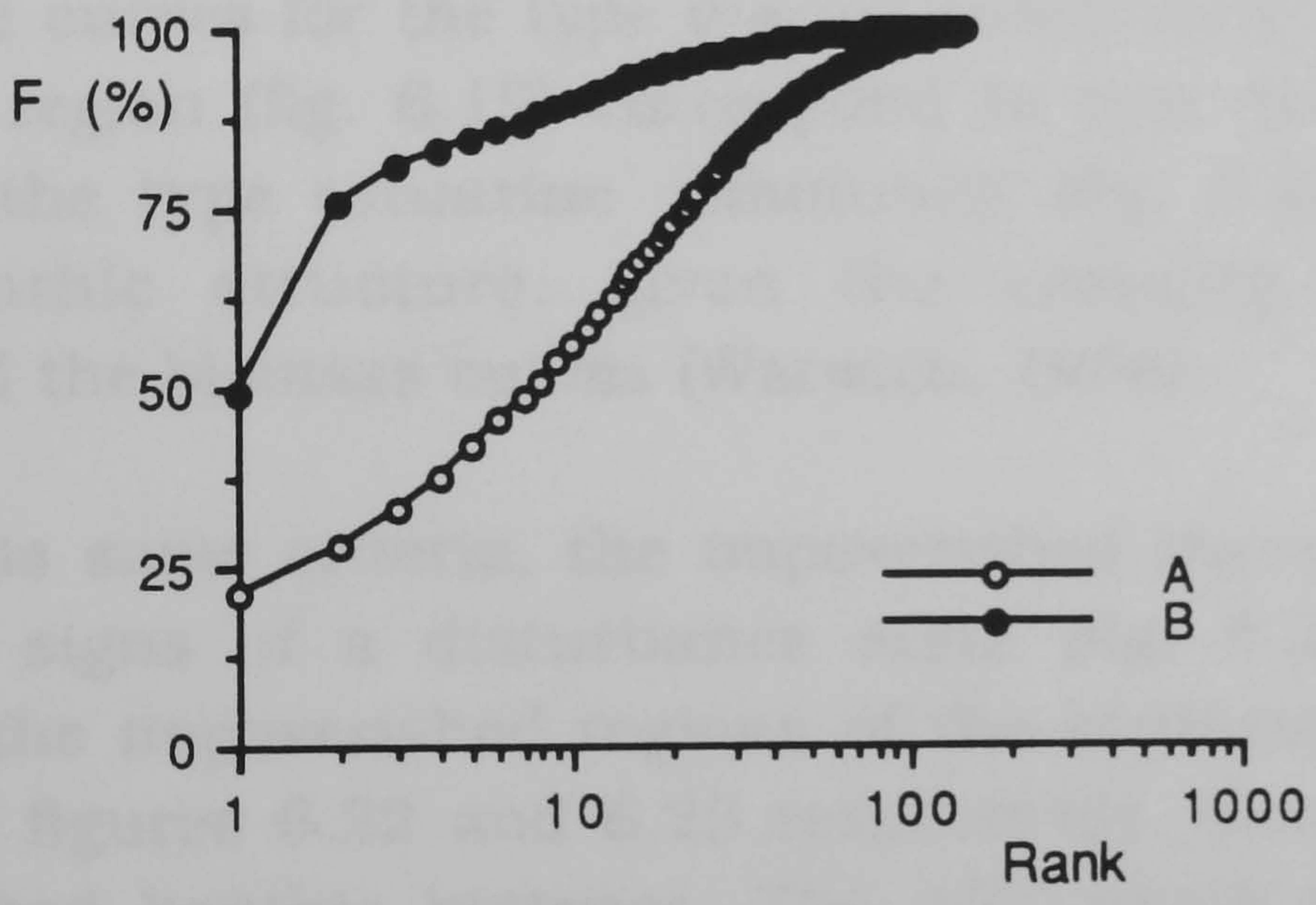


Figure 6.18 - Abundance/Biomass Comparison curves for the type marine community.

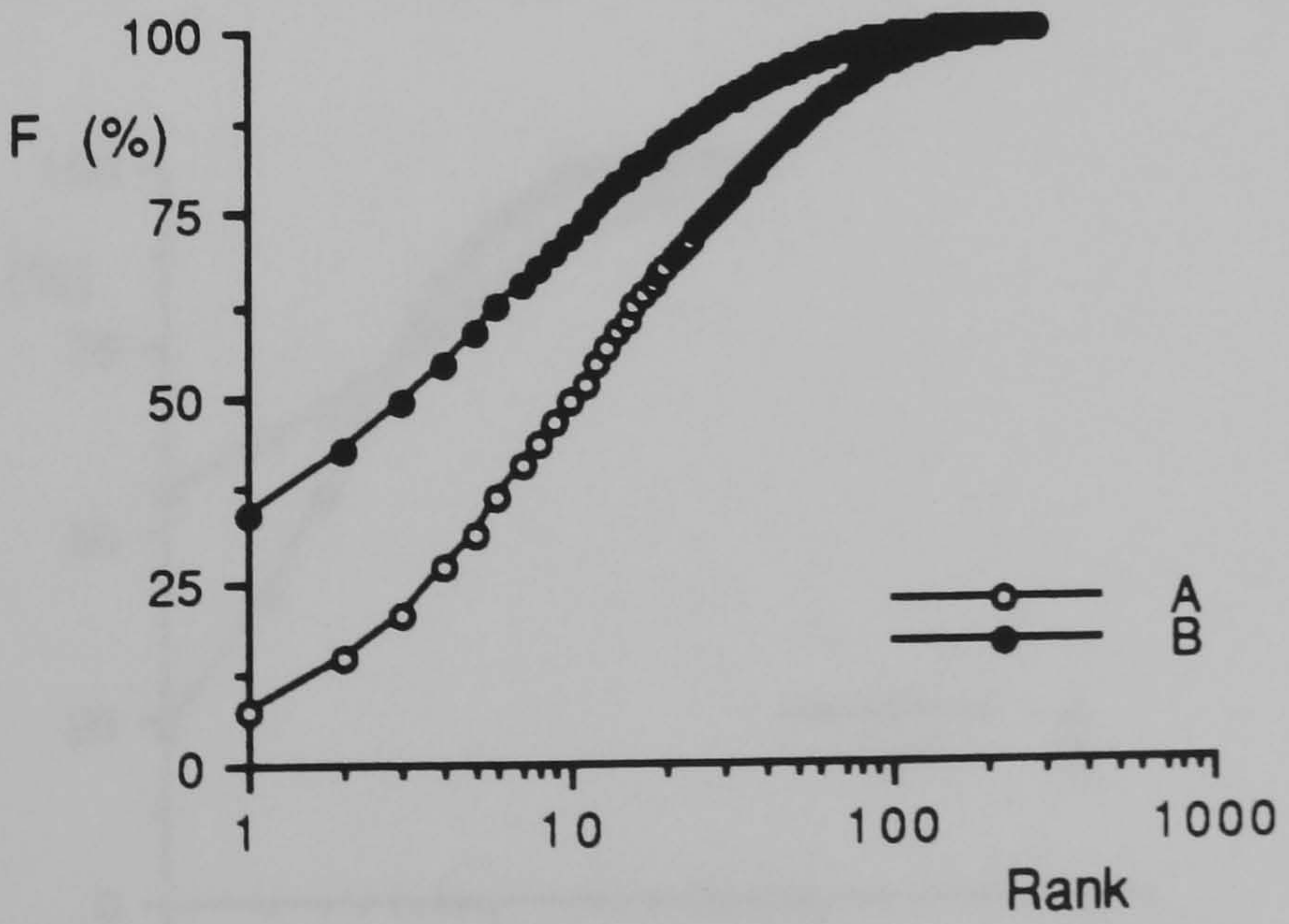


Figure 6.19 - Abundance /Biomass Comparison curves for the transition region.

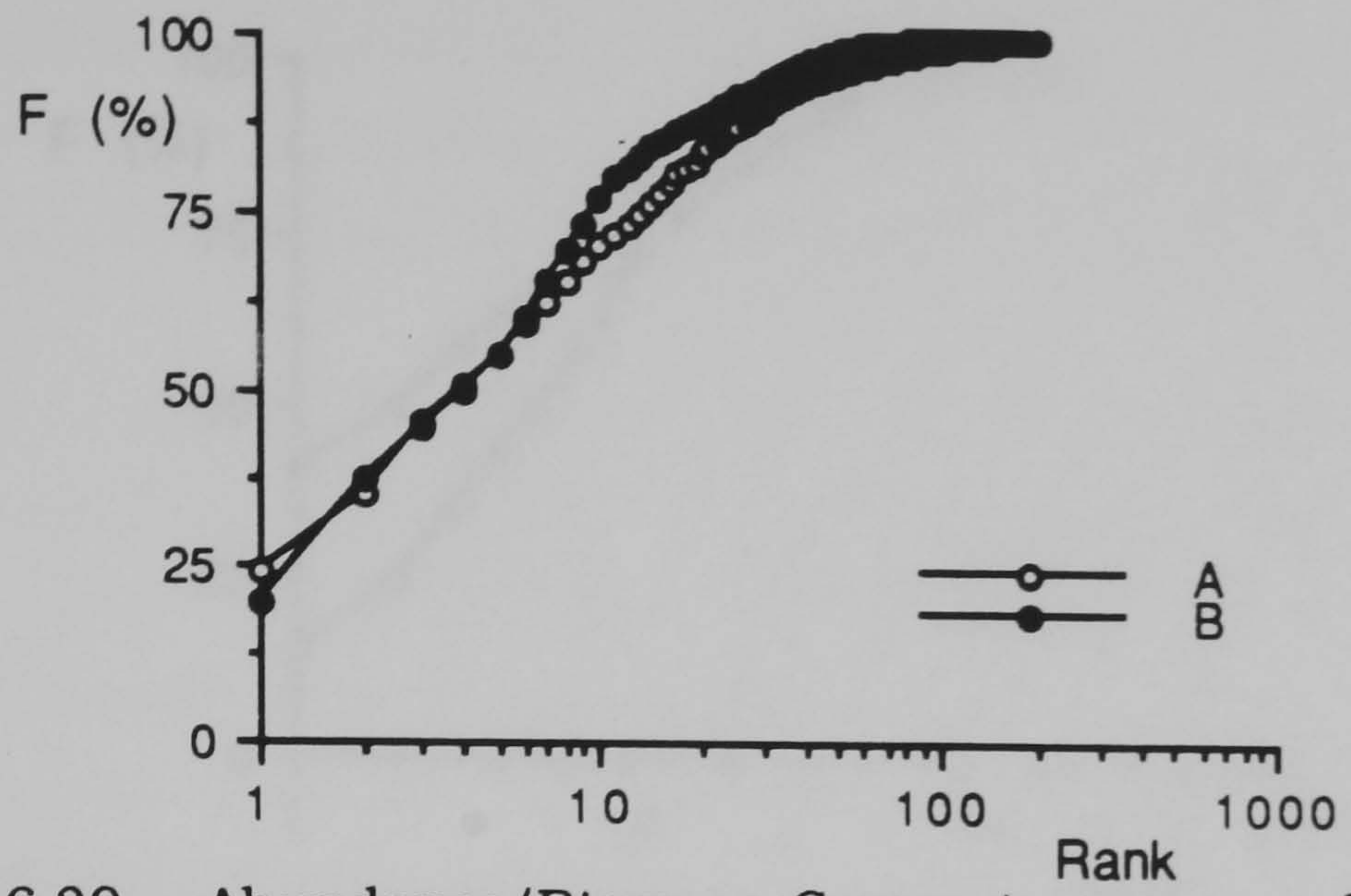


Figure 6.20 - Abundance/Biomass Comparison curves for the type estuarine community.

While the curves for the type marine community (fig. 6.18) and the transition region (fig. 6.19) correspond to non disturbed areas, the curve for the type estuarine community (fig. 6.20) indicates a disturbed benthic structure, given the crossing between the abundance and the biomass curves (Warwick, 1986).

Using this same criteria, the impoverished marine community presents also signs of a disturbance state (fig. 6.21), while the enriched and the impoverished regions of the estuarine community, represented in figures 6.22 and 6.23 respectively, would correspond to non disturbed benthic biotopes. The ABC curve for the highly disturbed areas in the estuarine community (fig. 6.24), corresponds to a strongly disturbed structure according to Warwick's concepts, with the abundance curve clearly overlaying the biomass curve.

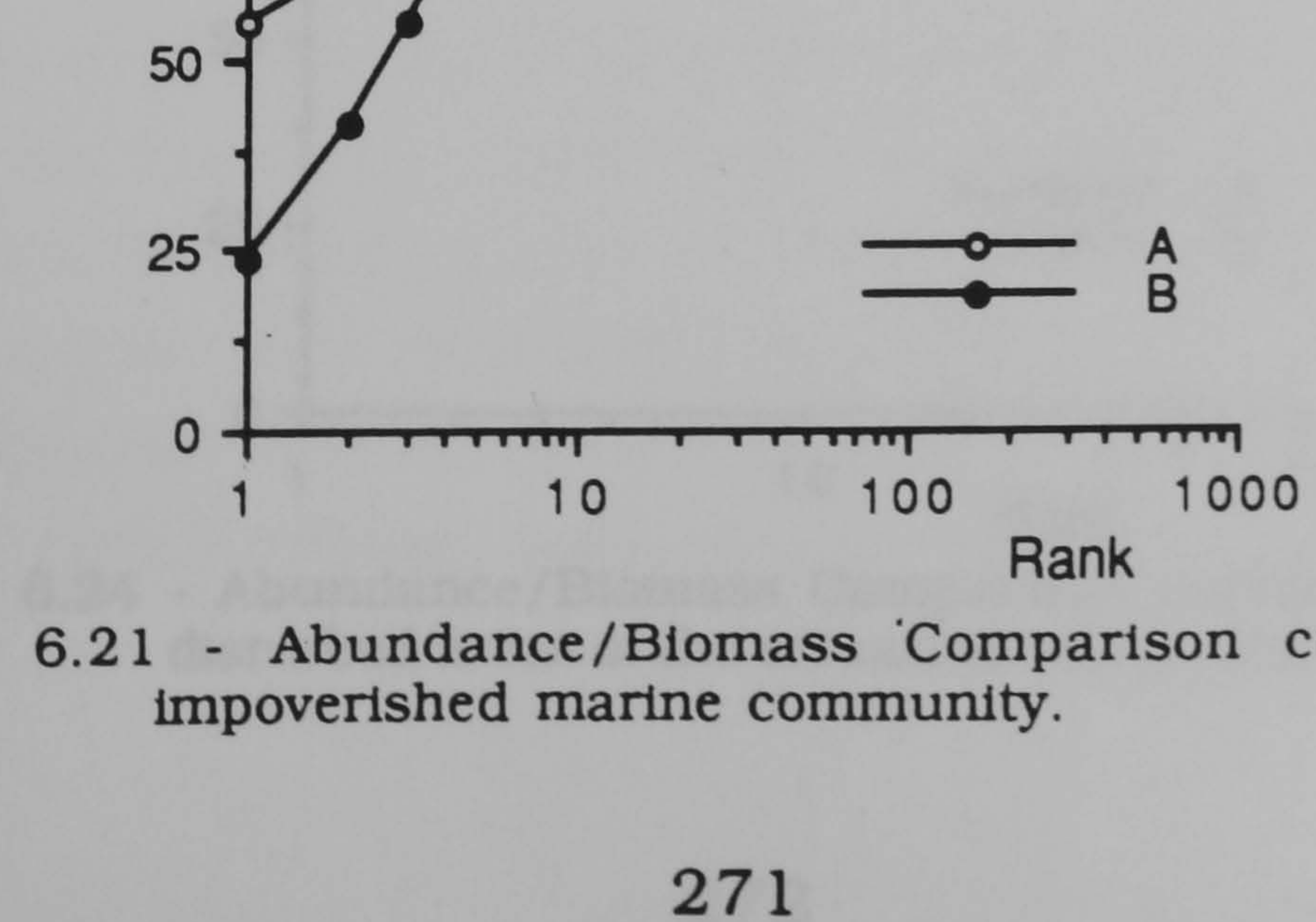


Figure 6.21 - Abundance/Biomass Comparison curves for the impoverished marine community.

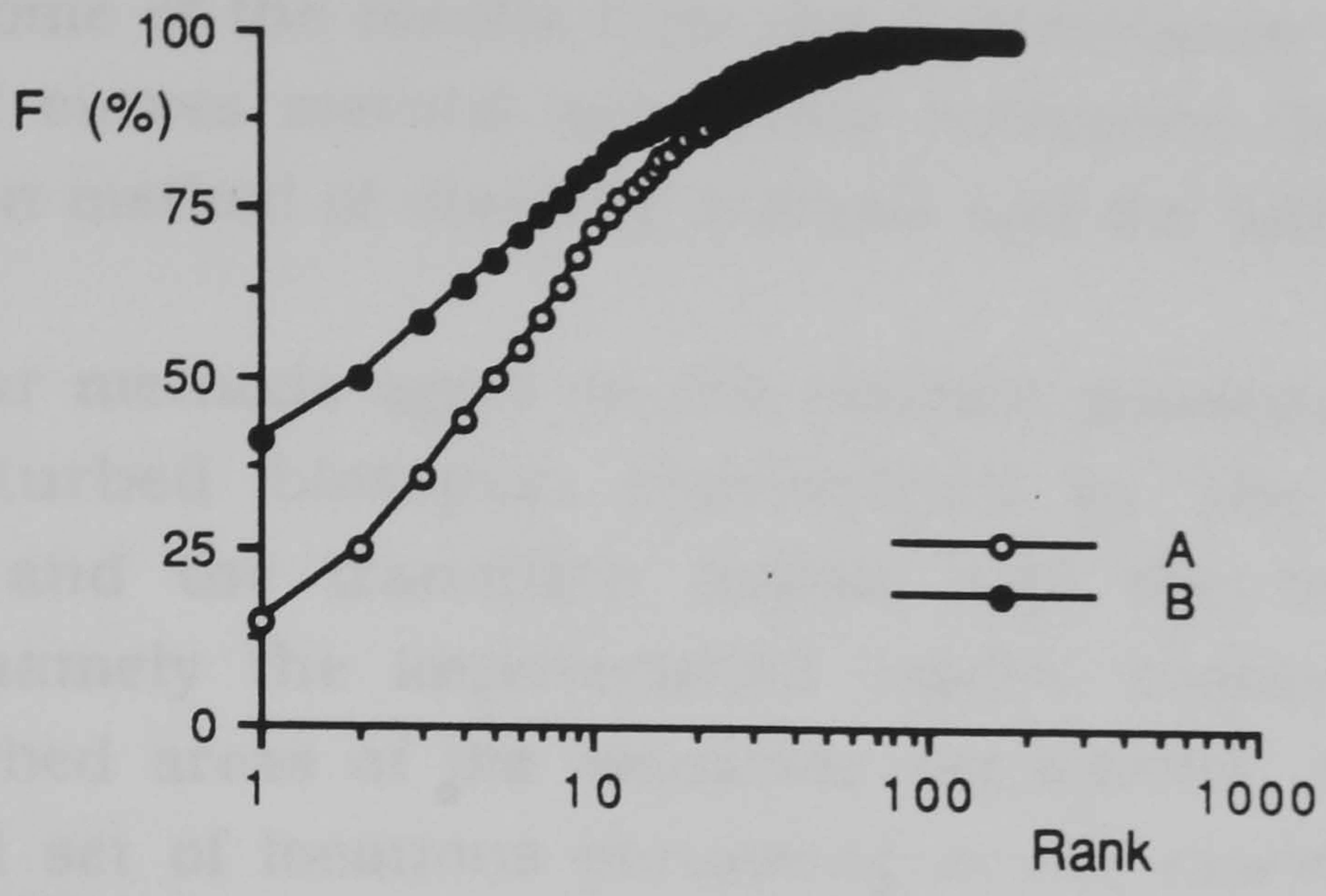


Figure 6.22 - Abundance/Biomass Comparison curves for the enriched areas of the estuarine community.

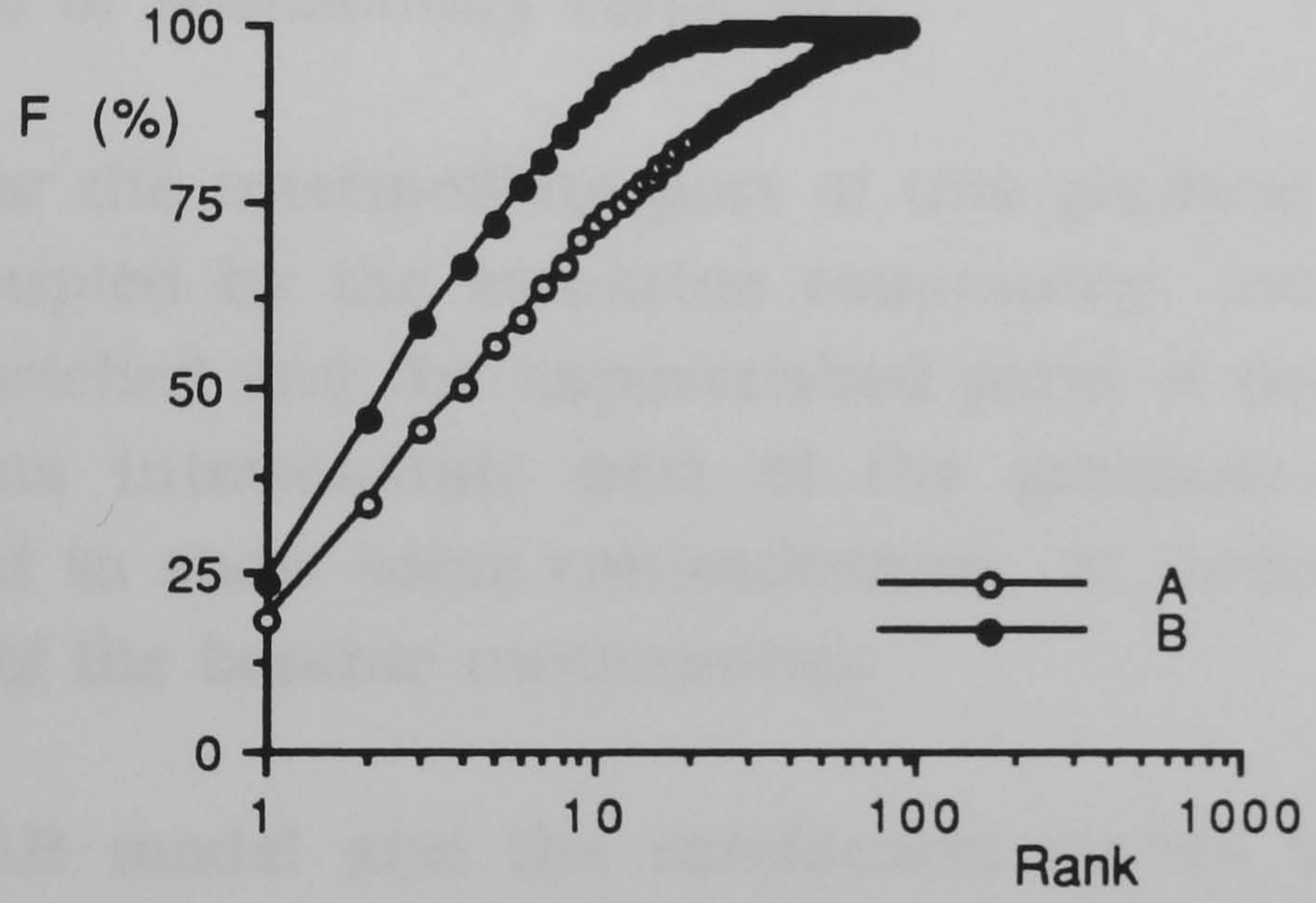


Figure 6.23 - Abundance/Biomass Comparison curves for the impoverished areas of the estuarine community.

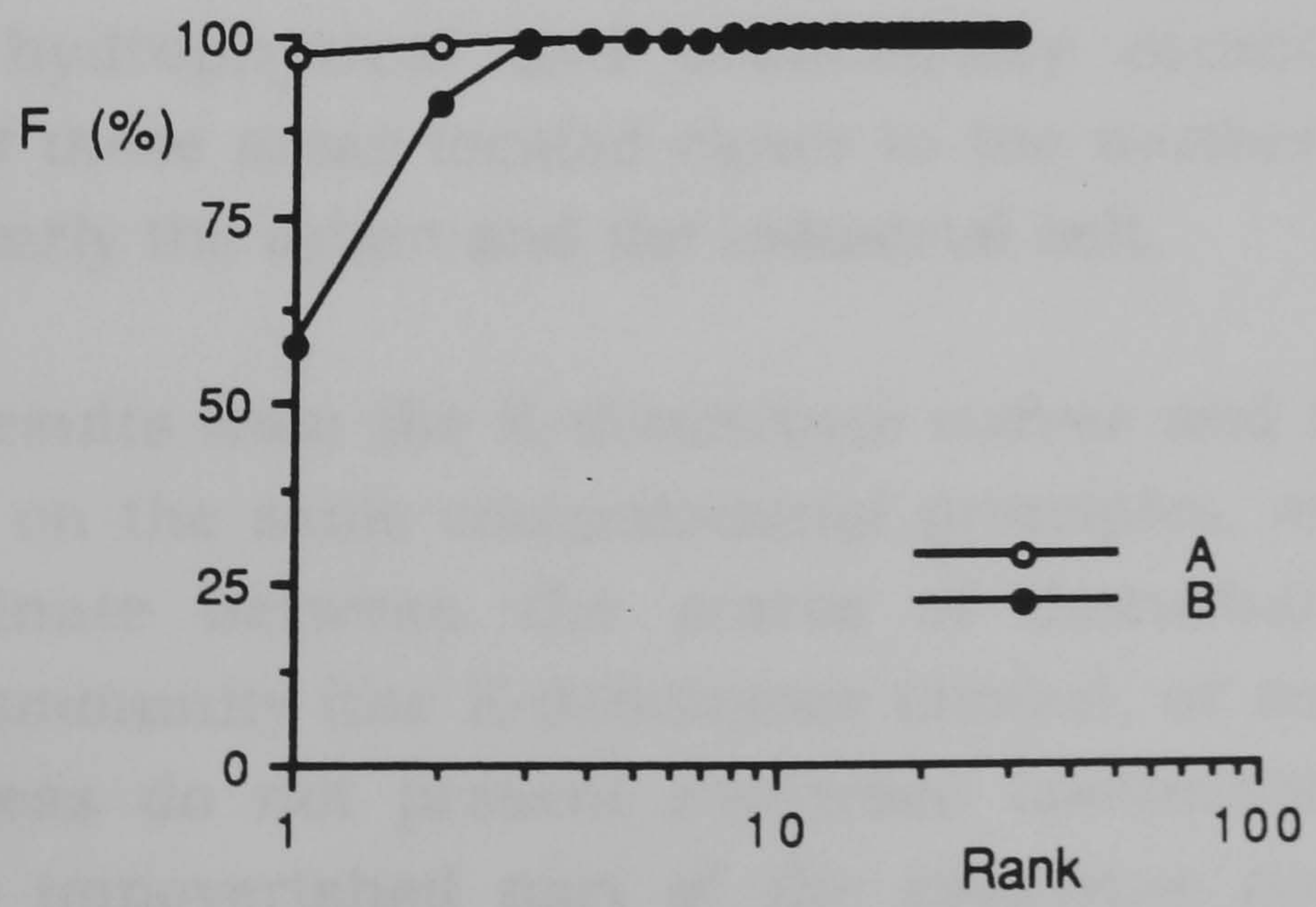


Figure 6.24 - Abundance/Biomass Comparison curves for the highly disturbed areas of the estuarine community.

Thus some of the results from the K-dominance curves method and the ABC curves method apparently contradict the results from the rarefaction method of diversity analysis and the SAB model.

The four methods agree on the extreme situations, namely the most undisturbed biotopes, represented by the type marine assemblage and the transition region, and the most disturbed situations, namely the impoverished marine community and the highly disturbed areas of the estuarine community. Apart from the impoverished set of locations pertaining to the marine community, these extreme situations correspond in fact to the two poles in the global estuarine gradient identified in this analysis of the outer part of the Sado estuary, whether analysed in respect to the prevailing hydrophysical or sedimentary conditions.

However the intermediate part of this gradient corresponds to the area occupied by the estuarine community, namely the typical areas, the enriched and the impoverished parts of this community. It is within this intermediate part of the gradient that the three methods tend to show some contradictions, in terms of the state of disturbance of the benthic communities.

The SAB model and the rarefaction curves both agree, and together with the classification and ordinations analysis results, suggest that the primary biological variables of the benthic communities in the Sado estuary are in agreement with the prevailing hydrophysical and sedimentary conditions, with the exception of those areas located closer to the northern margin of the estuary, namely the urban and the industrial belt.

The results from the K-dominance curves and the ABC curves, both based on the same computational principles, are either unable to discriminate between the states of disturbance within the estuarine community (the K-dominance curves), or suggest that some of these areas do not present disturbed community assemblages, namely the impoverished part of the estuarine community, while suggesting a disturbed state for the type estuarine community (the ABC curves).

This apparent contradiction (within a detailed aspect of the whole gradient analysed in this work) may result either from the fact that,

1) the K-dominance curves and the ABC curves were mainly derived for marine regions, while estuaries may present benthic communities with naturally more disturbed structures, as presented by the original Sanders work (1968), and by the detailed spatial analysis of several coastal portuguese systems (Quintino, 1988; Quintino & Rodrigues, 1989), and other similar coastal lagoon regions (Amanieu *et al.*, 1980, Blandin, 1980, Labourg, 1980), or,

2) the non disturbed state judged by the ABC method of the enriched and the impoverished facies of the estuarine community, may in fact be the consequence of the preferential distribution of larger species (namely the bivalve *Cardium paucicostatum*, an important species in this part of the estuary), as a result of the initial stages of organic enrichment.

CHAPTER 7

DISCUSSION

General

The bio-sedimentary survey undertaken in the Sado estuary showed that both the structure and composition of superficial sediments and also the benthic macrofauna clearly reflect the hydrophysical conditions prevailing in the estuary and organic enrichment of both natural and anthropogenic origin.

The granulometric study revealed gradients of increasingly fine sediments from the estuarine entrance towards the inner areas along both the southern and the northern channels. However, while the gradient established along the southern channel shows clear influence of both oceanic and river inputs, thus emphasizing a natural and common gradient found in many estuaries (e. g. Guelorget & Michel, 1977, Andrade, 1986, Elliott & Kingston, 1987, Perthuisot & Guelorget, 1987, Quintino, 1988, Mclusky, 1989, Quintino & Rodrigues, 1989, Currás & Mora, 1991), the gradient defined along the northern channel reflects both the natural accumulation characteristics of this region and the effect of the industrial effluents in enhancing the muddier sediments.

The organic content showed a good agreement with the fines content of the sediments. Along the northern margin, however, high organic content was found in both muds and sandier sediments (e.g. st.26, st.39). Low organic content was found in the estuarine entrance and in the majority of the southern channel and upper region (<1% and 1% - 3%). These areas are not directly affected by anthropogenic inputs and have levels of organic content comparable with Ria del Eo (NW Spain), where the highest values were found only in *Zostera* regions (7.4%) (Currás & Mora, 1991). The highest organic content values in the Sado estuary were found along the northern margin in the range of 10 - 14% (total sediment). Similar values have been found in the sediments of the Spanish rias Arosa (12 - 14%) and Muros (14 - 16%) (López-Jamar, 1982, López-Jamar &

Mejuto, 1986), where sediments are enriched mainly by the faeces of mussels, intensively cultivated in these systems, and also in Ria de Pontevedra (21%) subject to the influence of pulp mill effluent and urban sewage (López-Jamar, *op. cit*). Also, Hily (1984) mentioned values of 12 - 16% for the sediment of Rade de Brest, affected by urban sewage effluents, while Bachelet (1976, *in*: Hily) gave values for unpolluted muds in the range of 0.5 - 5% of total sediment.

Dissolved oxygen and nutrient levels in the water column have shown an effect of anthropogenic inputs along the northern channel and near the urban sewage outfall. It seems that this effect can be also detected along the southern channel at times (Chapter 3).

The fauna sampled in the survey clearly suggests that marine conditions prevail in the Sado outer estuary, with few species present which are associated with freshwater conditions (e. g. oligochaets, insect larvae). Thus the salinity gradient shows a mean annual salinity of about 33‰ in the most landward locations covered by the present study. The fauna is composed mainly of Annelids, Arthropods and Molluscs, which together comprised 93% of the total number of species and biomass and 98% of abundance. Annelids were the most abundant and species rich group, while Molluscs have been shown to be dominant in all the stations in terms of biomass, with the exception of the stations in the vicinity of the industrial complex where biomass was dominated by Annelids.

The Sado is inhabited by an abundant and diversified fauna with 362 species and 80218 individuals sampled comprising a total biomass of 2852.35 g wet-weight. The fauna is comparable to that of similar systems namely the Mira estuary (Andrade, 1986) and the lagoons of Óbidos and Albufeira (Quintino, 1988), western coast of Portugal, the Ria de Alvor (Rodrigues & Quintino, 1986), southern coast of Portugal, the Ria de Arosa (Mora, 1982) and Pontevedra (Mora *et al*, 1982), Spanish western coast, the Firth of Forth (Elliott & Kingston, 1987), eastern coast of Scotland. Some of the species found were previously known from the Sado, but 192 are reported from this estuary for the first time (Rodrigues, 1982, Gamito 1983, Cancela da Fonseca *et al*, 1987, Costa, 1988, Marques, 1989).

The fauna is characteristic of European ecosystems but also reflects the proximity of the Mediterranean sea, whose influence becomes more pronounced along the southern Portuguese coast (Alvor). In fact, 32 species found are among the most characteristic species of confined Mediterranean systems (e.g. *A. cirrosa, C. paucicostatum, B. candida, C. carinata, C. truncata, D. exoleta. E. oerstedi, G. fragilis, L. lacteus, M. versiculatus, S. plana, P. ciliata*) (Guelorget & Perthuisot, 1983).

A consideration of the amphipod fauna identified in the Sado estuary compared to those of the British Isles, the Roscoff region, the Portuguese coast (in general) and the Mediterranean (Marques, 1989) shows that several species were recorded in all the 4 regions (e.g. *A. diadema, A. brevicornis, A. spencebatei, A. guttatus, C. semisserratus, C. sundevalli, G. fucicola, L. pectinatus*), while others are considered solely Mediterranean species (*C. runcicorne, C. annulatum*). *Ericthonius puntactus* and *J. marmorata*, recorded in the present work, were known to the Roscoff fauna and Mediterranean (the former) or only to the B. Isles (the latter species) (Marques *op. cit.*). *Photis longipes* and *A. remora* have been recorded only along the Portuguese coast. The "*C. orientale - C. volutator* " complex, sampled for the first time in Ria de Alvor, southern Portuguese coast, seems to be an intermediate form between a meridional species (*C. orientale*) and a nordique species (*C. volutator*) (Rodrigues & Dauvin, 1987).

These comparisons emphasize that the Portuguese coast could constitutes a transition region between the Atlantic and the Mediterranean faunas, constituing for some species a limiting region for their zoogeographical distribution.

Two major faunal associations have been defined in the Sado estuary: a marine and an estuarine community separated by a transition region. The estuarine community however, has been shown to include several coherent areas identified as type, enriched, impoverished, highly disturbed and defaunated areas.

The Sado outer estuary has been shown to be a heterogeneous environment which makes a comparison of its faunal assemblages with the literature not a straightforward procedure. The Sado marine community, however showed some similarities with the communities identified in the lagoons of the western coast of Portugal and also with the biocenosis of the coarse sands and fine gravels under bottom currents (SGCF) defined by Pérès & Picard (1964) and by Pérès (1967) for the Mediterranean Sea. The Sado estuarine community showed some similarities with the faunal associations defined by these authors for muddy sands, and the biocoenosis of the superficial muddy sands in sheltered areas (SVMC). It also had some common features with the fàcies of *Melinna palmata* defined by Cabioch (1968) for the fine sands of the English channel, enriched however with species of the *Hyalinoecia bilineata* fácies also defined by this author in the same community.

The faunal associations identified in the Sado show characteristics which indicate that the main structuring factors are hydrodynamic, coupled with sediment type, and organic matter of natural and anthropogenic origin. These environmental factors have been shown to significantly influence the major patterns of macrofaunal distribution in the estuary. They act together throughout the estuary but their degree of importance differs in the various areas identified. Organic enrichment effects have been noted in all the areas studied and in general the Sado outer estuary has been shown to be an eutrophic system.

The most abundant and widely distributed species, present in all the regions defined, were the Cirratulids *Cirriformia* sp., *Tharyx* sp. and *Caulleriella* sp., the Capitellid *Capitella capitata*, the Spionid *Aonides oxycephala* and the Spiochaetopterid *Spiochaetopterus costarum*. These species are commonly associated with organically enriched areas and may even be present in anoxic conditions (Pearson & Rosenberg, 1978). They show, however, differential development in the various areas, thus pointing to different degrees of organic enrichment. The analysis of both biological and environmental factors of the different regions identified indicates increasing disturbance due mainly to organic enrichment along an axis marine community -> transition region -> estuarine community. type -> enriched -> impoverished -> disturbed -> defaunated areas.

Along this axis it was noticed that the number of Peracarid and Echinoderm species, after showing an increase in the transition region, decreased continously with Echinoderms disappearing in the impoverished and disturbed areas. These groups are in general considered very sensitive to environmental changes due either to natural causes (Quintino, 1988) or to pollution, being the first ones to disapear in highly organic enriched areas (Pearson, 1975, 1976, Rosenberg, 1976, Cabioch *et al.*, 1982, Gentil, 1982, Dauvin, 1984).

It also was noticed that the transition region contained 44 species present only once in the estuary, the larger proportion, whereas the marine community had 18, the estuarine type and the enriched, had 9 each and the estuarine impoverished and disturbed regions had 3 each. The systematic disappearance of rare species has been observed along gradients in which environmental conditions become more severe both by natural (Quintino, 1988) or anthropogenic causes (Gray *et al.*, 1990) and changes in their presence and absence patterns as indicators of pollution has been proposed by Gray *et al.* (*op. cit.*)

Marine Community

Type area

The marine community is established in a high energy area, mainly occupied by coarse clean sand. The fauna seems to be chiefly conditioned by hydrodynamism. It is mainly made up of interstitial polychaetes and archiannelids (e.g. *S. papillocercus, P. remota, P. elegans, S. bulbosa, P. appendiculatus*) and of mobile and quickly burrowing organisms (e. g. *N. cirrosa, G. galaica, U. grimaldi, B. guilliamsoniana*) having diversified trophic modes: filter feeders, surface and sub-surface deposit feeders, carnivores, herbivores or mixed strategies, filter/deposit feeders and herbivore/deposit feeders.

Most of the species which showed preferences for this region of the estuary are usually found in other ecosystems associated with coarse or medium clean sands. *G. spinifer* was found by Wolff (1973) in well-sorted medium and fine sands in the Delta area of the Netherlands, *B. guilliamsoniana, U. brevicornis* and *U. grimaldi* were commonly found along the Portuguese coast in sandy bottoms by Marques (1989), *S. solida* is mentioned by Tebble (1976) as prefering sandy bottoms and *G. capitata* seems to prefer coarse deposits (Vanosmael *et al.*, 1982). *Nepthys cirrosa* is known as a species prefering clean sands (Vanosmael *et al., op. cit.*, Wolff, 1971, 1973) and Alheit (1978, *in:* Vanosmael *et al., op. cit.*) mentioned that the oxygen supply correlated with salinity could be important factors in the distribution of this species. Peracarid, mainly amphipods are strongly represented in this region of the estuary, whereas cirratulid or capitellid species are scarce. The presence of *C. capitata* in this region (found only in station 1), is probably associated with local sources of organic enrichment.

Faunal associations with the same characteristics, as the ones found in the Sado marine community, are common in high energy environments, like sandbank areas (Vanosmael *et al., op. cit.*, Withers & Torp, 1978, Tyler & Shackley, 1980) or coastal waters stirred by waves (Pérès, 1967, Rodrigues & Quintino, 1988).

Impoverished area

In the impoverished marine area the hydrodynamical factors are less intense, with the fines and the total organic matter content of the sediment higher than in the type area. The fauna reflects the effect of organic enrichment. The most characteristic species are *Tellina tenuis* and *Scoloplos armiger*, the latter being, the most abundant species, representing 55% of the total abundance of this area.

Scoloplos armiger has been found in several bottom types but seems to prefer fine and muddy sands (Wolff, 1973, Rasmussen, 1973). It is a species known to be resistant to low oxygen content and even moderately resistant to anoxic conditions (Henriksson, 1969, Schoettler & Grieshaber, 1988). Pearson (1975) includes it in phase 2 corresponding to moderately organic enrichment. It was considered indicative of organic enrichment in a variety of areas (Pearson *et al.*, 1986) and was found by Henriksson (1969) with high densities near the sewage outlets of Copenhagen and Malmo in oxygen poor mud in the Baltic, and also in hard sand bottom in Danish waters (Muus, 1967). However Hily *et al.* (1986) include it in the group of pollution sensitive species.

Estuarine Community

The Sado estuarine community includes most of the northern and the southern channels and all the upper region. It has been shown to be an hetrogeneous community in which it was possible to recognise several subgroups: type, enriched, impoverished, disturbed and defaunated areas.

From the type to the defaunated areas the mean fines and total organic matter in the sediment increased continually, while sand and the hydrodynamical factors, flow, shear stress and current velocity decreased. The spatial variation of species richness, abundance and biomass have been shown, except for the abundance value of the disturbed areas, to be similar to the one proposed in the SAB model (Pearson & Rosenberg, 1978), thus indicating an increase in disturbance from the type areas towards the defaunated locations. The same general trend is shown by the analysis of the feeding modes of the species inhabiting the different regions. All the regions have species with various feeding strategies, which points to the availability of organic particles either in the water column and in the sediment. From the type areas towards the disturbed ones, however, the filter feeders decrease, disappearing in the disturbed regions, probably due to the concomitant increase of deposit feeders, a decrease in sediment stability, an increase in turbidity and changing quantities of organic matter (Pearson & Rosenberg, *op. cit.*).

From a consideration of the feeding modes of the most characteristic species it is evident that in the type areas they are mainly sub-surface deposit feeders and filter feeders, relying on the transport of particles in the water column and re-suspension from the sediment surface. In the enriched regions they are mainly surface deposit feeders reflecting the high amout of organics in the sediment surface due to high organic inputs or low hydrodynamism. In the impoverished regions they are mainly carnivores probably reflecting the availability of prey. In disturbed areas the most characteristic species were a sub-surface and a surface deposit feeder indicating in general a high content of organic material at the surface and inside the sediment.

This gradual change in the trophic strategies of the species observed in the Sado estuarine community could also correspond spatially, to what was found, in time, by Pearson *et al.* (1982) as a result of an increase of an organic input. These authors noticed that initially sub-surface deposit feeders appear to be favoured at the expense of surface deposit feeders and when the populations attain high densities carnivores increase. This gradual change in the trophic modes of species along an increasing gradient of stress imposed by organic enrichment was considered one of the major species adjustments to environmental changes induced by organic enrichment (Pearson & Rosenberg, 1978).

From the type areas towards the defaunated regions it seems that there exists a decreasing effect of hydrodynamic factors and an increasing effect due to organic enrichment in controlling the benthic macrofauna. According to the general circulation pattern in the estuary, in the type areas the organic material comes mainly from natural sources and in the other subgroups from anthropogenic inputs.

Type area

This region seems to be a moderately enriched area. It has species commonly found in organically enriched areas, like Cirratulids, Capitellids and Spionids, as well as species which are usually associated either with moderately enriched regions or even considered sensitive to organic pollution (Hoare & Wilson, 1977, Pearson & Rosenberg, 1978, Hily *et al.*, 1986).

Hydrodynamical factors are still important and some of the characteristic species of this region are resistant to high current speeds.

Lanice conchilega has been shown to be able to withstand current speeds higher than 1m/s (Buhr & Winter, 1977), by being able to rebuild its tube rapidly if necessary and if the tube is covered by sediment the species reacts by pulling itself across the sediment with the help of the tentacles (Pearson *pers. comm.*, Fauchald & Jumars, 1979). *Virgularia mirabilis*, also characteristic of this region, is a species which seems to avoid unstable sediment due to wave action, dredging or burrowing activities of other species but which however seems to be resistant to currents (Pearson *pers. comm.*, Hoare & Wilson, 1977). *Lygdamis muratus* appear in the Sado area mainly around the sandbanks and when the species presents high densities, the tubes of several individuals cement together and form like reef constructions, which may contribute to withstand strong currents. Also the tube mats of *Spiochaetopterus costarum*, widely distributed in the Sado but specially abundant in the type estuarine region, could be effective as a protection to high current speeds. This species is commonly found in the Spanish Rias de Muros, Arosa and Pontevedra in very fluid muddy sediments in which its long tubes constitute a good mechanism for fixation to the sediment (Lopez-Jamar, 1985).

Lanice conchilega was found to colonise Morlaix bay, affected by hydrocarbon pollution, following the development of opportunistic species and just before the establishment of the normal community (Ibanez & Dauvin, 1988). Pearson (1975), found it occupying the same successional place when studying the changes in the benthic fauna of Lochs Linnhe and Eil in response to organic enrichment due to a pulp mill effluent. He defined a macrofaunal succession of 4 phases, *L. conchilega* being included in Phase 3, corresponding to a high organic input, just before the opportunistic species development. Bhur & Winter (1977), however, recorded a very dense *L. conchilega* population (20000ind/m^2), in the Weser estuary, atributing the maintenance of so high populations to the ability of the species of filter and surface deposit feeding and pointing as its main food source natural inputs: the particulate load coming from the river, the tidal flats and the sea. In the Sado *L. conchilega* has been sampled mainly along the southern margin, around the sandbanks and in the Alcácer channel. It clearly avoids the northern margin in the vicinity of the industrial complex. The species has also been found in the intertidal region in the vicinity of discharges from the pulp mill industry, however in that area the individuals showed clear signs of physiological stress (Picado, 1991, Rodrigues *et al., in press*).

Virgularia mirabilis is a species known to avoid regions of heavily organic pollution being very sensitive to oxygen depletion and hydrogen sulphide (Pearson, *pers. comm.*, Hoare & Wilson, 1977). *Spiochaetopterus costarum* is a species associated in the Spanish rias with a high content of organic material where it appears to play the role taken elsewhere by *Capitella* in a sucession of increasing disturbance (Lopez-Jamar, 1985). In the Sado the species is widely distributed, which could be associated with the general enrichment of the estuary. Although it is present in the locations showing the highest organic enrichment, i. e. near the urban sewage and pulp mill outfalls, it is there in very low densities, and *Capitella* is the most abundant species.

Scalibregma inflatum is also important in the type area and has been found elsewhere in high numbers in areas enriched by predominantly labile carbon (Pearson *et al.*, 1986). Rosenberg (1976) mentioned it as appearing in a succession following pollution abatment in Sweden, after a *Capitella* stage. In Loch Linnhe and Loch Eil, however, Pearson (1975) considered it as a species present in the normal community, disappearing even in moderately increased organic input. In the Sado *S. inflatum* presents its highest densities in regions of the Alcácer channel, in the upper region and inner areas of the southern channel which seems to point to a relation either with organic material coming from the river or a preference for sediment with a higher percentage of fines. The species is also known to prefer muddy sand (Wolff, 1973, Pearson *et al.*, 1986) and most of its preferential area in the Sado corresponds to the muddier medium sand.

Another important species of this region is *Corbula gibba*. It feeds by filtering suspended particles from the water overlying the sediment and its presence usually means organic enrichment of the surface sediment (Pearson, 1971b). It is commonly found in organically enriched environments (Pearson, 1975, Pearson & Stanley, 1977). Tulkki (1968, *in*: Pearson, 1971b) considered it an indifferent organism to organic pollution. Rosenberg (1972, 1973, 1976) found it important in a "less mature community", Kocatas & Geldiay (1980) identified it as the characteristic species of a semi-polluted region and Pearson (1972, 1975) considered it a species characteristic of moderately increased organic input (phase 2), while Rosenberg (1980) states it as a tolerant species to hipoxia, surviving periodic oxygen depletion in several northern European fjords.

Enriched area

The faunal composition of the enriched region seems to be mainly defined by organic enrichment mainly of anthropogenic origin.

Species like *Cirriformia* sp. *Tharyx* sp., *Melinna palmata*, *Abra alba*, are present in all the stations and have their maximum development in this region. *Tubificoides benedeni*, is also an important species and *Spiochaetopterus costarum* is the most abundant species comprising 15% of total abundance of this region.

Most of these species are commonly found in organically enriched regions (Pearson & Rosenberg, 1978). *Cirriformia sp.*, *Tharyx sp.* and *H. filiformis* were included by Hily *et al.* (1986) in the group of opportunistic species, together with *C. capitata* and *M. fuliginosus*, whereas *M. palmata* and *A. alba* were included in the tolerant group of species. *Cirriformia sp.* and *M. palmata* were species found to persist after 3 months of the Amoco Cadiz pollution, with higher densities than before, and *Tharyx* sp. was one of the opportunistic species to settle and rapidly develop in the affected areas (Gentil, 1982). This latter species was mentioned by Fauchald & Jumars (1979) as very abundant in polluted regions.

Pearson & Rosenberg in their review paper (1978) mentioned various works in which *Cirriformia* was an important species in areas of high organic content either together with *C. capitata, M. fuliginosus* and *T. benedeni* or being secondarily important in areas dominated by them. *Cirriformia* is known to have physiological adaptations to hypoxic conditions (Warren, 1981, Bestwick & Warren, 1984) and Bestwick *et al.* (1989) found in specimens living intertidally that the sediment around the burrow is often hydrogen-sulphide rich.

Melinna palmata has been reported from various sewage sludge disposal grounds (Eagle *et al.*, 1978, *in*: Bryan & Gibbs, 1987). A high *M. palmata* population was also found by Hily (1984), flourishing in a highly organic enriched area of the Brest harbour, in the vicinity of a *Malacoceros-Capitella* zone. This population had the characteristic of having tubes 2 or 3 cm above the sediment, which according to Hily (*op. cit.*) seems to be an adaptation to anoxic conditions of the sediment. He also noted that *M. palmata* showed a life cycle with different characteristics according to the environmental physico-chemical and granulometric factors. This again points to an adaptation of the species for successful survival in severe environmental conditions, namely enriched areas.

Abra alba, although in a lesser degree, has the same characteristics as *M. palmata* of changing its growth, reproduction and life span, in relation to the environmental conditions (Hily, 1984, Dauvin, 1984). It is a species considered tolerant to organic pollution (Glémarec, 1979, Hily, 1984, Hily *et al.*, 1986). It was dominant in enriched areas in Sullom and Rona Voes (Pearson & Stanley, 1977). At Garroch Head sewage ground it was found at 1-2 Km beyond the centre (Pearson *et al.*, 1986), i. e. on the edge of the highly enriched areas.

Tubificoides benedeni is another species important in the enriched regions. It is known to be very resistant to low oxygen content and high hydrogen sulphide levels (Rasmussen, 1973, Pearson & Rosenberg, 1978). These latter authors mentioned several works which have recorded *T. benedeni* as being abundant in polluted localities, especially on the edge of abiotic zones. Also it was the most conspicous oligochaete in the polluted region of the Gothenburg estuary (Pearson & Rosenberg, *op. cit.*). McLusky (1982) includes it in the area of severe pollution defined in the Forth estuary around an effluent of a petrochemical industry, after the defaunated region. The species is considered an opportunistic species by McLusky & McCrory (1989).

Some species of amphipods belonging to the family *Ampeliscidae*, have shown a preferential development in this area. Among them *A. tenuicornis* is a species known to be particularly abundant in fine or muddy sand (Dauvin, 1984). In the Sado it seems to be associated with the fine sand of the northern channel. The other species are known either in muddy sand (*A. remora*) or from fine and coarse sediments (*A. diadema*) (Dauvin, *op. cit*, Myers & McGrath, 1991). Their development in this region could be due either to sediment preferences or to to the amount of food particles available.

Impoverished area

All the polychaete, oligochaete and bivalve species mentioned as the most characteristic species in the enriched area were also present here, however with lower densities and frequencies.

The stations belonging to the impoverished area are located close to the northern margin (except station 133 in Alcácer channel), in the vicinity of the industrial complex and the urban sewage outfall, and they are characterized by the lowest mean abundance and biomass per sampling station, within the estuarine community. The abundance value was lower than that expected by the SAB model, inducing in the abundance curve two maximum peaks instead of one. Almost 50% of the species present in this area were sampled only once. This suggests that factors other than organic enrichment might be acting and inhibiting the settlement or the development of the benthic macrofauna. In view of what is known about the industrial effluents and the levels of heavy metals in the area it seems that in this estuarine region, organic enrichment may be coupled with sediment toxicity.

Several species present in the northern channel seem to avoid the area in the vicinity of the industrial complex (e.g. *A. oxycephala, S. costarum, A. remora, A. diadema, C. gibba, C. paucicostatum, C. angulata*), while some of the species most important to this region like *Cirriformia sp., Tharyx sp., M. palmata* and *N. hombergii* are also frequently found in environments contaminated by high concentrations of heavy metals. They are known to be very resistant to heavy metal concentrations, either because they can accumulate metals in high concentrations or because they can regulate the heavy metal content in the tissues through detoxification mechanisms (Bryan & Gibbs, 1987). *Tharyx*, for example, is considered completely unsuitable as an indicator of heavy metals pollution in the sediments due to its ability to accumulate and regulate metal concentrations (Ag, Cu, Fe, Mn, Zn). *Cirriformia* is considered to regulate Fe, Mn, and Zn and in a lower extent Cd and Cu. *Melinna* is known to accumulate Cu, mainly in the branchiae, concentrations of Ag relate to Cu levels in the species and concentrations of Zn and possibly Mn did not respond to metal variations in the environment (Bryan & Gibbs, *op. cit.*).

Finally, *N. hombergii* is one of the commonest species in the vicinity of sewage-sludge areas and in estuaries draining metalliferous mining regions (Eagle *et al.*, 1978, 1979, *in* : Bryan & Gibbs, 1987, Norton *et al.*, 1981, *in* : Bryan & Gibbs, 1987). It is a species considered to regulate Mn and Zn and possibly, but to a lesser extent, Ag, Co, Pb and Fe (Bryan & Gibbs, *op. cit.*).

The high abundance of the amphipod *A. spinimana* in this region is not well understood and more knowledge of the biology of the species is necessary. Ampeliscidae species are known to be very sensitive to pollution effects (Dauvin, 1984, Gentil, 1982). However in experimental work of recolonization in Long Island Sound, a species of *Ampelisca, A. abdita*, was shown to be an opportunistic species appearing in high numbers with S. *benedicti* and C. *capitata* in the first successional stages (McCall, 1977). The presence of *Ampelisca* was attributed by the author to its capacity of rapidly finding suitable substratum to colonise and to the absence of infauna.

Disturbed area

The Sado disturbed area comprised 4 stations, located near the urban sewage outfall (st. 26), the pulp mill outfall (st. 92 and 93), and a ship painting and repairing industry (st.78). These four sites have a very strong hierarchical structure with *C. capitata* and *M. fuliginosus*, comprising 98,5% of the total abundance.

These two species are known to be very common in areas of excessive organic input and appear together in European and Mediterranean ecosystems (Pearson & Rosenberg, 1978, Bellan *et al.*, 1980). *Capitella capitata* is recorded all over the world in salinities above 10‰ and *M. fuliginosus* appears in waters normally down to ≈ 20‰ (Pearson & Rosenberg, *op. cit.*). *Capitella capitata* is considered an opportunistic species: it can grow rapidly, and have an almost continuous reproduction, producing both planktonic and benthic larvae (Grassle & Grassle, 1974, Dauvin, 1984, Chesney & Tenore, 1985, Grémare *et al.*, 1989). The life cycle of *Capitella* is driven by food availability and thus the species rapidly adjusts its growth and reproduction to the food available (Grémare *et al.*, *op. cit.*). In respect of its ability to withstand heavy metals it seems that the species is able to regulate Ni, but concentrations of Cd, Co, Cr, Hg, Zn and Sn tend to reflect its bioavailability in the sediment or in its detritus diet (Window *et al.*, 1982, Bryan & Gibbs, 1987). Thus, in relation to species like *Cirriformia sp*, *Tharyx sp*, *M. palmata* and *N. hombergii*, *C. capitata* seems to be more susceptible to high environmental heavy metal concentrations. In the Sado it was found in very low number in areas presumably contaminated by heavy metals.

Malacoceros fuliginosus is considered a species merely tolerant to pollution (Gray, 1979). It is known to have large eggs and long-lived pelagic larvae which, according to Gray (1971, *in*: Wolff, 1973) seem to prefer the presence of certain kinds of bacteria on the sediment particles for settlement. Based on studies in cultured populations, Pearson (*pers. comm.*) suggested that there is biological interaction between *M. fuliginosus* and *C. capitata*, with the former species being enhanced by the presence of the latter which might suggest that in highly organic areas *M. fuliginosus* is dependant on the occurence of *C. capitata* for settlement.

The four stations included in the disturbed area show, however, different effects in their faunal composition.

Station 26, the closest to the urban sewage outfall has a dense *C. capitata* population and *M. fuliginosus has* its highest density. This station is one of the locals with higher biomass and shows the highest production value.

There is a clear transition to moderately enriched adjacent areas. In general, *M. fuluginosus* disappears, *C. capitata* occurs at reduced density and *T. benedeni* populations develop. These species then disappear or the latter persists in very low numbers and Cirratulids, *A. alba* or *M. palmata* increase their densities and peracarid species appear in higher numbers.

Station 78 is surrounded by stations included in the impoverished Sado area. This station is characterized by a very poor fauna. *C. capitata* and *M. fuliginosus* are represented in very low numbers together with a few *Tharyx* sp and *Cirriformia* sp.

Stations 92 and 93, around the pulp mill effluent show intermediate characteristics between the two latter stations. The fauna present in site 92 is impoverished. *C. capitata* and *M. fuliginosus* are present in low numbers together with a few Tharyx sp., *Caulleriella* sp. and *S. costarum*. In station 93, *C. capitata* and *M. fuliginosus* show higher abundances. Besides these two species only a few *N. hombergii*, *S. costarum* and an oligochaete species were found. A gradient away from stations 92 and 93, as observed in the case of the urban sewage, was also seen.

From the evidence of the species composition and abundances it seems that, coupled with the organic enrichment, an increasing toxic effect occurs in the sense, station 26 -> 93 -> 92 -> 78, which prevents, in the case of the two latter stations, the development of even the opportunistic species.

Transition region

The transition region is characterized by species present either in the marine or estuarine communities, together with a set of unique species. Within the area covered by this work, this region presents the highest species richness and diversity values and the highest number of species with a frequency of occurence higher than 50%. It is also the region which has shown the lowest relative abundance represented by the first ranked species.

It is characterized by amphipod species commonly found along the Portuguese coast in several bottom types, *Corophium sextonae* and *C. runcicorne*, or, associated preferentially with coarse sand, *Photis longipes*, *Perioculodes longimanus*, *Leptocheirus pectinatus* (Marques, 1989). Also, the Molluscs *Spisula solida*, *Venerupis pullastra* and *Calyptraea chinensis* are important species of this area. *Spisula solida* was found in high densities associated with clean coarse sand in the Portuguese lagoons of Obidos and Albufeira (Quintino, 1988) and Tebble (1976) states the species preference for sandy sediments.*Venerupis pullastra* and *Calyptraea chinensis* were also abundant in the lagoons of Obidos and Albufeira, in clean coarse or slightly silty medium sand (Quintino, 1988). Wolff (1973) and Rasmussen (1973) mentioned the occurence of *V. pullastra* mainly in hard sand or stony bottoms.

These characteristics seem to point to this area as the least disturbed of the Sado estuary. However a detailed analysis of the fauna existing in each of the stations of this region shows clearly an organic enrichment effect in those located in the northern half of this region, including the ones of the northern channel. In those locations, *Caulleriella sp*, *Tharyx sp*, *M. capensis* or *A. alba* are either dominant species or are within the top five. These species were commonly found in the type and enriched areas of the estuarine community, thus suggesting an organic enrichment of the northern part of the transition region, probably mainly due to the sewage outfall.

The hydrodynamic factors in this region show lower values than in the marine and estuarine type areas. Normally this is translated into higher sediment stability, allowing species present in the estuarine entrance to develop here in higher densities (*P. longipes*, *C. sextonae*, *U. elegans*, *S. hyallina*...). Also it could provide the settlement conditions needed by other species e. g. *A. neglectus*, *B. lanceolatum*, *H. laevis*... The organic enrichment also permits the development of those species particularly associated with it or others which could benefit from an additional food source.

Thus the transition region seems to be mainly defined by sediment types but is also influenced by some organic enrichment of anthropogenic origin.

The main driving factors controlling the macrofauna in the several regions identifyed in the Sado estuary are summarised in table VII.1. Other relevant information on these regions is given in Table VI.26 (Chapter 6, page 245).

	MARINE		TRANSITION
	Type	**Impoverished**	
Mainly Defined by	Hydrodynamical factors	Hydrodynamical factors + organic enrichment	organic enrichment + Sediment types

	ESTUARINE				
	Type	**Enriched**	**Impoverished**	**Disturbed**	**Defaunated**
Mainly Defined by	Hydrodynamical factors + organic enrichment	organic enrichment + Sediment types	Sediment toxicity + high organic enrichment	high organic enrichment+ Sediment toxicity	Excessive organic input + Sediment toxicity

Table VII.1 - Main environmental factors controlling the benthic assemblages of the Sado outer estuary.

Quality Assessment

As discussed above, the different areas defined in the Sado outer estuary have been shown to be controlled by several factors. Some of them are controlled mainly by anthropogenic inputs while others reflect the effects of natural forces.

A detailed analysis of the macrofauna present in the impoverished marine area and the transition region has shown a clear effect of organic enrichment. In the former it seems to be mainly of natural origin, as was also shown for the Sado Southern channel and upper region (estuarine type area). For the transition region it seems to be mainly due to anthropogenic inputs, probably the urban sewage.

Considering also the effect on the macrofauna, the disturbed region of the estuarine community can be split according either to the degree of organic enrichment which allows the development of opportunistic species, or to a toxicity effect.

Thus any definition of the disturbance areas in the Sado estuary has to take into account the distinctions shown by the analysis of the macrofauna species. These are defined in table VII.2 and their spatial distribution is shown in figure 7.1

Methods

The methodological approach followed in this study has been shown to be effective in defining the major existing gradients and to effectively assess the quality status of the Sado outer estuary. Also, and as already recommended by several authors (Gray *et al.*, 1988, Underwood & Peterson, 1988, Rees *et al.*, 1990), to achieve this purpose several data treatment techniques have been considered.

All the data treatment methods were sensitive enough to detect the extreme pattern of the gradient identified in the Sado estuary, namely the less impacted region, represented by the type marine assemblage (Zone 1-Naturally impoverished) and the most disturbed one, namely the highly disturbed area of the estuarine community (Zone 6 - Opportunistic).

		DEFINED BY NATURAL FORCES			DEFINED BY ANTHROPOGENIC INPUTS			
		ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5	ZONE 6	ZONE 7
		Type marine area	Sts. from Transition region	Impoverished marine area + Type area	Enriched area + Sts.from Transition region	Impoverished area + Sts. 78.92 of disturbed area	Sts.26.93 from the disturbed area	Sts.95.120
		Impoverished	**Transition**	**Enriched**	**Enriched**	**Impoverished**	**Opportunistic**	**Defaunated**
Sediment	**TOM**	0.51	1.38	2.52	4.23	8.1	8.2	11.46
	Fines	2.11	9.99	22.99	33.43	74.13	65.77	93.44
	Type	coarse sand	coarse, medium sand	medium sand	coarse, medium, fine sand and mud	mud	fine sand, mud	Mud
Shear Stress		45.04	27.37	26.92	16.45	10.6	1.85	——
Flow		7.88	4.07	2.5	2.07	1.15	0.2	——
Velocity		0.41	0.3	0.29	0.22	0.18	0.09	——
Mean	**S**	32	59	32	58	17	12	Abiotic
	A	218	953	360	770	96	7967	
	B	5722.6	32182.1	15403	38893.2	5598.1	38933.3	
Important Species		*S. papillocercus*, *P. remota*, *P. appendiculatus*	*M. capensis*, *P. longipes*, *C. annulatum*, *A. latreilli*	*S. costarum*, *L.conchilega*, *S. inflatum*, *L. muratus*, *C. gibba*, *V. mirabilis*, *S. armiger*	*Cirriformia sp.*, *Tharyx sp.*, *Caulleriella sp.*, *T. benedeni*, *M. palmata*, *A. alba*, *A.tenuicornis*, *A. remora*, *C. paucicostatum*	*N. hombergi*, *A. spinimana*	*C. capitata*, *M. fuliginosa*	Abiotic
Mainly defined by		Hydrodynamical factors	Sediment types	Hydrodynamical factors + organic enrichment	organic enrichment + Sediment types	Sediment toxicity	high organic input	Excessive organic input+Sediment toxicity

Table VII.2 - Bio-sedimentary environmental quality assessment of the Sado estuary. Prevailing hydro-physical, sedimentary and biological characteristics of the zones identified.

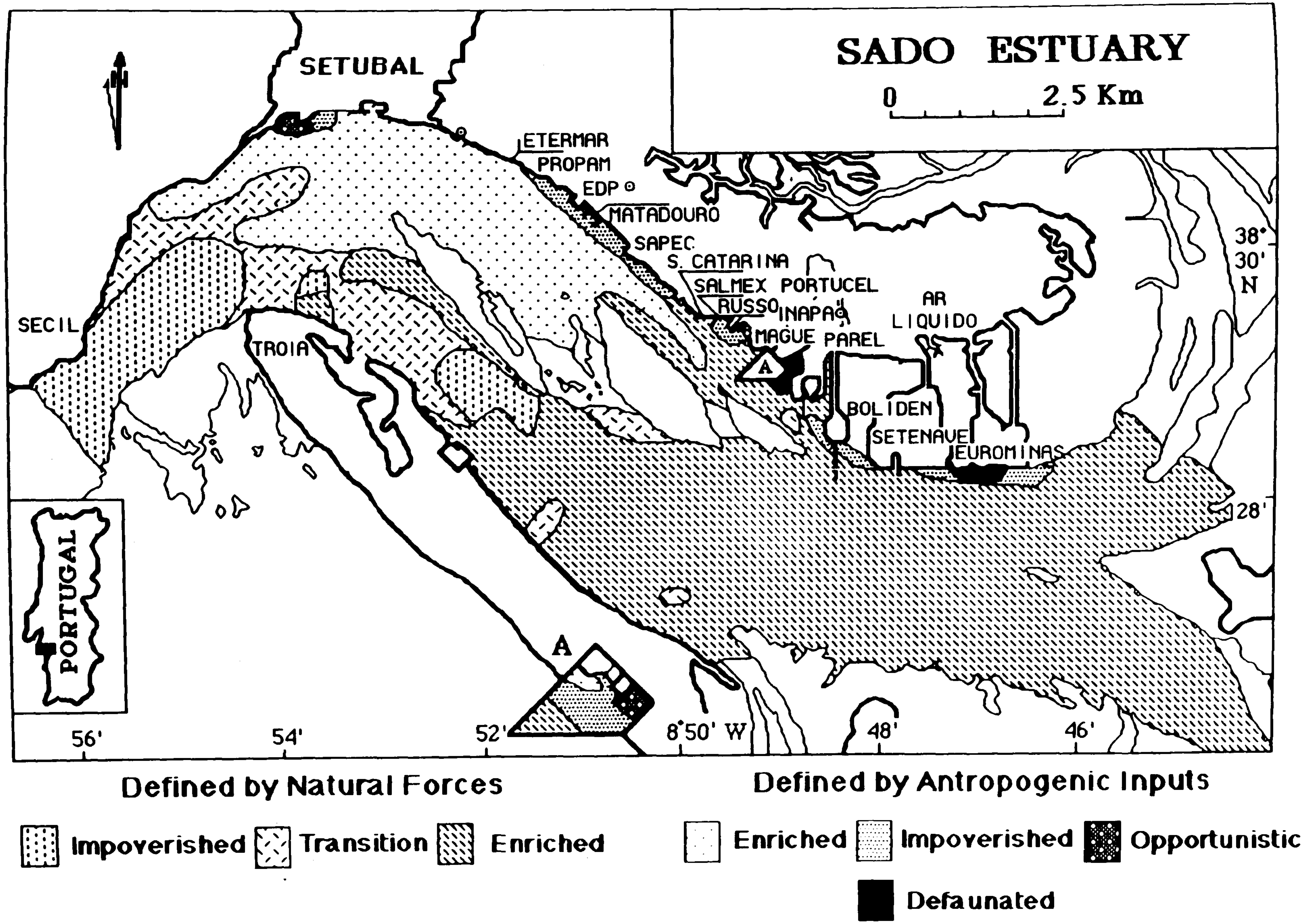


Figure 7.1 - Bio-sedimentary environmental quality assessment of the Sado estuary. Spatial distribution of the zones identified.

However, K-dominance (Lambshead *et al.*, 1983) and ABC curves (Warwick, 1986, Warwick *et al.*, 1987) have been shown to be poor at discriminating between the states of disturbance within the estuarine community, or giving reliable disturbance patterns in some areas. Such methodological deficiencies of the K-dominance and especially the ABC curves have already been noticed in some other studies (Beukema, 1988, Meire & Dereu, 1990, Warwick & Clarke, 1991)

In the present study the ABC curves suggest a disturbed structure for the type estuarine community and an undisturbed one for the enrichment and impoverished estuarine areas, contradicting the results given by the rarefaction curves (Sanders, 1968), the SAB model (Pearson & Rosenberg, 1978) and by the analysis of the most important species of each group.

The ABC method has been shown to give the same answer for either natural or pollution induced disturbance (Warwick *et al.*, 1987, Warwick & Ruswahyuni, 1987) and care has to be exercised when using it as a pollution assessment method in estuarine environments, which could feature naturally disturbed community structures. It is a method which relies heavily on the development of particular species and on the abundance of small individuals and it could be influenced by, for example, species recruitment (Beukema, 1988), by the natural aggregation patterns of species distribution, or by the screen mesh size used in the study (Meire & Dereu, 1990), to give disturbed structures for the natural features of species. In this study the disturbed structure given for the type estuarine area and the undisturbed one for the enriched area by the ABC method is the result of the presence, in the former, of small and abundant species (e.g. *S. costarum*, *Tharyx sp.*, *A. oxycephala*) and the presence of high biomass contributors, like *C. paucicostatum* and *L. stentina*, in the latter area.

Undisturbed structures could be produced by the ABC curves as the result of the analysis of a polluted area where organic enrichment is coupled with heavy metal toxicity effects, which is a common feature of estuaries under industrial development (McLusky, 1989).

thus preventing even the opportunistic species developing. This has been the case for the impoverished estuarine area which was suggested as undisturbed by the ABC curves. A similar situation was found by Meire & Dereu (*op. cit.*) when analysing a heavily polluted region which had a very poor macrofaunal assemblage.

Warwick & Clarke (1991) have shown that multivariate methods are very sensitive to community changes, retaining information which is lost by the univariate and graphical methods. In this work Twinspan and Canoco have been shown to be very useful methods. Canonical correspondence analysis, in particular, clearly proved to be a very sensitive method in detecting the gradation of the community changes, relating them with environmental characteristics and investigating which environmental variables best explained the community changes observed.

Some of the analyses developed through this study on the basis of biomass have been shown to give similar macrofaunal distribution patterns to the ones based on abundance data, however with less accurate results.

The organic enrichment effects in some areas, namely the transition region and the type estuarine area, have only been detected by a detailed analysis of the macrofauna species, emphasizing the need for knowledge of the basic biology of species.

The present study has been based on analysis at the species level. It should be noted that Kingston (1987), Warwick (1988c), Kingston & Ridle (1989) and Ferrarro & Cole (1990), have suggested that similar results can be achieved with less taxonomic detail or precision. It is likely that use of broader taxa (e.g. family level) will detect the extreme situations, but will be less sensitive to minor perturbations. This aspect will be developed in future work.

Future Work and Recommendations

The results obtained in the present work have shown clearly that in areas of similar organic enrichment, the macrofaunal assemblages presented different levels of disturbance. This fact could be related to different factors, such as the particular physico-chemical and biotic characteristics of the areas, the kind of organic material (more or less labile), or the toxicity associated with the anthropogenic inputs.

In order to analyse these questions a related research project, "Ecological Fate and Effects of Complex Organic Mixtures" has been started recently. The project will be developed through the following different successive phases to assess:

- source and effect of detrital carbon,
- effect of the different kinds and quantities of organic carbon on the macrofaunal succession,
- sub-lethal toxicity associated with anthropogenic sources of carbon, and,
- comparison of the results obtained, and preparation of descriptive models of the macrofaunal succession, in relation to the set of detrital carbon sources.

The overall information obtained through the analysis of the quality status of the Sado outer estuary (present study), the insights given by the project mentioned (which includes the identification and degradability rates of organic material), and the existing hydrodynamic and dispersion models, may together constitute a realistic background knowledge for the establishment of Environmental Quality Standards (EQS's) for the Sado estuary.

The Sado outer estuary has been shown to be a highly dynamic region, which is an important characteristic for the efficient dilution and dispersion of waste discharges (Wilson, 1988). It has also been shown however that all the industrial outfalls are located in the least suitable area, which has the lowest energy levels. The estuary has an abundant and diversified fauna and high biomass and production values (Jones 1974/75, Jaramillo *et al.*, 1984, Jones *et al.*, 1986, Andrade, 1986, Elliott & Kingston, 1987, Quintino, 1988, Quintino & Rodrigues, 1989) and if compared with eutrophic regions like the Baltic sea, the Kattegat and Skagerak (Bagge, 1969a, 1969b, Henriksson, 1969, Leppakoski, 1975, Rosenberg, 1985, Funen

County Council, 1991) or with areas of Southern Californian waters affected by domestic wastes (Reish, 1980, Bascom, 1982, Swartz *et al.*, 1986), the Sado could not be considered badly polluted. It does however have some defaunated and over-enriched areas which appear as a result of localised severe pollution .

The directives for the control of pollution issued from the Commission of the European Community are currently based on the Uniform Emission Standards (UES) approach. This is in contrast to the policy approach which seeks to establish Environmental Quality Objectives (EQO) and Environmental Quality Standards (EQS), which is already followed by some European countries (e.g. Milne *et al.*, 1986, Wilson, 1988, McLusky, 1989). The EQO/EQS policy takes into account the assimilating capacity of the ecosystems, being the degree of treatment required to keep the load below the level at which damage will be caused. To maintain the EQO/EQS policy regular monitoring is required.

A change in the EEC policy is reflected by the project proposal of a directive concerning the "Ecological Quality of Surface Waters" (XI/181/91-PT). In this proposal a high Ecological Quality (EQ) is defined according to nine environmental elements, which should reflect non disturbed structures. This document mentions that the structure and the quality of sediment should not be significantly disturbed by human activities and that the quality status of the benthic macroinvertebrates should represent an undisturbed state having key species/taxa, normally associated with the natural condition in the ecosystem.

As has been shown by the present study the sediment and the macrofaunal communities of the Sado are affected by anthropogenic inputs, which indicates the necessity of reducing the discharges into the estuary. This will be partially achieved by the treatment improvements which are being made to the urban sewage and the pulp mill effluents. Monitoring of the changes caused by these improvements will be partially analysed by the research project referred to above. Since other industrial projects are planned for the Sado estuary, some of them requiring dredging activities, a wider monitoring programme should now be implemented in order to analyse any spatio-temporal changes as a response to natural and human impacts, in the different areas shown by the present study.

The Sado, nowadays, is a multiple use system comprising both water quality dependent and independent uses (Chapter 2). Taking into account the new projects planned, Environmental Quality Objectives should be defined, as well as the necessary Environmental Quality Standards, in order to prevent or diminish incompatibilities of use.

The determination of assimilative capacity of the ecosystems and establishment of adequate EQS's is technically demanding and only possible if adequate resources are devoted to research in understanding the fate of effluents and their biological impact within the receiving ecosystems (Milne *et al.*, 1986, Wilson, 1988, McLusky, 1989). The response of ecosystems to pollutants is a very complex process and long term impact assessment requires a predictive capacity which is not yet available but which could be greatly assisted by future work.

REFERENCES

Abbott, M. B. 1979. *Computational Hydraulics. Elements of the theory of free surface flows.* Pitman Advanced Publishing Program, London. XVIII + 326 pp.

Amanieu, M. & G. Lasserre 1981. Niveaux de production des lagunes littorale méditerranéennes et contribution des lagunes à l'enrichissement des pêches démersales. *Ètud. Rev. C.G.P.M.*, 58: 81-94.

Amanieu, M., J. Ferraris & O. Guelorget 1980. Organisation et évolution des peuplements des lagunes littorales. Application à la macrofaune benthique des étangs palavasiens. *In*: *Recherches d'écologie théorique. Les stratégies adaptatives.* Ed. R. Barbault, P. Blandin & J. A. Meyer: 251-277.

Ambar, I. S. A., A. F. G. Fiúza, F. M. Sousa & I. R. Lourenço 1982. General circulation in the lower Sado river estuary under drought conditions. *Proceedings of Actual problems of oceanography in Portugal*, Ed. JNICT, Lisbon: 97-107.

Andrade, F. 1986. *O estuário do Mira: Caracterização geral e análise quantitativa da estrutura dos macropovoamentos bentónicos.* Tese de Doutoramento, Fac. Ciências, Univ. Lisboa. XI+393pp.

Antunes, M. P. L. Cunha & D. Moura 1991. Estudo do impacte dos efluentes urbano-industriais nas comunidades de peixes e crustáceos decápodes no estuário do Sado 1987/88. *LNETI-DEII report, Julho, 1991.* 3: 1 - 73.

Bagge, P. 1969a. Effects of pollution on estuarine ecosystems. I. Effects of effluents from wood-processing industries on the hydrography, bottom and fauna of Saltkällefjord (W. Sweden). *Meerentutkimuslait. julk.*, Skr. No. 228: 3-118.

Bagge, P. 1969b. Effects of pollution on estuarine ecosystems. II. The succession of the bottom fauna communities in polluted estuarine habitats in the Baltic - Skagerak region. *Meerentutkimuslait. julk.*, Skr. No. 228: 119-130.

Bascom, W. 1982. The effects of waste disposal on the coastal waters of Southern California. Environ. Sci. Technol., 16: 226A-236A.

Bayne, B. L., K. R. Clarke & J. S. Gray, (Eds.), 1988. Biological effects of pollutants. Results of a practical workshop. *Mar. Ecol. Prog. Ser.*, 46: 1-278.

Bellan, G. 1964. Contribution à l'étude systématique, bionomique et écologique des annélides polychétes de la Mediterranée. *Rec. Trav. Stn. Mar. Endoume.*, Bull. 33: 371 pp.

Bellan G., D. Bellan-Santini & J. Picard 1980. Mise en évidence de modèles éco-biologiques dans des zones soumises à pertubations par matières organiques. *Oceanol. Acta*, 3: 383-390.

Bellan-Santini, D., G. Karaman, G. Krapp-Schickel, M. Ledoyer, A. A. Myers, S. Ruffo & U. Schiecke 1982. The *Amphipoda* of the Mediterranean. *Mém. Inst. Oceanogr. Monaco*, 13: XIII+1-364pp.

Bestwick, B. W., I. J. Robbins & L. M. Warren 1989. Metabolic adaptations of the intertidal polychaete *Cirriformia tentaculata* to life in an oxygen-sink environment. *J. Exp. Mar. Biol. Ecol.*, 125: 193-202.

Bestwick, B. & L. Warren 1984. The role of phosphagens in the survival of hypoxic stress by polychaete annelids. *Trans. Biochem. Soc.*, 12: 799.

Beukema, J. J. 1988. An evaluation of the ABC-method (abundance/biomass comparison) as applied to macrozoobenthic communities living on tidal flats in the Dutch Waden Sea. *Marine Biology*, 99: 425-433.

Byliard, G. R., 1987. The value of benthic infauna in marine pollution monitoring studies. *Mar. Pollut. Bull.*, 18: 581-585.

Birch, D. W. 1981. Dominance in marine ecosystems. *Am. Nat.*, 118: 262-274.

Blackstock, J. 1984. Biochemical metabolic regulatory responses of marine invertebrates to natural environmental change and marine pollution. *Oceanogr. Mar. Biol. Ann. Rev.*, 22: 263-313.

Blandin, P. 1980. Évolution des écosystèmes et stratégies cénotiques. *In: Recherches d'écologie théorique. Les stratégies adaptatives.* Ed. R. Barbault, P. Blandin & J. A. Meyer: 221-235.

Boesh, D. F. 1977. A new look at the zonation of benthos along the estuarine gradient. *In: Ecology of marine benthos.* Ed. B. C. Coull, University South Carolina Press, Columbia: 245-266.

Bordalo Costa, M. M. & M. C. Peneda 1989. Heavy metal detection in the sediment - water components of the Sado estuary by multielemental analysis. *Environ. Technol. Lett.* 10, 213: 697-706.

Bryan, G. W. & P. E. Gibbs 1987. Polychaetes as indicators of heavy-metal availability in marine deposits. *In: Oceanic processes in marine pollution.* Eds. J. M. Capuzzo & D. R. Kester. *Biological processes and wastes in the ocean*, vol. I. Robert E. Krieger Publ. Co. Malabar: 37-49.

Buhr, K.-J. & J. E. Winter 1977. Distribution and maintenance of a *Lanice conchilega* association in the Weser estuary (FRG), with special reference to the suspension feeding behaviour of *Lanice* *conchilega. in: Biology of benthic organisms. 11th European Marine Biology Symposium, Galway, 5-11 Oct. 1976*, Ed. B. F. Keegan, P. Ó'Ceidigh & P. J. S. Boaden: 101-113.

Byers, S. C., E. L. Mills & L. Stewart, 1978. A comparison of methods of determining organic carbon in marine sediments, with suggestions for a standard method. *Hydrobiologia*, 58: 43-47.

Cabioch, L. 1968. Contribution à la connaissance des peuplements benthiques fr la Manche Occidentale. *Cah. Biol. Mar.*, tome IX, Cah. 5 (suppl.): 493-720.

Cabioch, L., J.-C. Dauvin, C. Retière, V. Rivain & D. Archambault 1982. Évolution de peuplements benthiques des fonds sédimentaires de la région de Roscoff, perturbés par les hydrocarbures de L'Amoco Cadiz. *Netherlands Journal of Sea Research*, 16: 491-501.

Cancela da Fonseca, L. 1989. *Estudo da influência da "abertura ao mar" sobre um sistema lagunar costeiro: a lagoa de Santo André.* Tese de Doutoramento, Fac. Ciências, Univ. Lisboa. X+255pp.

Cancela da Fonseca, L., F. Andrade & P. Pinto 1987. Contribuição para o conhecimento dos povoamentos bentónicos do estuário do Sado (Setúbal, Portugal). *I Congresso Nacional de áreas protegidas*, 9 pp.

Carriker, M. R. 1967. Ecology of estuarine benthic invertebrates. *In: Estuaries*, 83, Eds. G. H. Lauff. A.A.A.S., Washington, D. C.: 442-487.

Castro, O., A. M. Ferreira & C. Vale 1990. Transport and distribution of DDT and PCB in the upper Sado estuary and accumulation in oysters: importance of runoff. *In: Proceedings 6 European Symposium of Organic Micropollutants in the aquatic environment, Lisbon, 22-24 May 1990*: 80-88.

Castro, O & C. Vale 1991. Distribuição de PCB e DDT nos sedimentos do estuário do Sado. *Resumos do Seminário Alterações Ambientais e Repercussões no Biota, Lisboa, 6, 7 Maio, 1991*: 5.

Catarino, J., F. Duarte, F. Ralha, S. Karmali, M. Bordalo Costa & L. Hall 1989a. Caracterização das águas residuais da Propam - Consórcio Português de Panificação. *LNETI report, 20 pp.*

Catarino, J., F. Duarte, F. Ralha, S. Karmali, M. Bordalo Costa & L. Hall 1989b. Caracterização das águas residuais da Inapa - Indústria Nacional de Papéis. *LNETI report, 16 pp.*

Catarino, J., F. Duarte, F. Ralha, S. Karmali, M. Bordalo Costa & L. Hall 1989c. Caracterização das águas residuais da Portucel - Centro fabril de Setúbal. *LNETI report, 23 pp.*

Catarino, J., F. Duarte, F. Ralha, S. Karmali, M. Bordalo Costa & L. Hall 1989d. Caracterização das águas residuais da SAPEC. *LNETI report, 21 pp.*

Catarino, J., F. Duarte, F. Ralha, S. Karmali, M. Bordalo Costa & L. Hall 1989e. Caracterização das águas residuais da Fábrica de óleos vegetais de Sta Catarina. *LNETI report, 19 pp.*

Catarino, J., F. Duarte, F. Ralha, S. Karmali, M. Bordalo Costa & L. Hall 1989f. Caracterização das águas residuais da cidade de Setúbal veiculadas pela Ribeira do Livramento. *LNETI report, 18 pp.*

Catarino, J., F. Duarte, F. Ralha, S. Karmali, M. Bordalo Costa & L. Hall 1989g. Caracterização das águas residuais do Matadouro de Setúbal. *LNETI report, 22 pp.*

Chapman, P. M., R. N. Dexter & E. R. Long 1987. Synoptic measures of sediment contamination, toxicity and infaunal community composition (the Sediment Quality Triad) in San Francisco Bay. *Mar. Ecol. Prog. Ser.* 37: 75-96.

Chesney, E. J. & K. R. Tenore 1985. Oscillations of laboratory populations of the polychaete *Capitella capitata* (Type I): Their cause and implications for natural populations. *Mar. Ecol. Prog. Ser.*, 20: 289-296.

Clark, R. B., 1986. *Marine Pollution.* Clarendon Press. Oxford. 215 pp.

Clarke, K. R. & R. H. Green 1988. Statistical design and analysis for a biological effects' study. *Mar. Ecol. Prog. Ser.*, 46: 213-226.

Costa, M. H. 1988. *Macrofauna bêntica e factores abióticos no infralitoral do estuário do Sado. Variabilidade e interacções.* Tese de Doutoramento, Univ. Nova de Lisboa, Fac. de Ciências e Tecnologia. 288 pp.

Costa, M. H., S. J. Gamito & J. F. Oliveira 1984. Povoamentos bênticos litorais do estuário do Sado. Dados preliminares. *Actas IV Simp. Ibér. Estud. Bentos Mar,* volI: 89-107.

Costa, M. H., J. F. S. Oliveira & G. Bellan 1990. Ecologia bêntica em substratos móveis intertidais do Estuário do Sado. *2ª Conferência Nacional sobre a Qualidade do Ambiente, Lisboa, 4-6 Abril, 1990.* VolI: 225-235.

Crisp, D. J. 1984. Energy flow measurements. *in: Methods for the study of marine benthos.* Ed. N. A. Holme & A. D. McInthyre, 2nd edition, 387 pp.

Currás, A. & J. Mora 1991. Comunidades bentonicas de la ria del Eo (Galicia-Asturias, NW España). *Cah. Biol. Mar.*, 32: 57-81.

Daget, J. 1979. *Les modèles mathèmatiques en écologie.* Colléction d'Écologie, nº8. Ed. Masson, Paris: VIII+172 pp.

Dauvin, J.-C. 1984. Dynamique d'écosystèmes macrobenthiques des fonds sédimentaires de la Baie de Morlaix et leur pérturbation par les hydrocarbures de l'Amoco Cadiz. *Thèse Doctorat d'Etat. Univ. Paris VI.* 468 pp. + Annexes.

Doeglas, D. J. 1968. Grain-size indices, classification and environment. *Sedimentology,* 10: 83 - 100.

Duarte, M. F. & M. F. Henriques 1991. Caracterização fisico-quimica das águas do estuário do Rio Sado. *LNETI-DEII report, Outubro, 1991.* 14: 1 - 203.

Dyer, K. R. 1973. *Estuaries: A physical introduction.* John Wiley, London: 140 pp.

Dyer, K. R. (Ed.) 1979. *Estuarine hydrography and sedimentation.* EBSA handbook, Cambridge University press, Cambridge, 230pp.

Eleftheriou, A. & D. J. Basford 1989. The macrobenthique infauna of the offshore northern North sea. *J. mar. biol. ass. U.K.,* 69: 123-143.

Elliott, M. 1983 - The structure and function of the sublittoral benthic populations in the Forth estuary. *ES4/83. Forth River Purification Board.*

Elliott, M. & P. F. Kingston 1987. The sublittoral benthic fauna of the estuary and Firth of Forth, Scotland. *Proceedings of the Royal Society of Edinburgh,* 93B: 449-465.

Elliott, M. & M. G. O'Reilly 1991. The variability and prediction of marine benthic community parameters. *ECSA 19 Symposium.* Eds. M. Elliott & J.-P. Ducrotoy. Olsen & Olsen, International Symposium Series: 231-238.

Elliott, M. & C. J. L. Taylor 1989. The production ecology of the sublittoral benthos for the Forth estuary, Scotland. *In: Topics in Marine Ecology. 22nd European Marine Biology Symposium, Barcelona, 17-22 Aug. 1987.* Ed. J. D. Ros., *Scient. Mar.* 53 (2-3): 531-541.

Enequist, P. 1950. Studies on the soft bottom anphipods of the Skagerak. *Zool. Bidr. Uppsala,* 28: 297-492.

Fauchald, K. & P. A. Jumars, 1979. The diet of worms: a study of polychaete feeding guilds. *Oceanogr. Mar. Biol. Ann. Rev.,* 17: 193 - 284.

Fauvel, P. 1923 - Polychètes errantes. *Faune de France* 5, Paris, Lechevalier: 486 pp.

Fauvel, P. 1927- Polychètes sedentaires. *Faune de France* 16, Paris, Lechevalier: 494 pp.

Fenchel, T. 1987. *Ecology - Potentials and Limitations.* Ed. O. Kinne. Excellence in Ecology, Ecology Institute, Nordbünt, FRG, 1: XIX+186 pp.

Ferraro, S. P. & F. A. Cole 1990. Taxonomic level and sample size sufficient for assessing pollution impacts on the southern California Bight macrobenthos. *Mar. Ecol. Prog. Ser.*, 67: 251-262.

Ferreira, A. M., O. G. Castro & C. Vale 1989. Factors controlling PCBs and DDT variations in the upper Sado estuary. *International Symposium on integrated approaches to water pollution problems. SISIPPA 89*: II-83 - II-92.

Ferreira, J. N. R. & R. J. J. Neves 1987. Modelo matemático dos estuário do Sado. Extensão à plataforma adjacente. *I. S. T. report*: 141 pp.

Folk, R. L. & W. C. Ward, 1957. Brazos River bar, a study in the significance of grain-size parameters. *J. Sediment. Petrol.* 27: 3 - 27.

Frontier, S. 1976. Utilisation des diagrammes rang-fréquence dans l'analyse des ecosystèmes. *J. Rech. Océanogr.*, vol.I: 35-48.

Frontier, S. 1977. Réflexions pour une théorie des ecosystèmes. *Bull. Ecol.*, 8: 445-464.

Frontier, S. 1985. Diversity and structure of aquatic ecosystèmes. *Oceanogr. Mar. Biol. Ann. Rev.*, 23: 253-312.

FRPB, 1988 Marine Biological and Sedimentological Methods. *TW2/88. Forth River Purification Board (unpubl. report).*

Funen County Council, 1991. *Eutrophication of coastal waters. Coastal water quality management in the County of Funen, Denmark, 1976-1990. Legislation - Nutrient loads and eutrophication effects - Causes and trends.* Funen County Council, Dep. Technology and Environment. 287 pp.

Gamito, S. J. 1983. A macrofauna do infralitoral de algumas praias arenosas do estuário do Sado (Um estudo quantitativo). Estágio de Licenciatura, Fac. Ciências, 62 pp. (*unpub. report*).

Gauch, H. G. Jr. 1982. *Multivariate analysis in community ecology.* Eds. E. Beck, H. J. B. Birks & E. F. Connor. Cambridge University press. 298 pp.

Gentil, F. 1982. Description du benthos de l'Aber Wrac'h (Nord Bretagne) et impact à court terme des hydrocarbures de l' "Amoco Cadiz". *107e Congrès national des Sociétès savantes, Brest, 1982, sciences*, fasc. II: 111-125.

Glémarec, M. 1979. The benthic communities of the European North Atlantic continental shelf. *Oceanogr. Mar. Biol. Ann. Rev.*, 11: 263-289.

Gomez-Parra, A. & M. Frutos 1987. Representatividad de los valores de materia organica obtenidos en el estudio de sedimentos costeros. *Inv. Pesq.*, 51: 107-120.

Grassle J. F. & J. P. Grassle 1974. Opportunistic life histories and genetic systems in marine benthic polychaetes. *Journal of Marine Research*, 32: 253-284.

Gray, J. S. 1979. Pollution-induced changes in populations. *Phil. Trans. R. Soc. London.* B, 286: 545-561.

Gray, J. S. 1981. *The ecology of marine sediments. An introduction to the structure and function of benthic communities.* Cambridge University Press, Cambridge. XI + 185pp.

Gray, J. S. 1983. Use and misuse of the log-normal plotting method for detection of effects - a reply to Shaw *et al.* (1983). *Mar. Ecol. Prog. Ser.*, 11: 203-204.

Gray, J. S. 1985. Ecological theory and marine pollution monitoring. *Mar. Pollut. Bull.*, 16: 224-227

Gray, J. S., M. Aschan, M. R. Carr, K. R. Clarke, R. H. Green, T. H. Pearson, R. Rosenberg & R. W. Warwick 1988. Analysis of community attributes of the benthic macrofauna of Frierfjord/Langesundfjord and in a mesocosm experiment. *Mar. Ecol. Prog. Ser.*, 46: 151-165

Gray, J. S., K. R. Clarke, R. M. Warwick & G. Hobbs, 1990. Detection of initial effects of pollution on marine benthos: an exemple from the Ekofisk and Eldfisk oilfields, North Sea. *Mar. Ecol. Prog. Ser.*, 66: 285-299.

Gray, J. S. & F. B. Mirza 1979. A possible method for the detection of pollution-induced disturbance on marine benthic communities. *Mar. Pollut. Bull.*, 10: 142-146.

Gray J. S. & T. H. Pearson 1982. Objective selection of sensitive species indicative of pollution-induced change in benthic communities. 1. Comparative methodology. *Mar. Ecol. Prog. Ser.*, 9: 111-119.

Grémare, A., A. G. Marsh & K. R. Tenore 1989. Secondary production and reproduction of *Capitella capitata* type I (*Annelida: Polychaeta*) during a population cycle. *Mar. Ecol. Prog. Ser.*, 51: 99-105.

Guelorget, O. & P. Michel 1977. Etude sédimentologique dúne lagune saumâtre méditerranéenne, l'étang du Prevost (Hérault). *Vie et Milieu*, 27 (1B): 111-130.

Guelorget, O. & J.-P. Perthiusot 1983. Le domaine paralique. Expressions géologiques, biologiques et économiques du confinement. *Trav. Lab. Geol. E. N. S.*, Paris, 16: 136 pp.

Hartley, J. P. & B. Dicks 1987. Macrofauna of subtidal sediments using remote sensing. In: Biological surveys of estuaries and coasts. Ed. J. M. Baker & W. J. Wolff, EBSA handbook, Cambridge University press, Cambridge: 106-130.

Henriksson, R. 1969. Influence of pollution on the bottom fauna of the Sound (Öresund). *Oikos*, 20: 507-523.

Hill, M. O. 1979. *TWINSPAN - A FORTRAN Program for Arranging Multivariate Data in an Ordered Two-way Table by Classification of the the Individuols and Attributes*. Ithaca, N.Y.: Cornell University, 48pp.

Hill M. O., R. G. H. Bunce & M. W. Shaw 1975. Indicator species analysis, a divisive polythetic method of classification and its application to a survey of native pinewoods in Scotland. *Journal of Ecology*, 63: 597-613.

Hily, C. 1983. Macrozoobenthic recolonization after dredging in a sandy mud area of the Bay of Brest enriched by organic matter. *Oceanol. Acta. Proceedings 17th European Marine Biology Symposium, Brest, 27 Sept.-1 Oct., 1982*: 113-120.

Hily, C. 1984. *Variabilité de la macrofaune benthique dans les milieux hyper-trophiques de la rade de Brest*. Thèse Docteur Ès-Sciences, Univ. Bretagne Occidentale. Vol. I: 359 pp, Vol. II: 337 pp.

Hily, C., H. le Bris & M. Glémarec 1986. Impacts biologiques des emissaires urbains sur les ecosystèmes benthiques. *Océanis*, 12: 419-426.

Hoare, R. & E. H. Wilson 1977. Observations on the behaviour & distribution of *Virgularia mirabilis* O. F. Müller (*Coelenterata: Pennatulacea*) in Holyhead harbour, Anglesey. *in: Biology of benthic organisms. 11th European Marine Biology Symposium, Galway, 5-11 Oct. 1976*, Ed. B. F. Keegan, P. Ó'Ceidigh & P. J. S. Boaden: 329-337.

Holme, N. A. & D. McIntyre, (Eds), 1984. *Methods for the study of the Marine Benthos*. 2ª Edição. Blackwell Scientific Publications, Oxford. XII + 387 pp.Holthe, 1986

Hulbert, S. N. 1971. The non-concept of species diversity: a critique and alternatives parameters. *Ecology*, 52: 577-586.

IAEA - International Atomic Energy Agency 1985. Sediment K_ds and concentration factors for radionuclides in the marine environment. *Technical report series* nº 247: 73 pp.

Ibanez, F. & J.-C. Dauvin 1988. Long-term changes (1977 to 1987) in a muddy fine sand *Abra alba - Melinna palmata* community from the western English channel: Multivariate time-series analysis. *Mar. Ecol. Prog. Ser.*, 49: 65-81.

Ingle, R. W. 1980. *British crabs*. British Museum (Natural History): Oxford University press: 222 pp.

Inman, D. L. 1952. Measures for describing the size distribution of sediments. *J. Sediment. Petrol.*, 22: 125 - 145.

Jaramillo, E., S. Mulsow, M. Pino & H. Figueroa 1984. Subtidal benthic macroinfauna in an estuary of south Chile: distribution pattern in relation to sediment types. *P.S.Z.N.I.: Marine Ecology* 5 (2): 119-133.

Jeffrey, D. W., J. G. Wilson, C. R. Harris & D. L. Tomlinson 1985. *A manual for the assessment of estuarine quality*. Eds. D. G. Jeffrey & J. G. Wilson. Irish Estuarine Research Programme (IERP), Environmental Sciences Unit, TCD. 2nd edition: 161 pp+ 4 Appendices.

Jones, A. M. 1974/75. A survey of the benthos of the Tay estuary. *Proceedings of the Royal Society of Edinburgh* (B), 75: 113-135.

Jones, A. R., C. J. Watson-Russel & A. Murray 1986. Spatial patterns in the macrobenthic communities of the Hawkesbury Estuary, New South Wales. Aust. J. Mar. Freshw. Res., 37: 521-543.

Jongman, R.H.G., C. J. F. ter BRAAK & O. F. R., van TONGEREN (Eds.) 1987. *Data Analysis in Community and Landscape Ecology*. Pudoc, Wageningen. IXX + 299 pp.

Josefson, A. B., 1986. Temporal heterogeneity in deep water soft sediment benthos - an attempt to reveal temporal structure. *Estuarine coastal and shelf science*, 23: 147 - 169.

Katzmann, W., L. Laubier & J. Ramos 1974. *Pilargidae* (Annélides Polychètes errantes) de Méditerranée. *Bull. Inst. océanogr. Monaco*, 71 (1428), 40pp., 12figs.

Kennish, M. J. 1986. *Ecology of estuaries. Vol I. Physical and chemical aspects*. CRC Press, Inc.:254 pp.

Kingston, P. 1987. Field effects of platform discharges on benthic macrofauna. *Phil. Trans. R. Soc. London, Ser. B*, 316: 545-565.

Kingston, P. F. & M. J. Ridle 1989. Cost effectiveness of benthic faunal monitoring. *Mar. Pollut. Bull.*, 20: 490-496.

Kocatas, A & R. Geldiay 1980. Effects of domestic pollution in Izmir Bay (Turkey). *Helgoländer Meeresunters.*, 33: 393-400.

Kristensen, E. & F. Ø. Anderson, 1987. Determination of organic carbon in marine sediments: a comparison of two CHN-analyser methods. *J. Exp. Mar. Biol. Ecol.*, 109: 15-23.

Krumbein, W. C., 1934. Size frequency distribution of sediments. *J. Sediment. Petrol.*, 4: 65 - 77.

Labourg, P. J. 1980. Structure et évolution de la macrofaune invertébrée des écosystèmes lagunaires aménagés du bassin d'Arcachon. Application du concept de stratégie cénotique. *In*: *Recherches d'écologie théorique. Les stratégies adaptatives*. Ed. R. Barbault, P. Blandin & J. A. Meyer: 279-295.

Lambshead, P. J. D. & H. M. Platt 1985. Structural patterns of marine benthic assemblages and their relationship with empirical statistical models. *Proceedings 19th European Marine Biology Symposium, Plymouth, 16-21 Sep., 1984*. Ed. P. E. Gibbs: 371-380.

Lambshead, P. J. D., H. M. Platt & K. M. Shaw, 1983. The detection of differences among assemblages of marine benthic species based on an assessment of dominance and diversity. *Journal of Natural History*, 17: 859-874.

Landner, L., K. Nilsson & R. Rosenberg 1977. Assessment of industrial pollution by means of benthic macrofauna surveys along the Swedish Baltic coast. Vatten, 3/77: 324-379.

Larsen, B. & A. Jensen, 1989. Evaluation of the sensitivity of sediment stations in pollution monitoring. *Mar. Pollut. Bull.*, 20:556-560.

Larsonneur, C., 1977. La cartographie des depots meubles sur le plateau continental français: méthode mise au point et utilisée en Manche. *J. Rech. Océanogr.*, 2 (2): 33 - 39.

Legendre, L & P. Legendre 1984. *Ecologie numérique. 1. Le traitement multiple des donnés écologiques*. Collection d'Écologie, nº 12, Masson, Paris, 2ème édition: XV+260 pp.

Leppäkoski, E. 1975. Assessment of degree of pollution on the basis of macrozoobenthos in marine and brackish-water environments. *Acta Acad. abo.*, ser. B., 35: 1-90.

Lincoln, R. J. 1979. *British Marine Amphipoda: Gammaridea.* British Museum (Natural History), 658 pp.Lloyd & Ghelardi, 1964

Lloyd, M. & R. J. Ghelardi 1964. A table for calculating the "Equitability" component of species diversity. *J. Anim. Ecol.*, 33: 217-225.

Lopez-Jamar, E. 1982. Distribución espacial de las comunidades bentónicas infaunales de la ría de Arosa. *Bol. Inst. Esp. Oceanog.*, 7:255-268.

López-Jamar, E. 1985. Distribución espacial del poliqueto *Spiochaetopterus costarum* en las Rías Bajas de Galicia y su posible utilización como indicador de contaminación orgánica en el sedimento. *Bol. Inst. Esp. Oceanog.*, 2: 68-76.

López-Jamar, E. & J. Mejuto, 1986. Evolución temporal de cuatro comunidades infaunales submareales de las Rías de Arosa y Muros. Resultados preliminares. *Bol. Inst. Esp. Oceanog.*, 3: 95-110.

Marques, J. C. 1989 - *Amphipoda (Crustacea) bentónicos da costa portuguesa: estudo taxonómico, ecológico e biogeográfico.* Tese Doutoramento, Univ. Coimbra, Fac. de Ciência e Tecnologia, 394pp.

Marques, J. C. & D. Bellan- Santini 1985. Contribution à l'étude systématique et écologique des Amphipodes (Crustacea -

Amphipoda) des côtes du Portugal. Premier inventaire des espéces (Gamariens et Caprelliens). *Ciênc. Biol. Ecol. Syst. (Portugal)*, 5: 299-353.

McCall, P. L. 1977. Community patterns and adaptative strategies of the infaunal benthos of Long Island Sound. *Journal of Marine Research*, 35: 221-266.

McIntyre, A. D. 1984. What happened to biological effects monitoring. *Mar. Pollut. Bull.*, 15, 391-392.

McIntyre, A. D. 1986. Biological effects and pollution assessment. *Wat. Sci. Techn.*, 18: 155-160.

McLusky, D. S. 1982. The impact of petrochemical effluent on the fauna of ab intertidal estuarine mudflat. *Estuarine, Coastal and Shelf Science*, 14: 489-499.

McLusky, D. S. 1989. *The Estuarine Ecosystem.* 2ª Edição. Blackie Glasgon. VIII + 215pp.

McLusky, D. S. & M. Elliott 1981. The feeding and survival strategies of estuarine molluscs. *in: Feedings and survival strategies of estuarine organisms.* Ed. N. V. Jones & W. J. Wolff: 109-121.

McLusky, D. S. & M. McCrory 1989. A long-term study of an estuarine mudflat subject to industrial pollution. *In: Topics in Marine Biology.* ROS., J. D. (Ed.). *Scient. Mar.*, **53**, (2-3). *22nd European Marine Biology Symposium, Barcelona, 17-22 August*: 717-724.

McNeill, S. & J. H. Lawton 1970 - Annual production and respiration in animal populations. *Nature*, 225: 472-474.

Meire, P. M. & J. Dereu, 1990. Use of the abundance/biomass comparison method for detectinf environmental stress: some considerations based on intertidal macrozoobenthos and bird communities. *Journal of Applied Ecology*, 27: 210-223.

Mendonça, E. & A. M. Picado 1989. Testes de toxicidade de alguns efluentes industriais do estuário do Rio Sado com *Daphnia magna* Strauss (*Cladocera, Crustacea*). *LNETI report.* 42 pp.

Milne, R. A., P. C. Nicholas, C. Pattinson & W. Halcrow 1986. The definition of effluent discharge consent conditions in complex estuarine environments. *Wat. Sci. Techn.*, 18: 267-276.

Monteiro Marques, V. 1982. Echinodermes de l'estuaire du Sado (Setúbal, NW Portugal). *Tethys*, 10: 379-381.

Mora, J. 1982. Consideraciones generales sobre la macrofauna bentónica de la ría de Arosa. *Oecologia Aquatica*, 6: 41-49.

Mora, J., M. A. García & R. Acuña 1982. Contribución al conocimiento de las poblaciones de la macrofauna bentónica de la ría de Pontevedra. *Oecologia Aquatica*, 6: 51-56.

Muus, B. J. 1967. The fauna of Danish estuaries and lagoons. Distribution and ecology of dominating species in the shallow reaches of the mesohaline zone. *Fiskeri-OG Havunders*. ser.5 nº 1: 1-316.

Myers, A. A. & D. McGrath 1991. The *Ampelisca diadema* group of species (*Amphipoda: Gammaridea*) in British and Irish waters. *J. mar. biol. Ass. U. K.*, 71: 265-279.

Neves, R. J. J. 1985a. *Étude expérimentale et modélisation mathématique des circulations transitoire et résiduelle dans l'estuaire du Sado.* Thesis "Docteur en Sciences Appliquées", Univ. Liège, Belgic. 271 p.p

Neves, R. J. J. 1985b. Bidimensional model for residual circulation in coastal zones: application to the Sado estuary. *Annales Geophysicae*, 3, 4: 465-472.

Neves, R. J. J. 1986. Modelo matemático do estuário do Sado.Thesis summary. *I.S.T. report:* 94 pp.

O'Connor, B. D. S. 1987. The *Glyceridae* (Polychaeta) of the North Atlantic and Mediterranean, with description of two new species. *Journal of Natural History*, 21: 167-189.

Odum, E. P. 1971. *Fundamentals of ecology*. 3rd ed., W. B. Saunders Company, Philadelphia. 574 pp.

Odum, H. T. & B. J. Copeland 1974. A functional classification of the coastal systems of the United States. *In: Coastal ecological systems of the United States*. Eds. H. T. Odum, B. J, Copeland & E. A. McMahan, The Conservation Foundation, Washington, D. C.: 5-71.

Otto, G. H. 1939. A modified logarithmic probability graph for the interpretation of mechanical analysis of sediments. *J. Sediment. Petrol.*, 9: 62 - 76.

Pearson, T. H. 1971a. Studies on the ecology of the macrobenthic fauna of lochs Linnhe and Eil, west coast of Scotland. II - Analysis of the macrobenthic fauna by comparison of feeding groups. *Vie et Milieu*, suppl. nº 22: 53-91.

Pearson, T. H. 1971b. The benthic ecology of Loch Linnhe and Loch Eil, a sea-loch system on the west coast of Scotland. III. The effect on the benthic fauna of the introduction of pulp mill effluent. *J. exp. mar. Biol. Ecol.*, 6: 211-233.

Pearson, T. H. 1972. The effect of industrial effluent from pulp and paper mills on the marine benthic environments. *Proc. R. Soc. B*, 180: 469-485.

Pearson, T. H. 1975. The benthic ecology of Loch Linnhe and Loch Eil, a sea-loch system on the west coast of Scotland. IV. Changes in the benthic fauna attributable to organic enrichment. *J. exp. mar. Biol. Ecol.*, 20: 1-41.

Pearson, T. H. 1976. A comparative study of the effects on the marine environment of wastes from cellulose industries in Scotland and Sweden. *Ambio*: 77-79.

Pearson, T. H. 1980. Marine pollution effects of pulp and paper industry wastes. *Helgoländer Meeresunters.*, 33: 340-365.

Pearson, T. H., A. D. Ansell & L. Robb 1986. The benthos of the deeper sediments of the Firth of Clyde, with particular reference to organic enrichment. *Proceedings of the Royal Society of Edinburgh*, 90B: 329-350.

Pearson, T. H. & J. Blackstock 1983. Selection of indicator species: a coordinated ecological and biochemical approach to the assessment of pollution. *Oceanol. Acta. Proceedings 17th European Marine Biology Symposium, Brest, 27 Sept. - 1 Oct., 1982*: 147-151.

Pearson, T. H., G. Duncan & J. Nuttal, 1982. The Loch Eil project: Population fluctuations in the macrobenthos. *J. Exp. Mar. Biol. Ecol.*, 56: 305-321.

Pearson, T. H., J. S. Gray & P. J. Johannessen 1983. Objective selection of sensitive species indicative of pollution-induced change in benthic communities. 2. Data analyses. *Mar. Ecol. Prog. Ser.*, 12: 237-255.

Pearson, T. H. & R. Rosenberg 1978 - Macrobenthique sucession in relation to organic enrichment and pollution of the marine environment. *Oceanogr. Mar. Biol. Ann. Rev.* 16: 229-311.

Pearson, T. H. & R. Rosenberg 1987 - Feast and famine: structuring factors in marine benthic communities. *in: Organization of communities, past and present. 27th Symposium of the British Ecological Society, Aberystwyth, 1986*, Ed. J. H. R. Geeand P. S. Giller 373-395.

Pearson, T. H. & S. O. Stanley 1977. The benthic ecology of some Shetland Voes. *in: Biology of benthic organisms. 11th European Marine Biology Symposium, Galway, 5-11 Oct. 1976*, Ed. B. F. Keegan, P. Ó'Ceidigh & P. J. S. Boaden: 503-512.

Peneda, M. C. 1980. Estudo de impacte da central termoeléctrica de Setúbal. Resultados preliminares - Fase I. *Serviços de Estudo do Ambiente report.* 125 pp.

Peneda, M. C. 1981. Produção de energia termoeléctrica e salvaguarda do meio. *Rec. Hidr.*, 2: 33-60.

Peneda, M. C., M. M. Cruces, J. L. Biscaia, & M. C. Santos 1982a. Preliminary evaluation of physico-chemical and biological data collected during a yearly cycle in the Sado estuary. *Proceedings of Actual problems of oceanography in Portugal*, Ed. JNICT, Lisbon: 171-187.

Peneda, M. C., C. Santos, F. Melo, J. Santos & A. M. Rodrigues 1982b. Estudo de impacte da central termoeléctrica de Setúbal. Fase II - Resultados preliminares. *Seminário sobre o Ordenamento do Território, CIUR, Covilhã, Out. 1982.* 16pp.

Pérès, J. M. 1967. The Mediterranean benthos. *Oceanogr. Mar. Biol. Ann. Rev.*, 5: 449-533.

Pérès, J. M. & J. Picard 1964. Nouveau manuel de bionomie benthique de la mer Méditerranée. *Rec. Trav. Stn. Mar. Endoume*, Bull. 31: 137 pp.

Perthuisot, J.-P. & O. Guelorget 1987. Les milieux paraliques: diversité et unité. *Bull Écol.*, 18: 159-167.

Phelps, H. L. 1989. The Portuguese oyster, Crassostrea angulata : possible tributyltin effects. *Seminário - Aquacultura em Portugal, 18-20 Jan. 1989, Algarve.*

Picado, A. M. 1991. *Responses metaboliques d'invertebres marins aux pollutions. Cas particulier de la charge energetique adenylique.* Thèse pour l'obtention du diplôme de l'Ecole d'Hautes Études, Paris: 105 pp.

Pielou, E. C. 1966. The measurement of diversity in different types of biological collections. *J. theor. Biol.* 13, 131-144.

Pihl, L. & R. Rosenberg 1984. Food selection and comsumption of the shrimp *Crangon crangon* in some shallow marine areas in western Sweden. *Mar. Ecol. Prog. Ser.* 15: 159-168.

Pinto, P. 1982. Resultados preliminares sobre a cartografia bentónica do estuário do rio Sado (Setúbal, Portugal). *Oecologia Aquatica,* 6. *II Simpósio Ibérico de Bentos Marinho, Barcelona, Março 1981,* : 631-636.

Pleijel, F. 1988 - *Phyllodoce* (*Polychaeta, Phyllodocidae*) from Northern Europe. *Zoologica Scripta,* 17 (2):141-153)

Pritchard, D. W. 1955. Estuarine circulation patterns. *Am. Soc. Civil Eng.* 81: 717/1-717/11.

Quevauviller, Ph. 1987. *Etude geomorphologique, sedimentologique et geochimique du littoral de Galé et de l'estuaire du Sado (Portugal).* Thesis Doctorat en Oceanologie, Univ. Bordeaux, France. 256+LXXXIII pp.

Quevauviller, Ph. , J.-M. Jouanneau, C. Latouche & T. R. Pera 1986. Trace metal elements in fine-grained sediments of the Sado estuary (Portugal). *Proceedings of the International Conference - Chemicals in the environment, 1-3 July 1986, Lisbon.*

Quevauviller, Ph., R. Lavigne & L. Cortez 1989. Impact of industrial and mine drainage wastes on the heavy metal distribution in the drainage basin and estuary of the Sado river (Portugal). *Environ. Pollut.*, 59: 267-286.

Quevauviller, Ph., C. Vale, R. Lavigne, R. Pinel & M. Astruc 1988. Organotin compounds in intertidal sediments of the Sado estuary and mussel from the adjacent coastal area, Portugal. *In: Heavy metals in the hydrological cycle.* Eds. M. Astruc & J. N. Lester, Public. division, Selper Ltd, London, 1988: 425-432.

Quintino, V. 1988. *Structure et cinétique comparées des communautés de macrofaune benthique de deux systèmes lagunaires de la côte ouest du Portugal: Obidos et Albufeira.* Thèse de Doctorat, Oceanologie Biologique, Université Paris 6: 1-333.

Quintino, V & F. Gentil 1987. Etude faunistique et coenotique de la faune annélidienne des lagunes d'Albufeira et Obidos (Portugal). *Cah. Biol. Mar.*, 28: 59 - 72.

Quintino, V. & A. M. Rodrigues 1989. Environment gradients and distribution of macrozoobenthos in three Portuguese coastal systems: Óbidos, Albufeira and Alvor. *In: Reproduction, genetics and distributions of marine organisms. 23rd European Marine Biology Symposium, Swansea, 5-9 Sep.*, Ed. J. S. Ryland & P. A. Tyler: 441-450.

Quintino, V., A. M. Rodrigues & F. Gentil 1989. Assessement of benthic communities in the lagoon of Obidos, western coast of Portugal. *In: Topics in Marine Biology. 22nd European Marine Biology Symposium, Barcelona ,Barcelona, 17-22 Aug.* Ed. Ros., J. D.,*Scient. Mar.*, 53: 645-654.

Ramos, J. M. 1976. *Lumbrineridae* (Polychètes errantes) de Méditerranée. *Ann. Inst. océanogr., Paris,* 52: 103-137.

Rasmussen, E. 1973. Systematics and ecology of the Isefjord marine fauna (Denmark). *Ophelia,* 11: 1-507.

Rees, H. L., D. C. Moore, T. H. Pearson, M. Elliott, M. Servile, J. Pomfret & D. Johnson, 1990. Procedures for the monitoring of Marine Benthic Communities at UK Sewage Sludge Disposal Sites. *Dep. Agriculture and Fisheries for Scotland. Scottish Fisheries Information Pamphlet,* 18: 1-79.

Reish, D. J. 1980. Effect of domestic wastes on the benthic marine communities of southern California. *Helgoländer Meeresunters.*, 33: 377-383.

Reish, D. J. 1984. Domestic wastes. *In: Marine Ecology,* vol. V, part 4. Ed. O. Kinne. J. Wiley & Sons, Ltd.: 1711-1767.

Retière, C. 1979. *Contribution à la connaissance des peuplements benthiques du golfe Normanno-Breton.* Thèse D'État, Univ. Rennes. 431 pp.

Rhoads, D. C. & J. D. Germano 1982. Characterization of organism-sediment relations using sediment profile imaging: An efficient method of remote ecological monitoring of the sea floor (REMOTS^{TM} System). *Mar. Ecol. Prog. Ser.*, 8: 115-128.

Rhoads, D. C. & J. D. Germano 1986. Interpreting long-term changes in benthic community structure: a new protocol. *Hydrobiologia*, 142: 291-308.

Rhoads, D. C., P. L. McCall & J. Y. Yingst 1978. Disturbance and production on the estuarine sea floor. *Amer. Sci.*, 66: 577-586.

Ribeiro, M. M. C. & R. J. J. Neves 1982. Caracterização hidrográfica do estuário do Sado. *Serviço de Estudos do Ambiente report.*

Robertson, A. I. 1979. The relationship between annual production: biomass ratios and lifespans for marine macrobenthos. *Oecologia*, 38: 193-203.

Rodrigues, A. M. 1982. *Contribuição para o estudo da região adjacente à Central Termoeléctrica de Setúbal com referência particular ao macrozoobentos.* Estágio de Licenciatura,Univ. Lisboa, Fac. Ciências, 171 pp. (*unpub. report*).

Rodrigues, A. M. & J.-C. Dauvin 1987. Crustacés péracarides de la "ria de Alvor" (côte du Sud de Portugal). *Cah. Biol. Mar.*, 28: 207-223.

Rodrigues , A. M. & V. Quintino 1986. Macrofauna bentónica da Ria de Alvor, costa sul de Portugal: sedimentologia, estrutura e distribuição de povoamentos. *In: Caracterização ecológica da Ria de Alvor. Plano Geral Director de Aproveitamento e Valorização da Ria de Alvor. LNETI-DEII report, July 1986*: 88 - 188.

Rodrigues, A. M. & V. Quintino 1988. Avaliação do efeito dos efluentes das indústrias de pasta de papel Soporcel e Celbi sobre a macrofauna bentónica do meio receptor. *Actas da 1ª Conf. Nacional sobre a Qualidade do Ambiente, Aveiro, 22 - 24 Fevereiro 1988*, Eds. C. Borrego, I. Fernandes, A. R. Pires & A. Samagaio, 1: 250 - 262.

Rodrigues , A. M. & V. Quintino 1991a. Diagnóstico do estado de qualidade das comunidades biosedimentares subtidais da Peninsula da Mitrena, Estuário do rio Sado. *LNETI-DEII report, Outubro, 1991.* 13: 1- 36.

Rodrigues, A. M. & V. Quintino 1991b. Malacofauna da Ria de Alvor (costa Sul de Portugal) estudo faunístico e cenótico. *Actas V Simp. Ibér. Estud. Bentos Mar., Tenerife, 22-27 Sept.1986.* tomo 1: 167-192.

Rodrigues, A. M., A. M. Picado, V. Quintino, E. Mendonça, F. Duarte, J. Blackstock & T. H. Pearson. Análise ao nível do individuo e da comunidade dos efeitos biológicos associados à descarga de efluentes industriais: um caso de estudo. *Actas da 3ª Conf.*

Nacional sobre a Qualidade do Ambiente, Aveiro, 5 - 7 Fevereiro 1992 (in press).

Rosenberg, R. 1972. The benthic faunal recovery in a Swedish fjord following the closure of a sulphite pulp mill. *Oikos* 23: 92-108.

Rosenberg, R. 1973. Succession in benthic macrofauna in a Swedish fjord subsequent to the closure of a sulphite pulp mill. *Oikos* 24: 244-258.

Rosenberg, R. 1976. Benthic faunal dynamics during succession following pollution abatement in a Swedish estuary. *Oikos*, 27: 414-427.

Rosenberg, R. 1980. Effect of oxygen deficiency on benthic macrofauna fjords. *In: Fjord Oceanography*, Eds. H. J. Freeland, D. M. Farmer & C. D. Levings. Plenum Press, New York: 499-514.

Rosenberg, R. 1985. Eutrophication - the future marine coastal nuisance? *Mar. Pollut. Bull.*, 16: 227-231.

Sanders, H. L., 1968. Marine benthic diversity: a comparative study. *American Naturalist*, 102: 243-282.

Santos, M. C. S. 1990. Repartição espaço-temporal do zooplancton no estuário do rio Sado. *LNETI report, Provas de Acesso a Investigador Auxiliar.* XXVII+258pp.

Schoettler, U. & M. Grieshaber 1988. Adaptation of the polychaete worm *Scoloplos armiger* to hypoxic conditions. *Mar. Biol.*, 99: 215-222.

Swartz, R. C., F. A. Cole, D. W. Schults & W. A. DeBen 1986. Ecological changes in the Southern California Bight near a large sewage outfall: benthic conditions in 1980 and 1983. *Mar. Ecol. Prog. Ser.*, 31: 1-13.

Schwinghamer, P. 1988. Influence of pollution along a natural gradient and in a mesocosm experiment on biomass-size spectra of benthic communities. *Mar. Ecol. Prog. Ser.*, 46: 199-206.

Schwinghamer, P., Hargrave, D. Peer & C. M. Hawkins 1986 - Partitioning of production and respiration among size groups of organisms in an intertidal benthic community. *Mar. Ecol. Prog. Ser.*, 31: 131-142.

Segar, D. A. & E. Stamman 1986. A strategy for design of marine pollution monitoring studies. *Wat. Sci. Tech.*, 18, *Proceedings IAWPRC/NERC, Plymouth, 16-19 July, 1985*: 1-14.

Shannon, C. E. & W. Weaver, 1963. *The Mathematical Theory of Communication.* University of Illionois Press, Urbana Illinois: 117pp.

Shaw, K. M., P. J. D. Lambshead & H. M. Platt, 1983. The determination of pollution induced disturbance in marine benthic assemblages, with special reference to nematodes. *Mar. Ecol. Progr. Series*, 11: 195-202.

Sobral, J. T. 1977 - *Estuário do Sado. Observação de correntes de maré.* Ed. Instituto Hidrográfico, Lisbon.

Soulsby, P. G., D. Lowthion & M. C. M. Houston 1985. The identification and evaluation of environmental quality in Southampton water, UK, using limited manpower ressources. *In: Estuarine management and quality assessment.* Eds. J. G. Wilson & W. Halcrow, Plenum Press, London: 187-202.

Tebble, N. 1976. *British bivalve seashells. A handbook for identification.* Royal Scottish Museum, 2nd edition: 212 pp.

ter Braak, C. J. F. 1985. Correspondence analysis of incidence and abundance data: Properties in terms of a unimodal response model. *Biometrics*. 41: 859-873.

ter Braak, C. J. F. 1986. Canonical correspondence analysis: a new eigenvector technique for multivariate direct gradient analysis. *Ecology*, 67: 1167-1179.

ter Braak, C. J. F. 1987a. Ordination. *In: Data analysis in community and landscape ecology.* Eds. R. H. G. Jongman, C. J. F. ter Braak & O. F. R. van Tongeren: 91-173.

ter Braak, C. J. F. 1987b. The analysis of vegetation-environment relationship by canonical correspondence analysis. *Vegetatio* 69: 69-77.

ter Braak, C. J. F. 1987c. *Unimodal Models to Relate Species to Environment.* Agricultural Mathematics Group, Wageningen, 151 pp.

ter Braak, C. J. F. 1988. *CANOCO - a FORTRAN program for canonical community ordination by [partial] [detrended] [canonical] correspondence analysis, principal components analysis and redundancy analysis (version 2.1).* Agricultural Mathematics Group, Wageningen, 95 pp.

ter Braak, C. J. F. 1990. CANOCO, Version 3.11. Update notes. Agricultural Mathematics Group, Wageningen. (*Unpubl. report*) 35 pp.

ter Braak, C. J. F. & C. W. N. Looman 1987. Regression. *In: Data analysis in community and landscape ecology.* Eds. R. H. G. Jongman, C. J. F. ter Braak & O. F. R. van Tongeren: 29-77.

ter Braak, C. J. F. & I. C. Prentice 1988. A theory of gradient analysis. *Advances in Ecological Research*, 18: 271-317.

Thompson, G. B. & P. K. S. Shin 1983. Sewage pollution and the infaunal benthos of Victoria harbour, Hong Kong. *J. Exp. Mar. Biol. Ecol.*, 67: 279-299.

Thorson, G. 1957. Bottom communities (sublittoral or shallow shelf). *Mem. geol. Soc. Am.*, 67: 461-534.

Trask, P. D., 1930. Mechanical analysis of sediments by centrifuge. *Econ. Geol.*, 25: 581 - 599.

Tsutsumi, H., T. Kikuchi, M. Tanaka, T. Higashi, K. Imasaka & M. Miyazaki 1991. Benthic faunal succession in a cove organically polluted by fish farming. *Mar. Poll. Bull.*, 23: 233-238.

Tyler. P. A. & S. E. Shackley 1980. The benthic ecology of linear sandbanks: a modified Spisula sub-community. *In: Industrial embayments and their environmental problems.* Eds. M. B. Collins *et al.*, Pergamon press: 539-554.

Underwood, A. J. & C. H. Peterson, 1988. Towards an ecological framework for investigating pollution. *Mar. Ecol. Prog. Ser.*, 46: 227-234.

Vale, C. & B. Sundby 1982. A survey of the elemental composition of bottom sediments in the Sado estuary. *Proceedings of Actual problems of oceanography in Portugal*, Ed. JNICT, Lisbon: 189-200.

van Tongeren, O. F. R. 1987. Cluster analysis. *In: Data analysis in community and landscape ecology.* Eds. R. H. G. Jongman, C. J. F. ter Braak & O. F. R. van Tongeren: 174-212.

Vanosmael, C., K. A. Willems, D. Claeys, M. Vincx & C. Heip 1982. Macrobenthos of a sublittoral sandbank in the Southern Bight of the North Sea. *J. mar. bio. Ass. U. K.*, 62: 521-534.

Warren, L. M. 1981. Respiratory adaptations to temporary hypoxia by the polychaete Cirriformia tentaculata. *Comp. Biochem. Physiol. A*, 69: 321-324.

Warwick, R. M. 1986. A new method for detecting pollution effects on marine macrobenthos communities. *Mar. Biol.*, 92: 557-562.

Warwick, R. M. 1988a. Effects on community structure of a pollutant gradient - introduction. *Mar. Ecol. Prog. Ser.*, 46: 149.

Warwick, R. M. 1988b - Effects on community structure of a pollutant gradient - summary. *Mar. Ecol. Prog. Ser.*, 46: 207-211.

Warwick, R. M. 1988c. The level of taxonomic discrimination required to detect pollution effects on marine benthic communities. *Mar. Pollut. Bull.*, 19: 259-268.

Warwick, R. M. & K. R. Clarke 1991. A comparison of some methods for analysing changes in benthic community structure. *J. mar. bio. Ass. U. K.*, 71: 225-244.

Warwick, R. M, T. H. Pearson & Ruswahyuni, 1987. Detection of pollution effects on marine macrobenthos: further evaluation of the species abundance/biomass method. *Mar. Biol.*, 95: 193-200.

Warwick, R. M. & Ruswahyuni 1987. Comparative study of the structure of some tropical and temperate marine soft-bottom macrobenthic communities. *Mar. Biol.*, 95: 641-649.

Waters, T. F. 1969. The turnover ratio in production ecology of freshwater invertebrates. *American Naturalist* : 103: 173-185.

Wildish, D. J. 1983. Coastal zone management and the pulp and paper industry. *In: Pulp & Paper Can.*, 84: T145-T148.

Wildish, D. J. 1985. Geographical distribution of macrofauna on sublittoral sediments of continental shelves: a modified trophic ratio concept. *Proceedings of the 19 th European Marine Biology Symposium, Plymouth, Devon, U.K., 16-21 Sep. 1984.* Ed. P. E. Gibbs: 335-346.

Wildish, D. J., J. D. Martin, A. J. Wilson & A. M. DeCoste 1986. Hydrographic and sedimentary conditions in the l'Etang Inlet during 1985. *Can. Tech. Rep. Fish. Aquat. Sci.*, 1473: III+14pp.

Wildish, D. J., N. J. Poole & D. D. Kristmanson 1979. Pulp mill pollution in the l'Etang estuary, a case history and clean-up alternatives. *Fish. Mar. Serv. Tech. Rep.*, 884: III+6 pp.

Wilson, J. G. 1988. *The biology of estuarine management.* Croom Helm, London: 192 pp.

Window, H. L., K. T. Tenore & D. L. Rice 1982. Metal accumulation of the Polychaete Capitella capitata: Influence of metal content and nutritional quality of detritus. *Can. J. Fish. Aquat. Sci.*, 39: 191-196.

Withers, R. G. & C. H. Thorp 1978. The macrobenthos inhabiting in Langstone Harbour, Hampshire. *J. nat. Hist.*, 12: 445-455.

Wolff, W. 1971. Distribution of four species of Nepthys (Polychaeta) in the estuarine area of the rivers Rhine, Meuse, and Scheldt. *Vie et Milieu,* Suppl. 22: 677-698.

Wolff, W. J. 1973. The estuary as a habitat: an analysis of data on the soft bottom macrofauna of the estuarine area of the rivers Rhine, Meuse and Scheldt. *Zool. Verhandel. Leiden.* 126: 1-242.

Wollast, R. 1978a - Rio Sado. Campagne de mesures de juillet 1978, *Secretaria de Estado do Ambiente report,* Lisbon.

Wollast, R. 1978b - Rio Sado. Campagne de mesures de décembre 1978, *Secretaria de Estado do Ambiente report,* Lisbon.

Wollast, R. 1979 - Rio Sado. Campagne de mesures d'ávril 1978, *Secretaria de Estado do Ambiente report.*

ANNEXES

Annex I - Minimum and maximum value, range, mean and standard deviation of the physico-chemical parameters considered: temperature, salinity, suspended solids, dissolved oxygen, BOD, ammonia, nitrates, nitrites and phosphates.

TEMPERATURE (°C)

Stations		Minimum	Month	Maximum	Month	Range	Mean ± St.Deviation
A	Surface	12.96	Feb.	20.92	Ag.	7.96	17.28 ± 2.381
	Bottom	13.03	Feb.	20.09	Ag.	7.06	16.83 ± 1.981
B	Surface	11.93	Feb.	21.49	Ag.	9.56	17.20 ± 2.934
	Bottom	12.44	Feb.	20.72	Ag.	8.28	16.75 ± 2.576
C	Surface	12.23	Feb.	22.62	Ag.	10.39	17.97 ± 3.324
	Bottom	12.26	Feb.	20.93	Ag.	8.67	17.27 ± 2.646
D	Surface	12.55	Feb.	22.98	June	10.43	18.10 ± 3.688
	Bottom	12.51	Feb.	21.75	Sept.	9.24	17.61 ± 3.309
E	Surface	12.69	Feb.	22.77	July	10.08	18.68 ± 3.920
	Bottom	12.1	Feb.	22.65	July; Ag.	10.55	18.03 ± 3.585
F	Surface	16.02	March	25.45	Sep.	9.43	20.60 ± 3.537
	Bottom	16.01	March	24.81	Sep.	8.8	19.94 ± 3.366
G	Surface	16.5	March	25.24	Sep.	8.74	20.75 ± 3.516

SALINITY (‰)

Stations		Minimum	Month	Maximum	Month	Range	Mean ± St.Deviation
A	Surface	35.04	April	37.29	July	2.25	36.13 ± 0.688
	Bottom	35.12	April	37.07	June	1.95	36.05 ± 0.513
B	Surface	31.67	Feb.	37.44	Aug.	5.77	35.20 ± 1.608
	Bottom	34.21	March	37.02	July	2.82	35.62 ± 0.939
C	Surface	31.85	Feb.	37.01	June	5.16	35.16 ± 1.544
	Bottom	33.48	Feb.	37.37	Aug.	3.89	35.49 ± 1.092
D	Surface	31.3	Feb.	36.82	June	5.52	34.75 ±1.626
	Bottom	31.6	Feb.	36.99	Aug.	3.39	34.97 ± 1.560
E	Surface	31.18	Feb.	38.02	Aug.	6.84	34.60 ± 1.880
	Bottom	31.39	Feb.	36.95	Aug.	5.56	34.76 ± 1.608
F	Surface	29.64	March	34.34	Oct.	4.71	32.36 ± 1.852
	Bottom	29.69	March	35.59	Sept.	5.9	33.40 ± 2.094
G	Surface	28.96	March	33.9	Oct.	4.95	32.01 ± 1.723

SS (mg/l)

Stations		Minimum	Month	Maximum	Month	Range	Mean ± St.Deviation
A	Surface	12	Nov.	26.8	July	14.8	18.14 ± 4.791
	Bottom	10.6	May	22.5	April	11.9	15.84 ± 4.032
B	Surface	12.6	Nov.	23.7	Oct.	11.1	17.42 ± 3.079
	Bottom	12.2	Jul/Nov	38.7	April	26.5	20.44 ± 7.700
C	Surface	11.6	Sep.	25.4	Aug.	13.8	16 ± 4.207
	Bottom	3.2	Jan.	24.2	June	21	16.47 ± 7.277
D	Surface	11.2	Nov.	99.7	Aug.	88.5	32.65 ± 25.989
	Bottom	14.5	Sep.	52.5	Aug.	38	30.74 ±11.838
E	Surface	12.3	Sep.	40.2	April	27.9	19.74 ± 8.031
	Bottom	12.9	Fev/Nov	37.2	Aug.	24.3	22.4 ± 9.552
F	Surface	18.2	March	30.5	Aug.	12.3	24.39 ± 3.795
	Bottom	12.1	Nov.	37.3	March	25.2	27.95 ± 9.661
G	Surface	17.2	Oct.	49.9	Aug.	32.7	29.64 ± 19.17

Annex I (continued)

OD (mg/l)

Stations		Minimum	Month	Maximum	Month	Range	Mean ± St.Deviation
A	**Surface**	7.37	May	9.53	Oct.	2.16	8.24 ± 0.658
	Bottom	7.45	May	9.49	Oct.	2.04	8.20 ± 0.682
B	**Surface**	6.47	Dec.	8.42	Feb.	1.95	7.87 ± 0.586
	Bottom	3.03	Feb.	8.41	Sep.	5.38	7.37 ± 1.515
C	**Surface**	7.23	April	9.31	Oct.	2.08	8.34 ± 0.650
	Bottom	6.66	Sep.	9.32	Oct.	2.66	7.93 ± 0.702
D	**Surface**	5.32	Dec.	7.85	Oct.	2.53	6.93 ± 0.732
	Bottom	5.14	Dec.	7.63	Jan/Oct	2.49	6.87 ± 0.822
E	**Surface**	7.06	Sep.	9.29	Oct.	2.23	7.77 ± 0.631
	Bottom	5.7	Sep.	8.79	Oct	3.09	7.56 ± 0.808
F	**Surface**	6.44	Aug.	9.1	Oct.	2.66	7.32 ± 0.786
	Bottom	6.34	Sep.	8.9	Oct.	2.56	7.43 ± 0.965
G	**Surface**	6.12	Aug.	9.35	Oct.	3.23	7.56 ± 1.097

BOD (mg/l)

Stations		Minimum	Month	Maximum	Month	Range	Mean ± St.Deviation
A	**Surface**	0.16	April	1.89	July	1.73	1.03 ± 0.529
	Bottom	0.31	April	2.36	June	2.05	1.01 ± 0.651
B	**Surface**	0.35	April	3.88	Aug.	3.53	1.28 ± 0.978
	Bottom	0.64	Nov.	2.67	Aug.	2.03	1.37 ± 0.693
C	**Surface**	0.13	April	3.06	Aug.	2.93	1.30 ± 0.791
	Bottom	0.45	May	1.67	June	1.22	0.98 ± 0.388
D	**Surface**	0.69	Oct.	5.75	Feb.	5.06	1.83 ± 1.421
	Bottom	0.1	Dec.	3.32	Feb.	3.22	1.46 ± 0.939
E	**Surface**	0.47	April	1.89	Aug.	1.42	1.05 ± 0.417
	Bottom	0.26	March	2.06	Aug.	1.8	0.95 ± 0.529
F	**Surface**	0.1	Oct.	2.15	July	2.05	1.12 ± 0.672
	Bottom	0.86	April	2.46	June	1.6	1.30 ± 0.508
G	**Surface**	0.24	April	2.96	March	2.72	1.41 ± 0.871

AMMONIA (µatg/l N)

Stations		Minimum	Month	Maximum	Month	Range	Mean ± St.Deviation
A	**Surface**	0.15	Feb.	2.35	Oct.	2.2	1.01 ± 0.771
	Bottom	0.12	May	1.73	Oct.	1.61	0.64 ± 0.528
B	**Surface**	0.97	April	6.61	Sep.	5.64	2.93 ± 1.729
	Bottom	0.22	May	3.91	Sep.	3.69	1.77 ± 1.179
C	**Surface**	0.26	Sep.	4.28	Oct.	4.02	1.41 ± 1.061
	Bottom	0.48	Jan/Sep	3.55	Oct.	3.07	1.32 ± 1.089
D	**Surface**	0.78	April	84.42	Feb.	83.64	14.83 ± 24.132
	Bottom	0.54	May	99.57	Feb.	99.03	13.20 ± 27.909
E	**Surface**	0.63	Sep.	4.47	Oct.	3.84	1.90 ± 1.018
	Bottom	0.72	July	4.28	Oct.	3.56	1.46 ± 1.040
F	**Surface**	0.16	Sep.	4.84	Oct.	4.68	1.41 ± 1.481
	Bottom	0.26	Sep.	3.68	Oct.	3.42	1.44 ± 1.314
G	**Surface**	0.06	July	3.35	Oct.	3.29	1.42 ± 1.023

Annex I (continued)

NITRATES (µatg/l N)							
Stations		Minimum	Month	Maximum	Month	Range	Mean ± St.Deviation
A	Surface	0.7	Aug.	7.05	Feb.	6.35	2.20 ± 2.061
	Bottom	0.41	Aug.	6.92	Feb.	6.51	2.24 ± 2.091
B	Surface	0.32	Sep.	7.19	Feb.	6.87	3.075 ± 2.390
	Bottom	0.41	July	7.69	Oct.	7.28	2.97 ± 2.507
C	Surface	0.21	Aug.	10.73	Feb.	10.52	3.18 ± 3.180
	Bottom	0.27	July	7.25	Oct.	6.98	2.55 ± 2.466
D	Surface	0.39	Sep.	24.64	Feb.	24.25	5.88 ± 6.685
	Bottom	0.32	Sep.	16.12	Feb.	15.8	4.40 ± 4.760
E	Surface	0.62	Sep.	7.82	Nov.	7.36	3.44 ± 2.762
	Bottom	0.54	July	18.47	Oct.	17.93	5.12 ± 5.794
F	Surface	0.3	July	7.33	Oct.	7.03	2.70 ± 2.636
	Bottom	0.52	May	7.3	Oct.	6.78	2.56 ± 5.864
G	Surface	0.08	July	9.08	Nov.	9	3.19 ± 3.254

NITRITES (µatg/l N)							
Stations		Minimum	Month	Maximum	Month	Range	Mean ± St.Deviation
A	Surface	0.25	Nov	1.08	Sep.	0.83	0.40 ± 0.274
	Bottom	0.13	July	0.47	Nov.	0.34	0.27 ± 0.104
B	Surface	0.13	April	0.48	Nov.	0.35	0.32 ± 0.115
	Bottom	0.11	July	0.85	Jan.	0.74	0.34 ± 0.200
C	Surface	0.12	Sep.	1.11	July	0.99	0.42 ± 0.285
	Bottom	0.15	Sep.	0.91	Nov.	0.76	0.34 ± 0.235
D	Surface	0.17	April	0.69	Sep.	0.52	0.49 ± 0.153
	Bottom	0.12	Oct.	0.91	Jan/Nov	0.79	0.42 ± 0.304
E	Surface	0.01	Sep.	0.88	Oct.	0.87	0.42 ± 0.231
	Bottom	0.09	Sep.	0.73	Oct.	0.64	0.32 ± 0.175
F	Surface	0.22	Jun/Ju	0.75	Aug.	0.53	0.47 ± 0.181
	Bottom	0.08	Sep.	0.75	Oct.	0.67	0.38 ± 0.212
G	Surface	0.17	June	0.72	Sep/Nov	0.55	0.48 ± 0.216

PHOSPHATES (µatg/l P)							
Stations		Minimum	Month	Maximum	Month	Range	Mean ± St.Deviation
A	Surface	0.1	May	9.66	July	9.56	1.98 ± 2.897
	Bottom	0.06	Sep.	5.99	July	5.93	1.74 ± 1.928
B	Surface	0.49	March	2.68	Dec.	2.19	1.41 ± 0.643
	Bottom	0.12	Feb.	10.31	July	10.19	1.81 ± 2.764
C	Surface	0.67	Jan.	14.01	July	13.34	2.66 ± 3.887
	Bottom	0.49	Jan.	11.44	July	10.95	2.27 ± 3.182
D	Surface	0.86	April	46.29	Feb.	45.43	9.48 ± 14.496
	Bottom	0.67	March	38.98	Feb.	38.31	7.4 ± 12.129
E	Surface	0.55	Sep.	9.58	Aug.	9.03	2.66 ± 2.572
	Bottom	0.44	March	4.27	Aug.	3.83	1.83 ± 1.256
F	Surface	0.56	April	5.66	Aug.	5.1	2.13 ± 1.543
	Bottom	0.74	April	9.73	June	8.99	3.21 ± 2.944
G	Surface	0.45	May	5.56	Aug.	5.11	2.12 ± 1.557

Annex II

Macrobenthic fauna list, taxonomic remarks and main texts used.

The faunal list has been organized mainly according to Bellan-Santini *et al.*, 1982, Barnes, 1980, Campoy, 1982, Chambers, 1985, D'Angelo & Gargiullo, 1978, Fauvel, 1923, 1927, Fage, 1951, Fauchald, 1977, George & Hartmann-Schröder, 1985, Holdich & Jones, 1983, Graham, 1971, Jones, 1976, Lejuez, 1966, Lincoln, 1979, Makings, 1977, Naylor, 1972, Tattersall & Tattersall, 1951, Tebble, 1976, Tebble & Chambers, 1982, Tortonese, 1965. Besides these books, several papers dealing with specific species or genus have been used for the faunistic determinations.

Despite the fact that the aim of this work is not of a detailed taxonomic study of the Sado macrofauna, some remarks appear interesting namely in what concerns the polychaets. Most of the *Polynoidae* species were identified with the help of Dra. S. Chambers from the Scottish Museum of Natural History and some differences appear on the Sado *Harmothöe* species, *H. imbricata, H. ljungmani* and *H. lunulata,* in relation to what was described namely in Chambers (1985) and Fauvel (1923). *H. imbricata* from the Sado estuary presents elytra frindged with papillae almost all round and longer than the ones drawn by the authors mentioned; the elytra of most of the specimens of Sado *H. ljungmani* show on the surface a path of small papillae and, finally in some specimens of *H. lunulata* were found elytra with a patch of papillae on the surface (like the one described in Tebble & Susan, *op.cit.*), and others in which the papillae were distributed more or less equally on all the elytra surface.

Besides *Harmothöe* species, another scale worm showed particular characteristics. It was identified as *Acoetes sp.* The single specimen sampled presented characteristics from *Panthalis oerstedi* Kinberg and *Polyodontes maxillosus* Ranzani. The head corresponds to the discription of *P. maxillosus* , though we did not find the branchiae described for this species, while the chaetae are similar to the ones described for*P. oerstedi.* The specimen was compared with *P. maxillosus* and *P. oerstedi* from the British Museum collection, and finnally it was seen by Drs. M. Pettibonne and K. Fauchauld who identified it as *Acoetes sp.*, mentioning that it could be a new species, but more specimens would be needed to confirm this hypothesis.

Another species found in the Sado, identifyed as *Dyalichone cf. acustica,* also caused some dificulties as it didn't match well with the known descriptions, the branchae being different. Nevertheless, after seeing the British Museum material and discussing with Dr. P. Knight-Jones, the specimens were named *Dyalichone cf acustica.*

The cirratulids determination also caused some problems. The *Tharyx* and the *Cirriformia* species seem to be *T. marioni* and *C. tentaculata.* However considering the existing identification problems of this family and the available keys, their determination followed an unpublished key provided by Dr. J. D. George from the British Museum (Natural History), which allows the identification only to the genus level.

The key used for the determination of the capitellids allows the classification of *Capitella* as *C. capitata* and this is the way it is refered in the text. It is likely though that our specimens may belong to a range of genotypes, as mentioned e. g. by Grassle & Grassle (1974).

Other interesting polychaets found in the Sado were an *Opheliidae, Ophelia laubieri,* a species only known from the Sado estuary and firstly described by Bellan & Costa (1987), and a Chrysopettalid, however also represented by a single individual, which was sent to Dr. C. Watson-Russel of the Northern Territory Museum of Arts and Sciences, Australia, who identified it as *Bahawnia cf. goodei.*

In respect to molluscs, the most interesting case concerns the gastropod *Nassarius argenteus.* The two specimens sampled in the course of this study were identified by Dr. J. J. van Aarsten, Netherlands, according to whom the species was only known from the west African coast.

In respect to the amphipods, some of the species determined in this study are known only from the Mediterranean and the Black sea or their presence outside this area is reported only from the Sado estuary (Marques, 1989). This is the case of *Corophium annulatum* and *C. runcicorne.* Also *Corophium* "complex" is a designation for *Corophidae* specimens which have mixed characteristics of the species *C. orientale* Schellenberg, a mediterranean endemic species, and *C. volutator* (Pallas), an Atlantic species. Specimens of *Corophim* "complex" were firstly described for the "Ria de Alvor" (southern coast of Portugal) by Rodrigues & Dauvin (1987) and were also collected in the Sado estuary both in the course of this work and afterwards (Rodrigues & Quintino, 1991). These specimens were always found in the upper regions of both estuaries.

References:

Barnes, R. D. 1980. *Invertebrate Zoology.* 4th ed., Holte-Saunders International Editions, Philadelphia: 1089 pp.

Bellan, G. & M. H. Costa 1987. Deux nouvelles espèces d'*Ophelia* abranches (*Polychaeta, Opheliidae*): *O. laubieri* et *O. amoureuxi. Bull. Mus. natn. Hist. nat. Paris,* s.4, 9:829-834.

Bellan-Santini, D., G. Karaman, G. Krapp-Schickel, M. Ledoyer, A. A. Myers, S. Ruffo & U. Schiecke 1982. The *Amphipoda* of the Mediterranean. *Mém. Inst. Oceanogr. Monaco,* 13: XIII+1-364pp.

Campoy, A. 1982. *Fauna de anelidos poliquetas de la Peninsula Iberica.* Thesis "Doctor", Fac. Ciencias, Univ. Navarra, Edciones Universidad de Navarra, S.A., Pamplona, XXIX+781 pp.

Chambers, S. 1985. *Polychaetes from Scottish waters. Part. 2 Families Aphroditidae, Sigalionidae and Polyodontidae.* Royal Scottish Museum Studies, 38 pp.

D'Angelo, G. & S. Gargiullo 1978. *Guida alle Conchiglie Mediterranee.* Fabri, Milano: 224 pp.

Fage, L. 1951. Cumacés. *Faune de France* 54, Paris, Lechevalier: 135 pp.

Fauchald, K. 1977. The polychaete worms. Definitions and keys to the orders, families and genera. Ed. R. E. Ostermeyer. *Natural History Museum of Los Angeles County, Science Series* 28: 1-190.

Fauvel, P. 1923 - Polychètes errantes. *Faune de France* 5, Paris, Lechevalier: 486 pp.

Fauvel, P. 1927- Polychètes sedentaires. *Faune de France* 16, Paris, Lechevalier: 494 pp.

George, J. D. & G. Hartmann-Schröder 1985. *Polychaetes: British Amphinomida, Spintherida & Eunicida.* Synopsis of the British fauna (new series), nº 32. Eds. D. M. Kermack & R. S. K. Barnes. E. J. Brill/Dr. W. Backhuys: 221pp.

Graham, A. 1971. *British Prosobranchs.* Synopsis of the British fauna, nº2. Academic press: VI+112 pp.

Grassle J. F. & J. P. Grassle 1974. Opportunistic life histories and genetic systems in marine benthic polychaetes. *Journal of Marine Research,* 32: 253-284.

Holdich & Jones 1983. *Tanaids.* Synopses of the British fauna, nº 27. CUP.

Jones, N. S. 1976. *British Cumaceans.* Synopsis of the British fauna (new series), nº7. Academic press, London: 66 pp.

Lejuez, R. 1966. Comparaison morphologique, biologique et genétique de quelques espèces du genre *Sphaeroma* Latreille (*Isopodes Flabellifères*). *Arch. Zool. exp. gén.,* 107: 460-546. 546 pp.

Lincoln, R. J. 1979. *British Marine Amphipoda: Gammaridea.* British Museum (Natural History), 658 pp.Lloyd & Ghelardi, 1964

Marques, J. C. 1989 - Amphipoda (Crustacea) bentónicos da costa portuguesa: estudo taxonómico, ecológico e biogeográfico. Tese Doutoramento, Univ. Coimbra, Fac. de Ciência e Tecnologia, 394pp.

Makings, P. 1977. A guide to the British Coastal Mysidacea. *Fld. Std.,* 4: 575-595.

Naylor, E. 1972. *A synopsis of the British marine isopodes.* Synopses of the British fauna, nº3. Academic press: 86 pp.

Rodrigues, A. M. & J.-C. Dauvin 1987. Crustacés péracarides de la "ria de Alvor" (côte du Sud de Portugal). *Cah. Biol. Mar.,* 28: 207-223.

Rodrigues , A. M. & V. Quintino 1991. Diagnóstico do estado de qualidade das comunidades biosedimentares subtidais da Peninsula da Mitrena, Estuário do rio Sado. *LNETI-DEII report:* 36 pp.

Tebble, N. 1976. *British bivalve seashells. A handbook for identification.* Royal Scottish Museum, 2nd edition: 212 pp.

Tebble, N. & S. Chambers 1982. *Polychaetes from Scottish Waters. Part 1 Family Polynoidae.* Royal Scottish Museum Studies, 73pp.

Tattersal, W. M. & O. S. Tattersal 1951. The British Mysidacea. Ray Society, London: 460 pp.

Tortonese, E. 1965. *Echinodermata. Fauna d'Italia.* 6. Calderini, Bologna: 419pp.

ANNELIDA

POLYCHAETA

	Pr.	Ab.	Biom. (mg)
Orbiniidae			
Orbinia (=Aricia) foetida (Claparède)	3	6	1260.3
Scoloplos armiger (O. F. Müller)	62	1304	11999.0
Paraonidae			
Paradoneis lyra Southern	41	230	89.7
Spionidae			
Aonides oxycephala (Sars)	91	2066	10484.3
Malacoceros ciliata(Keferstein)	7	46	231.2
Malacoceros (=Scolelepis) fuliginosus (Claparède)	5	170	155.2
Microspio mecznikowianus (Claparède)	1	4	5.2
Polydora armata Langerhans	1	220	22.8
Polydora caeca (Oersted)	75	999	892.6
Polydora ciliata (Johnston)	3	4	1.2
Polydora hoplura Claparède	1	1	0.1
Prionospio cirrifera Wiren	20	71	42.6
Prionospio malmgreni Claparede	10	28	14.2
Pseudopolydora antennata (Claparède)	53	778	1339.2
Pygospio elegans Claparede	1	3	2.7
Spio decoratus Bobretzki	17	39	36.3
Spionidae sp.	3	4	1.6
Spiophanes bombyx (Claparede)	10	19	31.8
Streblospio shrubsolii (Buchanan)	4	12	1.2
Magelonidae			
Magelona alleni Wilson	5	12	112.6
Poecilochaetidae			
Poecilochaetus serpens Allen	15	57	113.2
Chaetopteridae			
Chaetopterus variopedatus (Renier)	1	1	412.2
Spiochaetopterus costarum (Claparède)	89	7187	57622.6
Cirratulidae			
Caulleriella sp.	103	2783	10278.5
Cirriformia sp.	100	3673	53426.7
Tharyx sp.	90	4796	11428.0
Capitellidae			
Capitella capitata (Fabricius)	20	15720	25928.1
Heteromastus filiformis (Claparède)	58	374	1731.4
Mediomastus capensis Day	72	1673	5100.2
Notomastus latericeus Sars	78	1066	14096.4
Maldanidae			
Clymenura clypeata (Saint-Joseph)	6	48	196.4
Euclymene oerstedi (Claparède)	2	59	613.6
Euclymene palermitana (Grube)	33	536	7909.0
Praxillella affinis (Sars)	1	3	47.9
Opheliidae			
Armandia cirrosa (Filippi)	3	5	4.4
Ophelia laubieri Bellan & Costa	3	10	6.8
Ophelia neglecta Schneider	1	1	2.5
Scalibregmatidae			
Scalibregma inflatum Rathke	51	660	3737.7
Phyllodocidae			
Anaitides lineata (Claparède)	47	163	1190.4
Anaitides mucosa (Oersted)	71	390	444.9
Eulalia viridis aurea Gravier	1	2	3.8
Eumida sanguinea (Oersted)	16	29	29.2
Eteone sp.	2	2	17.4

Hesionura elongata (Southern)	4	6	0.6
Mysta picta (Quatrefages)	4	6	56.8
Paranaitis kosteriensis (Malmgren)	4	9	31.5
Pseudomystides limbata Saint-Joseph	4	6	0.6
Protomystides sp.	2	2	0.2
Polynoidae			
Adyte pellucida Ehlers	1	1	3.6
Harmothoë imbricata Linnaeus	5	10	51.0
Harmothoë cf. impar (Johnston)	34	68	516.8
Harmothoë ljungmani (Malmgren)	15	65	234.0
Harmothöe lunulata (Delle Chiage)	5	7	35.7
Harmothöe marphysae McIntosh	6	8	40.8
Acoetidae			
Acoetes sp.	1	1	952.8
Sigalionidae			
Pholoë synophthalmica Claparède	9	17	157.3
Sigalion squamosum Delle Chiaje	1	1	94.1
Sthenelais boa (Johnston)	32	55	2319.6
Chrysopetalidae			
Bhawania cf goodei	1	1	7.3
Pisionidae			
Pisione remota (Southern)	17	206	95.7
Hesionidae			
Gyptis propinquos Marion et Bobretzky	4	6	129.5
Kefersteinia cirrata (Keferstein)	1	1	1.4
Microphtalmus cf. aberrans Webster & Benedict	2	14	1.6
Podarke agilis Ehlers	1	2	1.0
Pilargiidae			
Sigambra tentaculata (Treadwell)	3	7	8.3
Pilargis verrucosa Saint-Joseph	3	3	33.0
Syllidae			
Autolytus cf. langerhansi Gidholm	4	7	6.3
Diplosyllis cirrosa Gidholm	1	1	0.1
Exogone naidina Oersted	2	4	0.4
Exogone verrugera Claparède	10	22	2.2
Parapionosyllis elegans (Pierantoni)	29	222	27.2
Parapionosyllis labronica Cognetti	2	9	0.9
Sphaerosyllis bulbosa Southern	18	93	11.3
Sphaerosyllis hystrix Claparède	1	2	0.2
Sphaerosyllis taylori Perkins	1	1	0.1
Syllis cf. garciae (Campoy)	1	1	0.9
Syllis hyalina Grube	49	332	297.3
Syllis sp.	1	1	0.9
Nereidae			
Eunereis longissima Johnston	18	38	638.4
Laeonereis glauca (Claparède)	2	2	819.2
Neanthes caudata (Delle Chiaje)	1	8	22.4
Neanthes succinea (Frey et Leuckart)	1	2	226.8
Platynereis dumerilii (Audouin et Milne-Edwards)	1	1	41.5
Glyceridae			
Glycera capitata Oersted	19	85	1355.2
Glycera rouxii Audouin y Milne Edwards	5	19	2507.1
Glycera tridactyla (=convoluta) Schamarda	80	268	4385.2
Glycera unicornis Savigny	7	8	6041.5
Goniadidae			
Goniada eremita Audouin y Milne Edwards	1	1	99.1
Goniadella galaica (Rioja)	32	229	156.1
Goniadella gracilis (Verrill)	3	6	25.0
Nephtyidae			
Aglaophamus rubella Michaelsen	1	4	1038.6

Nepthys cirrosa Ehlers	40	136	5897.0
Nepthys hombergii Savigny	49	140	16245.8
Onuphidae			
Diopatra neapolitana delle Chiaje	21	34	14376.1
Hyalinoecia bilineata Baird	11	25	559.3
Nothria conchilega (Sars)	3	3	30.6
Nothria geophiliformis (Moore)	1	1	15.6
Eunicidae			
Eunice vittata (Chiaje)	15	44	1468.3
Lysidice ninetta Audoin & Milne-Edwards	1	1	1.0
Marphysa sanguinea (Montagu)	10	13	8464.4
Nematonereis unicornis (Grube)	24	57	399.3
Lumbrineridae			
Lumbrinereis latreilli (Audouin y Milne Edwards)	65	382	19956.7
Lumbrinereis paradoxa (Saint-Joseph)	2	2	21.9
Iphitimidae			
Drilonereis filum (Claparède)	25	47	766.7
Dorvilleidae			
Ophyotrocha sp.	1	8	0.8
Protodorvillea kefersteini (McIntosh)	31	175	61.3
Schistomeringos neglecta (Fauvel)	3	5	1.0
Schistomeringos rudolphi (Chiaje)	11	16	3.2
Oweniidae			
Myriochele heeri Malmgren	3	8	4.7
Owenia fusiformis delle Chiaje	15	67	4289.7
Flabelligeridae			
Flabelligeridae sp.	2	8	4.7
Pherusa monolifer (Delle Chiaje)	2	2	1066.2
Sabellariidae			
Lygdamis murata (Allen)	30	356	75442.4
Sabellaria spinulosa (Linnaeus)	20	85	240.9
Pectinariidae			
Lagis koreni Malmgren	7	8	188.8
Ampharetidae			
Ampharete lindstroemi Malmgren	7	8	120.9
Melinna palmata Grube	66	2221	54267.2
Terebellidae			
Amaena trilobata Sars	7	18	1017.7
Lanice conchilega (Pallas)	50	243	5784.6
Neoamphitrite affinis (Malmgren)	14	31	767.3
Pista cristata (Müller)	55	283	14796.5
Polycirrus sp.	34	266	1651.5
Sabellides octocirrata (Sars)	1	1	1.8
Sabellidae			
Dialychone cf. acustica Claparède	18	31	864.7
Jasmineira elegans Saint-Joseph	1	1	1.5
Megalomma vesiculosum (Montagu)	12	13	5075.3
Myxicola infundibulum (Renier)	7	9	3842.1
Sabella pavonina Savigny	12	65	9242.6
Serpulidae			
Serpulidae spp	19	244	739.7
Polygordiidae			
Polygordius appendiculatus Fraipont	8	115	41.7
Saccocirridae			
Saccocirrus papillocercus Bobretzky	11	55	8.8
OLIGOCHAETA			
Tubificidae			
Tubificoides benedeni (Udekem)	22	874	592.3
Tubificidae spA	16	101	10.1

Tubificidae spB	33	319	215.9
MOLLUSCA			
POLYPLACOPHORA			
Callochitonidae			
Callochiton septenvalvis (Montagu)	1	1	210.7
Ischnochitonidae			
Chaetopleura angulata Splenger	39	92	186768.9
Chitonidae			
Lepidochiton cancellatus (Jeffreys)	3	3	487.0
Lepidochitona cinerea (Linnaeus)	1	3	59.7
SCAPHOPODA			
Dentalium sp.	1	1	319.3
GASTEROPODA			
Trochidae			
Gibbula magnum Linnaeus	1	1	1100.0
Jujubinus striatus (Linnaeus)	1	8	84.0
Trochidae sp.	1	1	1.7
Hydrobiidae			
Hydrobia ulvae (Pennant)	4	5	21.8
Rissoidae			
Alvania-beani (Thorpe)	1	5	16.8
Onoba vitrea (Montagu)	1	1	5.6
Rissoa labiosa (Montagu)	1	14	39.5
Turritellidae			
Turritella triplicata Brocchi	3	3	2396.5
Cerithiidae			
Bittium reticulatum (da Costa)	2	14	16.1
Epitoniidae			
Epitonium clathratulum (Kanmacher)	3	4	1372.6
Calyptraeidae			
Calyptraea chinensis (Linnaeus)	44	346	10928.8
Naticidae			
Natica alderi Forbes	1	1	1200.0
Nassaridae			
Nassarius argenteus (Marrat)	1	2	167.4
Nassarius incrassatus (Lamarck)	30	67	5606.5
Nassarius reticulatus (Linnaeus)	27	116	124695.5
Conidae			
Mangelia coarctata (Forbes)	1	1	24.3
Atyidae			
Haminea navicula (da Costa)	6	7	6141.9
Philinidae			
Philine aperta (Linnaeus)	12	16	3375.4
Retusidae			
Retusa sp.	2	3	4.8
Pyramidellidae			
Chrysallida terebelum (Philippi)	2	3	4.5
Akeridae			
Akera sp.	2	7	14.0
Nudibranch sp. indet.	3	6	26.4
BIVALVIA			
Nuculidae			
Nucula nucleus Linnaeus	34	196	43164.6
Solemyidae			

Solemya togata Poli	3	3	15.5
Arcidae			
Arca lactea Linnaeus	3	10	1607.0
Anomiidae			
Monia patelliformis Linnaeus	1	8	230.3
Mytilidae			
Musculus costulatus (Risso)	1	1	3.1
Mytilus galloprovincialis Lamarck	1	1	241.4
Modiolus sp.	7	8	8690.5
Ostreidae			
Lopha stentina (Payraudeau)	4	23	21620.2
Lucinidae			
Divaricella divaricata (Linnaeus)	9	25	566.9
Loripes lacteus (Linnaeus)	8	9	746.1
Lucinoma borealis (Linnaeus)	10	31	934.3
Thyasiridae			
Thyasira flexuosa (Montagu)	3	3	2.7
Carditidae			
Cardita calyculata Linnaeus	1	4	106.8
Kelliidae			
Kellia suborbicularis (Montagu)	2	2	1.4
Leptonidae			
Hemilepton nitidum (Turton)	37	971	2119.6
Montacutidae			
Montacuta ferruginosa (Montagu)	1	2	1.2
Mysella bidentata (Montagu)	6	11	15.0
Cardiidae			
Cardium paucicostatum Sowerby	35	119	556547.7
Cerastoderma edule (Linnaeus)	31	103	1255.8
Laevicardium crassum (Gmelin)	3	4	11668.5
Parvicardium exiguum (Gmelin)	22	57	12842.0
Parvicardium scriptum (B.D.D.)	4	5	9.5
Veneridae			
Dosinia exoleta (Linnaeus)	5	6	7253.1
Dosinia lupinus (Linnaeus)	1	1	1260.8
Gafrarium minimum (Montagu)	2	3	542.5
Pitaria rudis Poli	1	1	1349.8
Venerupis pullastra (Montagu)	25	275	428547.7
Venus casina Linnaeus	6	7	5894.8
Venus fasciata da Costa	4	6	5806.5
Venus striatula (da Costa)	19	34	61321.0
Venus verrucosa Linnaeus	2	3	24629.9
Mactridae			
Spisula solida (Linnaeus)	26	103	53221.5
Spisula subtruncata (da Costa)	12	16	18723.1
Lutrariidae			
Lutraria lutraria (Linnaeus)	22	37	40781.6
Mesodesmatidae			
Ervilia castanea (Montagu)	11	41	458.9
Tellinidae			
Gastrana fragilis (Linnaeus)	1	1	88.4
Tellina donacina Linnaeus	13	24	2121.3
Tellina fabula Gronovius	3	11	149.1
Tellina tenuis da Costa	12	44	3984.5
Tellina pulchella Lamarck	1	1	323.9
Tellina pygmaea Loven	1	2	100.0
Tellina serrata (Remieri)	1	1	3690.2
Scrobiculariidae			
Abra alba (Wood)	77	1652	115920.9
Abra nitida O. F. Müller)	7	43	2360.4
Scrobicularia plana (da Costa)	17	22	42460.2

Gariidae			
Gari depressa (Pennant)	1	1	293.0
Solenidae			
Ensis ensis Linnaeus	9	14	11060.0
Solen marginatus Pennant	21	46	163375.2
Corbulidae			
Corbula gibba (Olivi)	60	187	46901.0
Hiatellidae			
Hiatella arctica (Linnaeus)	2	6	13.7
Pholadidae			
Barnea candida (Linnaeus)	1	1	2878.9
Thraciidae			
Thracia sp.	6	10	11428.0
Lyonsiidae			
Lyonsia norvegica (Gmelin)	3	3	10.7
Pandoridae			
Pandora albida (Röding)	5	5	763.3

ARTHROPODA

MALACOSTRACA

LEPTOSTRACA			
Nebalia bipes (Fabricius)	7	9	22.5
CUMACEA			
Bodotriidae			
Bodotria scorpioides (Montagu)	16	27	21.6
Iphinoë tenella Sars	84	1335	1200.6
Iphinoë trispinosa (Goodsir)	1	1	2.6
Dyastylidae			
Diastylis rugosa Sars	2	2	2.8
TANAIDACEA			
Paratanaidae			
Heterotanais oerstedi (Krøyer)	24	87	17.4
Apseudidae			
Apseudes latreilli (Milne Edwards)	21	1282	1271.4
Apseudes talpa (Montagu)	48	805	3298.3
MYSIDACEA			
Mysidae			
Gastrosaccus spinifer (Goës)	25	95	570.0
Heteromysis microps (G. O. Sars)	16	52	265.2
ISOPODA			
Gnathiidae			
Paragnathia formica (Hesse)	6	16	4.8
Anthuridae			
Anthuridae sp.	7	48	144.0
Cyathura carinata (Kroyer)	63	846	5611.9
Cirolanidae			
Cirolanidae sp.	14	18	1129.8
Eurydice pulchra Leach	4	7	9.1
Sphaeromatidae			
Cymodoce truncata Leach	2	7	41.3
Sphaeroma cf. bocqueti Daguerre de Hureaux, Hoestlan Lejuez	3	4	1.2
Sphaeroma hookeri Leach	2	3	8.4
Sphaeroma monodi Bocquet, Hoestlandt, Levi	15	35	429.9

Idoteidae			
Synisoma sp.	3	6	6.8
Arcturidae			
Arcturella sp.	2	16	17.6
Astacilla longicornis (Sowerby)	13	38	86.6
Janiridae			
Jaera nordmani (Rathke)	1	2	0.2
AMPHIPODA			
Lysianassidae			
Hippomedon denticulatus (Bate)	2	4	2.0
Lepidepecreum longicorne (Bate & Westwood)	4	8	25.6
Lysianassa inesperata Lincoln	2	2	3.0
Orchomene massiliensis Ledoyer	2	9	11.1
Orchomene nana (Krøyer)	6	40	59.8
Tryphosites longipes (Bate & Westwood)	4	8	12.0
Ampeliscidae			
Ampelisca brevicornis Costa	10	107	269.0
Ampelisca diadema Costa	27	307	425.6
Ampelisca remora Bellan-Santini & Dauvin	28	292	210.2
Ampelisca spinimana Chevreux	15	270	305.1
Ampelisca tenuicornis Liljeborg	74	1323	1847.0
Amphilochidae			
Amphilochus neapolitanus Delle Valle	13	20	10.0
Amphilochus spencebatei (Stebbing)	7	11	5.5
Leucothoidae			
Leucothöe incisa Robertson	10	22	37.5
Leucothöe richiardii Lessona	2	3	5.1
Stenothoidae			
Stenothöe marina (Bate)	9	31	6.3
Gammaridae			
Gammarus locusta (Linnaeus)	1	1	1.6
Melitidae			
Ceradocus semiserratus (Bate)	1	5	1.0
Cheirocratus sundevalli (Rathke)	49	232	314.4
Gammarella fucicola (Leach)	7	16	25.6
Maera othonis (Milne-Edwards)	11	102	203.3
Melita gladiosa Bate	6	47	102.6
Melita obtusata (Montagu)	36	301	536.1
Melita palmata (Montagu)	4	14	16.8
Haustoridae			
Bathyporeia guilliamsoniana (Bate)	1	28	350.9
Urothoë brevicornis (Bate)	4	23	31.8
Urothöe elegans Bate	9	87	62.8
Urothöe grimaldii Chevreux	7	13	18.2
Oedicerotidae			
Perioculodes longimanus (Bate & Westwood)	28	86	42.0
Synchelidium longidigitatum Ruffo	1	1	0.5
Synchelidium haplocheles (Grube)	6	10	5.0
Phoxocephalidae			
Harpinia antennaria Meinert	3	22	17.6
Harpinia laevis Sars	3	14	11.2
Harpinia pectinata Sars	39	231	185.0
Metaphoxus pectinatus (Walker)	24	69	41.0
Melphidippidae			
Megaluropus agilis Hoek	3	7	11.2
Liljeborgiidae			
Listriella picta (Norman)	14	68	102.7
Calliopiidae			
Apherusa clevei Sars	1	1	0.6

Apherusa ovalipes Norman & Scott	14	31	15.5
Atylidae			
Atylus guttatus (Costa)	20	39	129.2
Atylus swammerdami (Milne-Edwards)	2	4	13.6
Atylus vedlomensis (Bate & Westwood)	18	122	411.7
Dexaminidae			
Dexamine spinosa (Montagu)	16	47	154.2
Amphithoidae			
Amphithoe gammaroides (Bate)	1	2	1.2
Amphithoe neglecta Lincoln	1	16	10.3
Aoridae			
Aora typica Krøyer	8	211	128.8
Aoridae sp.	8	15	9.0
Leptocheirus pectinatus (Norman)	41	282	424.8
Leptocheirus pilosus Zaddach	7	22	33.0
Microdeutopus cf. stationis Della Valle	1	6	5.4
Microdeutopus versiculatus (Bate)	54	372	337.8
Isaeidae			
Microprotopus maculatus Norman	3	4	3.6
Gammaropsis maculata (Johnston)	22	402	649.2
Gammaropsis sophiae (Boeck)	6	8	12.8
Gammaropsis sp.	1	3	1.6
Photis longicaudata (Bate & Westwood)	1	2	1.8
Photis longipes (Della Valle)	44	2417	2156.6
Corophiidae			
Corophium acutum Chevereux	1	1	0.5
Corophium annulatum Chevreux	88	2611	1322
Corophium "complexe"	3	5	39.3
Corophium insidiosum Crawford	1	1	0.5
Corophium runcicorne Della Valle	32	663	390.9
Corophium sextonae Crawford	32	925	856.5
Siphonoecetes striatus Myers & McGrath	1	1	7.9
Ischyroceridae			
Ericthonius puntactus (Bate)	14	163	113.0
Jassa marmorata Holmes	3	16	8.0
Microjassa cumbrensis (Stebbing & Robertson)	1	1	0.5
Caprellidae			
Caprella cf. acanthifera Leach	24	181	126.1
Pariambus typicus (Krøyer)	47	2014	978.6
Phtisica marina Slabber	60	454	322.9
Pseudoprotella phasma (Montagu)	4	9	25.9
Amphipod sp. indet.	4	12	6.0
DECAPODA			
Processidae			
Processa macropthalma Nouvel & Holthius	1	1	930.3
Crangonidae			
Crangon crangon (Linnaeus)	17	23	3787.4
Philoceras monacanthus (Holthius)	1	1	9.2
Callanassidae			
Upogebia cf typica (Nardo)	21	37	52797.4
Paguridae			
Pagurus sp.	9	16	2257
Porcellanidae			
Pisidia longicornis (Linnaeus)	4	7	225.3
Dorippidae			
Medorippe lanata (Linnaeus)	6	9	78.4
Leucosiidae			
Ebalia edwardsi Costa	1	1	315.8

Ebalia tumefacta (Montagu)	2	2	340.4
Atelecyclidae			
Atelecyclus undecimdentatus (Herbst)	12	30	3283.7
Portunidae			
Liocarcinus arcuatus (Leach)	5	5	8200.4
Liocarcinus corrugatus (Pennant)	4	5	314.6
Liocarcinus holsatus (Fabricius)	2	2	94.6
Liocarcinus pusilus (Leach)	3	3	102.8
Liocarcinus cf. vernalis (Risso)	1	1	997.2
Liocarcinus sp.	1	1	189.4
Carcinus maenas (Linnaeus)	2	2	419.0
Xanthidae			
Xantho sp.	1	1	96.2
Pinnotheridae			
Pinnotheres pisum (Linnaeus)	2	3	83.3
Majidae			
Eurynome aspera (Pennant)	1	1	482.8
Inachus communisimus Rizza	1	2	30.8
Inachus dorsettensis (Pennant)	8	9	138.6
Macropodia rostrata (Linnaeus)	1	1	13.3
INSECTA			
Insect larvae	1	5	14.7
PYCNOGONIDA			
Pycnogonide sp. indet.	2	2	1.0
OSTRACODA			
Ostracod spA	28	77	795.6
Ostracod spB	29	165	224
Ostracod spC	14	71	78.1
ECHINODERMATA			
HOLOTHURIOIDEA			
Sinaptidae			
Labidoplax digitata (Montagu)	1	1	963.5
Leptosynapta inhaerens (O. F. Müller)	9	17	2398.4
OPHIUROIDEA			
Amphiuridae			
Amphiura chiajei Forbes	1	1	493.2
Amphipholis squamata (delle Chiage)	18	89	195.8
Ophiuridae			
Ophiura albida Forbes	1	1	248.1
ECHINOIDEA			
Echinidae			
Psammechinus miliaris (Gmelin)	2	4	1925.6
Fibulariidae			
Echinociamus pusillus (O. F. Müller)	2	2	19.0
VARIA			
Sipunculids sp. indet.	11	63	11913.8
Platyhelminthes sp. indet.	10	14	21.3
Phoronis sp.	25	110	695.1
Virgularia mirabilis (O. F. Müller)	53	299	52202.5
Edwarsia claparedii (Panceri)	4	8	833.6

Anthozoa spA	18	75	86364.2
Anthozoa spB	3	3	334.5
Anthozoa spC	12	32	2209.4
Nemertea spA	35	464	694.1
Nemertea spB	71	288	1262.3
Nemertea spC	23	33	27287.4
Branchiostoma lanceolatum (Pallas)	1	6	1084.4
Ascidian sp. indet.	2	4	197.9
Pomatoschistus microps (Krøyer)	2	2	196.3
Pomatoschistus minutus (Pallas)	1	1	120.9
Pomatoschistus pictus (Malm)	1	2	152.6
Pomatoschistus sp.	1	1	51.1

Annex III

Species names and respective codes.

CODES		SPECIES NAME
2	ABRAALB	Abra alba
3	ABRANIT	Abra nitida
4	ACOESPA	Acoetes sp.
5	ADYTPEL	Adyte pellucida
6	AGLARUB	Aglaophamus rubella
7	AKERSPA	Akera sp.
8	ALVABEA	Alvania beani
9	AMAETRI	Amaena trilobata
10	AMPEBRE	Ampelisca brevicornis
11	AMPEDIA	Ampelisca diadema
12	AMPEREM	Ampelisca remora
13	AMPESPI	Ampelisca spinimana
14	AMPETEN	Ampelisca tenuicornis
15	AMPHCHI	Amphiura chiajei
16	AMPHGAM	Amphithoe gammaroides
17	AMPHLIN	Ampharete lindstroemi
18	AMPHNEA	Amphilochus neapolitanus
19	AMPHNEG	Amphithoe neglecta
20	AMPHSPE	Amphilochus spencebatei
21	AMPHSQA	Amphipholis squamata
22	ANAILIN	Anaitides lineata
23	ANAIMUC	Anaitides mucosa
24	ANFISPA	Amphipod sp. indet.
25	ANTHSPA	Anthozoa spA
26	ANTHSPB	Anthozoa spB
27	ANTHSPC	Anthozoa spC
28	ANTUSPA	Anthuridae sp.
29	AONIOXY	Aonides oxycephala
30	AORATYP	Aora typica
31	AOTISPA	Aoridae sp.
32	APHECLE	Apherusa clevei
33	APHEOVA	Apherusa ovalipes
34	APSELAT	Apseudes latreilli
35	APSETAL	Apseudes talpa
36	ARCALAC	Arca lactea
37	ARCTSPA	Arcturella sp.
38	ARICFOE	Orbinia (=Aricia) foetida
39	ARMACIR	Armandia cirrosa
40	ASCISPP	Ascidian sp. indet.
41	ASTALON	Astacilla longicorns
42	ATELUND	Atelecyclus undecimdentatus
43	ATYLGUT	Atylus guttatus
44	ATYLSWA	Atylus swammerdami
45	ATYLVED	Atylus vedlomensis
46	AUTOLAN	Autolytus cf. langerhansi
47	BARNCAN	Barnea candida
48	BATHGUI	Bathyporeia guilliamsoniana
49	BHAWSPA	Bhawania cf goodei
50	BITTRET	Bittium reticulatum
51	BODOSCO	Bodotria scorpioides
52	BRANLAN	Branchiostoma lanceolatum
53	CALLSEP	Callochiton septenvalvis
54	CALYCHI	Calyptraea chinensis
55	CAPICAP	Capitella capitata
56	CAPRACA	Caprella cf. acanthifera
57	CARCMAE	Carcinus maenas
58	CARDCAL	Cardita calyculata
59	CARDPAU	Cardium paucicostatum
60	CAULSPP	Caulleriella sp.
61	CERAEDU	Cerastoderma edule
62	CERASEM	Ceradocus semiserratus
63	CHAEANG	Chaetopleura angulata
64	CHAEVAR	Chaetopterus variopedatus
65	CHEISUN	Cheirocratus sundevalli
66	CHLOSPA	Flabelligeridae sp.
67	CHRYTER	Chrysallida terebelum
68	CIROSPA	Cirolanidae sp.
69	CIRRSPA	Cirriformia sp.
70	CLYMCLY	Clymenura clypeata
71	CORBGIB	Corbula gibba
72	COROACU	Corophium acutum
73	COROANN	Corophium annulatum
74	COROCOM	Corophium "complexe"
75	COROINS	Corophium insidiosum
76	CORORUN	Corophium runcicorne
77	COROSEX	Corophium sextonae
78	CRANCRA	Crangon crangon
79	CYATCAR	Cyathura carinata
80	CYMOTRU	Cymodoce truncata
81	DENTSPA	Dentalium sp.
82	DEXASPI	Dexamine spinosa
83	DIALACU	Dialychone cf. acustica
84	DIASRUG	Diastylis rugosa
85	DIOPNEA	Diopatra neapolitana
86	DIPLCIR	Diplosyllis cirrosa
87	DIVADIV	Divaricella divaricata
88	DOSIEXO	Dosinia exoleta
89	DOSILUP	Dosinia lupinus
90	DRILFIL	Drilonereis filum
91	EBALEDW	Ebalia edwardsi
92	EBALTUM	Ebalia tumefacta
93	ECHIPUS	Echinociamus pusillus
94	EDWACLA	Edwarsia claparedii
95	ENSIENS	Ensis ensis
96	EPITCLA	Epitonium clathratulum
97	ERICPUN	Ericthonius puntactus
98	ERVICAS	Ervilia castanea
99	ETEOSPA	Eteone sp.
100	EUCLOER	Euclymene oerstedi
101	EUCLPAL	Euclymene palermitana
102	EULAAUR	Eulalia viridis aurea
103	EUMISAN	Eumida sanguinea
104	EUNELON	Eunereis longissima
105	EUNIVIT	Eunice vittata
106	EURYASP	Eurynome aspera
107	EURYPUL	Eurydice pulchra
108	EXOGNAI	Exogone naidina
109	EXOGVER	Exogone verrugera
110	GAFRMIN	Gafrarium minimum
111	GAMMFUC	Gammarella fucicola
112	GAMMLOC	Gammarus locusta
113	GAMMMAC	Gammaropsis maculata
114	GAMMSOP	Gammaropsis sophiae
115	GARIDEP	Gari depressa
116	GAROSPA	Gammaropsis sp.
117	GASTFRA	Gastrana fragilis
118	GASTSPI	Gastrosaccus spinifer
119	GIBUMAG	Gibbula magnum
120	GLYCCAP	Glycera capitata
121	GLYCROU	Glycera rouxii
122	GLYCTRY	Glycera tridactyla (=convoluta)
123	GLYCUNI	Glycera unicornis
124	GONIERE	Goniada eremita
125	GONIGAL	Goniadella galaica
126	GONIGRA	Goniadella gracilis
127	GYPTPRO	Gyptis propinquos
128	HAMINAV	Haminea navicula
129	HARMIMB	Harmothoë imbricata
130	HARMIMP	Harmothoë cf. impar
131	HARMLJU	Harmothoë ljungmani
132	HARMLUN	Harmothöe lunulata
133	HARMMAR	Harmothöe marphysae

CODES		SPECIES NAME
134	HARPANT	Harpinia antennaria
135	HARPLAE	Harpinia laevis
136	HARPPEC	Harpinia pectinata
137	HEMINIT	Hemilepton nitidum
138	HESIELO	Hesionura elongata
139	HETEFIL	Heteromastus filiformis
140	HETEMIC	Heteromysis microps
141	HETEOER	Heterotanais oerstedi
142	HIATART	Hiatella arctica
143	HIPPDEN	Hippomedon denticulatus
144	HYALBIL	Hyalinoecia bilineata
145	HYALVIT	Onoba vitrea
146	HYDRULV	Hydrobia ulvae
147	INACCOM	Inachus communisimus
148	INACDOR	Inachus dorsettensis
149	IPHITEN	Iphinoë tenella
150	IPHITRI	Iphinoë trispinosa
151	JAERNOR	Jaera nordmani
152	JASMELE	Jasmineira elegans
153	JASSMAR	Jassa marmorata
154	JUJUSTR	Jujubinus striatus
155	KEFECIR	Kefersteinia cirrata
156	KELLSUB	Kellia suborbicularis
157	LABIDIG	Labidoplax digitata
158	LAEVCRA	Laevicardium crassum
159	LANICON	Lanice conchilega
160	LARVINS	Insect larvae
161	LEPICAN	Lepidochiton cancellatus
162	LEPICIN	Lepidochitona cinerea
163	LEPILON	Lepidepecreum longicorne
164	LEPTGLA	Laeonereis glauca
165	LEPTINH	Leptosynapta inhaerens
166	LEPTPEC	Leptocheirus pectinatus
167	LEPTPIL	Leptocheirus pilosus
168	LEUCINC	Leucothöe incisa
169	LEUCRIC	Leucothöe richiardii
170	LIOCARC	Liocarcinus arcuatus
171	LIOCCOR	Liocarcinus corrugatus
172	LIOCHOL	Liocarcinus holsatus
173	LIOCPUS	Liocarcinus pusilus
174	LIOCSPA	Liocarcinus sp.
175	LIOCVER	Liocarcinus cf. vernalis
176	LISTPIC	Listriella picta
177	LOPHSTE	Lopha stentina
178	LORILAC	Loripes lacteus
179	LUCIBOR	Lucinoma borealis
180	LUMBLAT	Lumbrinereis latreilli
181	LUMBPAR	Lumbrinereis paradoxa
182	LUNAALD	Natica alderi
183	LUTRLUT	Lutraria lutraria
184	LYGDMUR	Lygdamis murata
185	LYONNOR	Lyonsia norvegica
186	LYSIINE	Lysianassa inesperata
187	LYSIMIN	Lysidice ninetta
188	MACRROS	Macropodia rostrata
189	MAEROTH	Maera othonis
190	MAGEALL	Magelona alleni
191	MALACIL	Malacoceros ciliata
192	MALAFUL	Malacoceros (=Scolelepis) fuliginosus
193	MANGCOA	Mangelia coarctata
194	MARPSAN	Marphysa sanguinea
195	MEDICAP	Mediomastus capensis
196	MEDOLAN	Medorippe lanata
197	MEGAAGI	Megaluropus agilis
198	MEGAVES	Megalomma vesiculosum
199	MELIGLA	Melita gladiosa
200	MELIOBT	Melita obtusata
201	MELIPAL	Melinna palmata
202	MELTPAL	Melita palmata
203	METAPEC	Metaphoxus pectinatus
204	MICRABE	Microphtalmus cf. aberrans
205	MICRCUM	Microjassa cumbrensis
206	MICRMAC	Microprotopus maculatus
207	MICRMEC	Microspio mecznikowianus
208	MIDESPA	Microdeutopus cf. stationis
209	MIDEVER	Microdeutopus versiculatus
210	MODISPA	Modiolus sp.
211	MONIPAT	Monia patelliformis
212	MONTFER	Montacuta ferruginosa
213	MUSCCOS	Musculus costulatus
214	MYRIHEE	Myriochele heeri
215	MYSEBID	Mysella bidentata
216	MYSTPIC	Mysta picta
217	MYTIGAL	Mytilus galloprovincialis
218	MYXIINF	Myxicola infundibulum
219	NASSARG	Nassarius argenteus
220	NASSINC	Nassarius incrassatus
221	NASSRET	Nassarius reticulatus
222	NEBABIP	Nebalia bipes
223	NEMAUNI	Nematonereis unicornis
224	NEMESPA	Nemertea spA
225	NEMESPB	Nemertea spB
226	NEMESPC	Nemertea spC
227	NEOAAFF	Neoamphitrite affinis
228	NEPTCIR	Nepthys cirrosa
229	NEPTHOM	Nepthys hombergii
230	NERECAU	Neanthes caudata
231	NERESUC	Neanthes succinea
232	NOTHCON	Nothria conchilega
233	NOTHGEO	Nothria geophiliformis
234	NOTOLAT	Notomastus latericeus
235	NUCUNUC	Nucula nucleus
236	NUDISPA	Nudibranch sp. indet.
237	OLIGSPA	Tubificidae spA
238	OLIGSPB	Tubificidae spB
239	OPHELAU	Ophelia laubieri
240	OPHENEG	Ophelia neglecta
241	OPHIALB	Ophiura albida
242	OPHYSPA	Ophyotrocha sp.
243	ORCHMAS	Orchomene massiliensis
244	ORCHNAN	Orchomene nana
245	OSTRSPA	Ostracod spA
246	OSTRSPB	Ostracod spB
247	OSTRSPC	Ostracod spC
248	OWENFUS	Owenia fusiformis
249	PAGUSPP	Pagurus sp.
250	PANDALB	Pandora albida
251	PARAELE	Parapionosyllis elegans
252	PARAFOR	Paragnathia formica
253	PARAKOS	Paranaitis kosteriensis
254	PARALAB	Parapionosyllis labronica
255	PARALYR	Paradoneis lyra
256	PARITYP	Pariambus typicus
257	PARVEXI	Parvicardium exiguum
258	PARVSCR	Parvicardium scriptum
259	PECTKOR	Lagis koreni
260	PERILON	Perioculodes longimanus
261	PHERMON	Pherusa monolifer
262	PHILAPE	Philine aperta
263	PHILMON	Philoceras monacanthus
264	PHOLSYN	Pholoë synophthalmica
265	PHORSPA	Phoronis sp.

CODES		SPECIES NAME
266	PHOTLOC	Photis longicaudata
267	PHOTLON	Photis longipes
268	PHTIMAR	Phtisica marina
269	PICNSPA	Pycnogonide sp. indet.
270	PILAVER	Pilargis verrucosa
271	PINOPIS	Pinnotheres pisum
272	PISILON	Pisidia longicornis
273	PISIREM	Pisione remota
274	PISTCRI	Pista cristata
275	PITARUD	Pitaria rudis
276	PLATDUM	Platynereis dumerilii
277	PLATSPA	Platyhelminthes sp. indet.
278	PODAAGI	Podarke agilis
279	POECSER	Poecilochaetus serpens
280	POLYAPP	Polygordius appendiculatus
281	POLYARM	Polydora armata
282	POLYCAE	Polydora caeca
283	POLYCIL	Polydora ciliata
284	POLYHOP	Polydora hoplura
285	POLYSPA	Polycirrus sp.
286	POMAMIC	Pomatoschistus microps
287	POMAMIN	Pomatoschistus minutus
288	POMAPIC	Pomatoschistus pictus
289	POMASPA	Pomatoschistus sp.
290	PRAXAFF	Praxillella affinis
291	PRIOCIR	Prionospio cirrifera
292	PRIOMAL	Prionospio malmgreni
293	PROCMAC	Processa macropthalma
294	PROTKEF	Protodorvillea kefersteini
295	PROTSPA	Protomystides sp.
296	PSAMMIL	Psammechinus miliaris
297	PSEUANT	Pseudopolydora antennata
298	PSEULIM	Pseudomystides limbata
299	PSEUPHA	Pseudoprotella phasma
300	PYGOELE	Pygospio elegans
301	RETUSPA	Retusa sp.
302	RISSLAB	Rissoa labiosa
303	SABEOCT	Sabellides octocirrata
304	SABEPAV	Sabella pavonina
305	SABESPI	Sabellaria spinulosa
306	SACCPAP	Saccocirrus papillocercus
307	SCAINF	Scalibregma inflatum
308	SCHINEG	Schistomeringos neglecta
309	SCHIRUD	Schistomeringos rudolphi
310	SCOLARM	Scoloplos armiger
311	SCROPLA	Scrobicularia plana
312	SERPSPP	Serpulidae spp
313	SIGASQU	Sigalion squamosum
314	SIGATEN	Sigambra tentaculata
315	SIPHSTR	Siphonoecetes striatus
316	SIPUSPP	Sipunculids sp. indet.
317	SOLEMAR	Solen marginatus
318	SOLETOG	Solemya togata
319	SPHABOC	Sphaeroma cf. bocqueti
320	SPHABUL	Sphaerosyllis bulbosa
321	SPHAHOO	Sphaeroma hookeri
322	SPHAHYS	Sphaerosyllis hystrix
323	SPHAMON	Sphaeroma monodi
324	SPHATAY	Sphaerosyllis taylori
325	SPIOBOM	Spiophanes bombyx
326	SPIOCOS	Spiochaetopterus costarum
327	SPIODEC	Spio decoratus Bobretzki
328	SPIONDE	Spionidae sp.
329	SPISSOL	Spisula solida
330	SPISSUB	Spisula subtruncata
331	STENMAR	Stenothöe marina
332	STHEBOA	Sthenelais boa
333	STRESHR	Streblospio shrubsolii
334	SYLLGAR	Syllis cf. garciae
335	SYLLHYA	Syllis hyalina
336	SYLLSPA	Syllis sp.
337	SYNCHAP	Synchelidium haplocheles
338	SYNCLON	Synchelidium longidigitatum
339	SYNISPA	Synisoma sp.
340	TELLDON	Tellina donacina
341	TELLFAB	Tellina fabula
342	TELLPUL	Tellina pulchella
343	TELLPYG	Tellina pygmaea
344	TELLSER	Tellina serrata
345	TELLTEN	Tellina tenuis
346	THARSPA	Tharyx sp.
347	THRASPA	Thracia sp.
348	THROSPA	Trochidae sp.
349	THYAFLE	Thyasira flexuosa
350	TRYPLON	Tryphosites longipes
351	TUBIBEN	Tubificoides benedeni
352	TURRTRI	Turritella triplicata
353	UPOGTYP	Upogebia cf typica
354	UROTBRE	Urothoë brevicornis
355	UROTELE	Urothöe elegans
356	UROTGRI	Urothöe grimaldii
357	VENEPUL	Venerupis pullastra
358	VENUCAS	Venus casina
359	VENUFAS	Venus fasciata
360	VENUSTR	Venus striatula
361	VENUVER	Venus verrucosa
362	VIRGMIR	Virgularia mirabilis
363	XANTSPA	Xantho sp.

Annex IV

Convertion factors, dry weight/ash-free dry weight biomass, expressed as a percentage of the wet.weight biomass.

	DW	AFDW		DW	AFDW		DW	AFDW
ABRAALB	34.87	5.27	*CHAEVAR*	15.02	11.34	*GONIGRA*	15.02	11.34
ABRANIT	34.87	5.27	*CHEISUN*	11.78	9.92	*GYPTPRO*	15.02	11.34
ACOESPA	15.64	13.94	*CHLOSPA*	15.02	11.34	*HAMINAV*	59.27	6.92
ADYTPEL	15.64	13.94	*CHRYTER*	59.27	6.92	*HARMIMB*	15.64	13.94
AGLARUB	19.98	14.8	*CIROSPA*	18.72	7.98	*HARMIMP*	15.64	13.94
AKERSPA	9.46	4.39	*CIRRSPA*	17.23	14.08	*HARMLJU*	15.64	13.94
ALVABEA	59.27	6.92	*CLYMCLY*	15.02	11.34	*HARMLUN*	15.64	13.94
AMAETRI	15.45	8.9	*CORBGIB*	57.54	6.31	*HARMMAR*	15.64	13.94
AMPEBRE	11.47	9.11	*COROACU*	13.76	11.40	*HARPANT*	11.78	9.92
AMPEDIA	11.47	9.11	*COROANN*	13.76	11.40	*HARPLAE*	11.78	9.92
AMPEREM	11.47	9.11	*COROCOM*	13.76	11.40	*HARPPEC*	11.78	9.92
AMPESPI	11.47	9.11	*COROINS*	13.76	11.40	*HEMINIT*	38.64	5.62
AMPETEN	11.47	9.11	*CORORUN*	13.76	11.40	*HESIELO*	14.65	13.60
AMPHCHI	44.14	7.75	*COROSEX*	13.76	11.40	*HETEFIL*	14.23	11.82
AMPHGAM	11.78	9.92	*CRANCRA*	16.43	11.29	*HETEMIC*	9.59	8.86
AMPHLIN	15.42	8.90	*CYATCAR*	16.99	15.85	*HETEOER*	15.69	13.37
AMPHNEA	11.78	9.92	*CYMOTRU*	18.72	7.98	*HIATART*	57.54	6.31
AMPHNEG	11.78	9.92	*DENTSPA*	59.27	6.92	*HIPPDEN*	11.78	9.92
AMPHSPE	11.78	9.92	*DEXASPI*	11.78	9.92	*HYALBIL*	13.15	11.78
AMPHSQA	44.14	7.75	*DIALACU*	15.02	11.34	*HYALVIT*	59.27	6.92
ANAILIN	14.65	13.60	*DIASRUG*	14.20	12.32	*HYDRULV*	59.27	6.92
ANAIMUC	14.65	13.60	*DIOPNEA*	13.15	11.78	*INACCOM*	16.43	11.29
ANFISPA	11.78	9.92	*DIPLCIR*	15.02	11.34	*INACDOR*	16.43	11.29
ANTHSPA	16.84	13.93	*DIVADIV*	57.54	6.31	*IPHITEN*	14.20	12.32
ANTHSPB	17.22	14.30	*DOSIEXO*	70.19	7.91	*IPHITRI*	14.20	12.32
ANTHSPC	17.83	14.90	*DOSILUP*	70.19	7.91	*JAERNOR*	17.19	14.92
ANTUSPA	16.99	15.85	*DRILFIL*	17.69	15.92	*JASMELE*	15.02	11.34
AONIOXY	10.59	9.69	*EBALEDW*	16.43	11.29	*JASSMAR*	11.78	9.92
AORATYP	11.78	9.92	*EBALTUM*	16.43	11.29	*JUJUSTR*	59.27	6.92
AORISPA	11.78	9.92	*ECHIPUS*	46.76	5.61	*KEFECIR*	15.02	11.34
APHECLE	11.78	9.92	*EDWACLA*	17.22	14.30	*KELLSUB*	38.64	5.62
APHEOVA	11.78	9.92	*ENSIENS*	57.54	6.31	*LABIDIG*	13.54	11.33
APSELAT	15.69	13.37	*EPITCLA*	59.27	6.92	*LAEVCRA*	67.87	4.53
APSETAL	15.69	13.37	*ERICPUN*	11.78	9.92	*LANICON*	15.42	8.90
ARCALAC	57.54	6.31	*ERVICAS*	57.54	6.31	*LARVINS*	14.20	12.32
ARCTSPA	16.99	15.85	*ETEOSPA*	14.65	13.60	*LEPICAN*	54.85	7.35
ARICFOE	20.83	13.03	*EUCLOER*	15.02	11.34	*LEPICIN*	54.85	7.35
ARMACIR	15.02	11.34	*EUCLPAL*	15.02	11.34	*LEPILON*	11.78	9.92
ASCISPP	13.54	11.33	*EULAAUR*	14.65	13.60	*LEPTGLA*	15.02	11.34
ASTALON	16.99	15.85	*EUMISAN*	14.65	13.60	*LEPTINH*	13.54	11.33
ATELUND	12.58	6.75	*EUNELON*	15.02	11.34	*LEPTPEC*	11.78	9.92
ATYLGUT	11.78	9.92	*EUNIVIT*	15.02	11.34	*LEPTPIL*	11.78	9.92
ATYLSWA	11.78	9.92	*EURYASP*	16.43	11.29	*LEUCINC*	11.78	9.92
ATYLVED	11.78	9.92	*EURYPUL*	18.72	7.98	*LEUCRIC*	11.78	9.92
AUTOLAN	15.02	11.34	*EXOGNAI*	15.02	11.34	*LIOCARC*	23.24	11.51
BARNCAN	57.54	6.31	*EXOGVER*	15.02	11.34	*LIOCCOR*	23.24	11.51
BATHGUI	11.29	10.28	*GAFRMIN*	70.19	7.91	*LIOCHOL*	23.24	11.51
BHAWSPA	15.64	13.94	*GAMMFUC*	11.78	9.92	*LIOCPUS*	23.24	11.51
BITTRET	59.27	6.92	*GAMMLOC*	11.78	9.92	*LIOCSPA*	23.24	11.51
BODOSCO	14.20	12.32	*GAMMMAC*	11.47	9.56	*LIOCVER*	23.24	11.51
BRANLAN	18.08	14.62	*GAMMSOP*	11.47	9.56	*LISTPIC*	11.78	9.92
CALLSEP	54.85	7.35	*GARIDEP*	78.31	12.10	*LOPHSTE*	57.54	6.31
CALYCHI	55.03	6.13	*GAROSPA*	11.47	9.56	*LORILAC*	57.54	6.31
CAPICAP	13.90	11.92	*GASTFRA*	78.31	12.10	*LUCIBOR*	57.54	6.31
CAPRACA	11.10	11.03	*GASTSPI*	9.59	8.86	*LUMBLAT*	17.69	15.92
CARCMAE	23.24	11.51	*GIBUMAG*	59.27	6.92	*LUMBPAR*	17.69	15.92
CARDCAL	57.54	6.31	*GLYCCAP*	14.86	13.68	*LUNAALD*	59.27	6.92
CARDPAU	67.87	4.53	*GLYCROU*	14.86	13.68	*LUTRLUT*	57.54	6.31
CAULSPP	14.47	11.41	*GLYCTRY*	14.86	13.68	*LYGDMUR*	13.65	11.76
CERAEDU	67.87	4.53	*GLYCUNI*	14.86	13.68	*LYONNOR*	57.54	6.31
CERASEM	11.78	9.92	*GONIERE*	15.02	11.34	*LYSIINE*	11.78	9.92
CHAEANG	54.85	7.35	*GONIGAL*	15.02	11.34	*LYSIMIN*	15.02	11.34

Species	Conv. Factors	
	DW	AFDW
MACRROS	16.43	11.29
MAEROTH	11.78	9.92
MAGEALL	15.02	11.34
MALACIL	10.59	9.69
MALAFUL	10.59	9.69
MANGCOA	59.27	6.92
MARPSAN	15.02	11.34
MEDICAP	14.23	11.82
MEDOLAN	16.43	11.29
MEGAAGI	11.78	9.92
MEGAVES	15.02	11.34
MELIGLA	11.78	9.92
MELIOBT	11.78	9.92
MELIPAL	17.01	11.60
MELTPAL	11.78	9.92
METAPEC	11.78	9.92
MICRABE	15.02	11.34
MICRCUM	11.78	9.92
MICRMAC	11.47	9.56
MICRMEC	10.59	9.69
MIDESPA	11.78	9.92
MIDEVER	11.78	9.92
MODISPA	57.54	6.31
MONIPAT	57.54	6.31
MONTFER	38.64	5.62
MUSCCOS	57.54	6.31
MYRIHEE	15.02	11.34
MYSEBID	38.64	5.62
MYSTPIC	14.65	13.60
MYTIGAL	57.54	6.31
MYXIINF	15.02	11.34
NASSARG	59.27	6.92
NASSINC	66.94	6.39
NASSRET	59.34	7.27
NEBABIP	14.20	12.32
NEMAUNI	15.02	11.34
NEMESPA	14.41	11.83
NEMESPB	14.41	11.83
NEMESPC	13.91	11.85
NEOAAFF	15.42	8.90
NEPTCIR	19.98	14.80
NEPTHOM	19.98	14.80
NERECAU	15.02	11.34
NERESUC	15.02	11.34
NOTHCON	13.15	11.78
NOTHGEO	13.15	11.78
NOTOLAT	16.40	11.18
NUCUNUC	79.54	9.40
NUDISPA	9.46	4.39
OLIGSPA	20.79	14.49
OLIGSPB	20.79	14.49
OPHELAU	15.02	11.34
OPHENEG	15.02	11.34
OPHIALB	44.14	7.75
OPHYSPA	15.02	11.34
ORCHMAS	11.78	9.92
ORCHNAN	11.78	9.92
OSTRSPA	11.35	8.12
OSTRSPB	11.35	8.12
OSTRSPC	11.35	8.12
OWENFUS	15.02	11.34
PAGUSPP	16.43	11.29
PANDALB	57.54	6.31
PARAELE	15.02	11.34
PARAFOR	17.19	14.92
PARAKOS	15.02	11.34
PARALAB	15.02	11.34
PARALYR	15.02	11.34
PARITYP	11.10	11.03
PARVEXI	67.87	4.53
PARVSCR	67.87	4.53
PECTKOR	15.02	11.34
PERILON	11.78	9.92
PHERMON	15.02	11.34
PHILAPE	9.46	4.39
PHILMON	16.43	11.29
PHOLSYN	15.64	13.94
PHORSPA	15.02	11.34
PHOTLOC	11.47	9.56
PHOTLON	11.47	9.56
PHTIMAR	11.10	11.03
PICNSPA	14.20	12.32
PILAVER	15.02	11.34
PINOPIS	16.43	11.29
PISILON	16.43	11.29
PISIREM	15.02	11.34
PISTCRI	15.42	8.90
PITARUD	70.19	7.91
PLATDUM	15.02	11.34
PLATSPA	9.46	4.39
PODAAGI	15.02	11.34
POECSER	15.02	11.34
POLYAPP	15.02	11.34
POLYARM	10.59	9.69
POLYCAE	10.59	9.69
POLYCIL	10.59	9.69
POLYHOP	10.59	9.69
POLYSPA	15.42	8.90
POMAMIC	18.08	14.62
POMAMIN	18.08	14.62
POMAPIC	18.08	14.62
POMASPA	18.08	14.62
PRAXAFF	15.02	11.34
PRIOCIR	10.59	9.69
PRIOMAL	10.59	9.69
PROCMAC	16.43	11.29
PROTKEF	15.02	11.34
PROTSPA	14.65	13.60
PSAMMIL	46.76	5.61
PSEUANT	10.59	9.69
PSEULIM	14.65	13.60
PSEUPHA	11.10	11.03
PYGOELE	10.59	9.69
RETUSPA	59.27	6.92
RISSLAB	59.27	6.92
SABEOCT	15.42	8.90
SABEPAV	15.02	11.34
SABESPI	13.65	11.76
SACCPAP	15.02	11.34
SCALINF	15.02	11.34
SCHINEG	15.02	11.34
SCHIRUD	15.02	11.34
SCOLARM	20.83	13.03
SCROPLA	34.87	5.27
SERPSPP	15.02	11.34
SIGASQU	15.64	13.94
SIGATEN	15.02	11.34
SIPHSTR	13.76	11.40
SIPUSPP	70.30	5.21
SOLEMAR	57.54	6.31
SOLETOG	57.54	6.31
SPHABOC	18.72	7.98
SPHABUL	15.02	11.34
SPHAHOO	18.72	7.98
SPHAHYS	15.02	11.34
SPHAMON	18.72	7.98
SPHATAY	15.02	11.34
SPIOBOM	10.59	9.69
SPIOCOS	13.03	7.79
SPIODEC	10.59	9.69
SPIONDE	10.59	9.69
SPISSOL	57.54	6.31
SPISSUB	57.54	6.31
STENMAR	11.78	9.92
STHEBOA	15.64	13.94
STRESHR	10.59	9.69
SYLLGAR	15.02	11.34
SYLLHYA	15.02	11.34
SYLLSPA	15.02	11.34
SYNCHAP	11.78	9.92
SYNCLON	11.78	9.92
SYNISPA	17.19	14.92
TELLDON	78.31	12.10
TELLFAB	78.31	12.10
TELLPUL	78.31	12.10
TELLPYG	78.31	12.10
TELLSER	78.31	12.10
TELLTEN	78.31	12.10
THARSPA	13.57	11.67
THRASPA	57.54	6.31
THROSPA	59.27	6.92
THYAFLE	57.54	6.31
TRYPLON	11.78	9.92
TUBIBEN	20.79	14.49
TURRTRI	59.27	6.92
UPOGTYP	15.96	12.12
UROTBRE	11.29	10.28
UROTELE	11.29	10.28
UROTGRI	11.29	10.28
VENEPUL	70.19	7.91
VENUCAS	70.19	7.91
VENUFAS	70.19	7.91
VENUSTR	70.19	7.91
VENUVER	70.19	7.91
VIRGMIR	18.98	14.07
XANTSPA	16.43	11.29
Fragments	16.03	12.31

Annex V

Number of presences of each species in each of the affinity groups defined by Twinspan (for species codes see annex III).

	MARINE		TRANSITION	ESTUARINE				
	A1	A2	B1	B2A	I	II	B2B"	
	13 St.	8 St.	31 St.	43 St.	19 St.	13 St.	4 St.	TOTAL
ABRAALB	1	1	27	22	19	7		77
ABRANIT				3	2	2		7
ACOESPA			1					1
ADYTPEL						1		1
AGLARUB			1					1
AKERSPA				1	1			2
ALVABEA	1							1
AMAETRI			1	5		1		7
AMPEBRE		1	4	4	1			10
AMPEDIA			9	7	11			27
AMPEREM			8	6	13	1		28
AMPESPI	1		2	1	5	6		15
AMPETEN	2		22	30	16	4		74
AMPHCHI					1			1
AMPHGAM			1					1
AMPHLIN			3	1	3			7
AMPHNEA	2		7		4			13
AMPHNEG			1					1
AMPHSPE			6	1				7
AMPHSQA	1		14	2	1			18
ANAILIN	3	2	20	9	11	1	1	47
ANAIMUC	4	1	25	18	15	7	1	71
ANFISPA	3		1					4
ANTHSPA			6	7	5			18
ANTHSPB	1		1	1				3
ANTHSPC	2		5	3	2			12
ANTUSPA	2		5					7
AONIOXY	3	1	29	37	19	1	1	91
AORATYP			2	3	2	1		8
AOTISPA			1	1	2	4		8
APHECLE	1							1
APHEOVA	1		5	3	4	1		14
APSELAT	3	2	14	2				21
APSETAL			22	8	16	2		48
ARCALAC	2		1					3
ARCTSPA			2					2
ARICFOE		2		1				3
ARMACIR			3					3
ASCISPP			2					2
ASTALON			6	4	3			13
ATELUND	1		10	1				12
ATYLGUT	1		7	8	2	2		20
ATYLSWA	1		1					2
ATYLVED	3		15					18
AUTOLAN			1	1	2			4
BARNCAN				1				1
BATHGUI	1							1
BHAWSPA	1							1
BITTRET	1		1					2
BODOSCO		1	7	5	3			16
BRANLAN			1					1
CALLSEP	1							1
CALYCHI	2	1	22	11	8			44
CAPICAP	1	2	7	2	2	2	4	20
CAPRACA	2	1	14	6		1		24
CARCMAE						1	1	2
CARDCAL	1							1
CARDPAU			4	12	15	4		35
CAULSPP	3	5	30	35	19	8	3	103
CERAEDU	3	4	5	15	2	2		31
CERASEM			1					1
CHAEANG			10	15	12	1	1	39

	MARINE		TRANSITION	ESTUARINE				
	A1	A2	B1	B2A	I	II	B2B"	
	13 St.	8 St.	31 St.	43 St.	19 St.	13 St.	4 St.	TOTAL
CHAEVAR					1			1
CHEISUN	3		15	17	11	2	1	49
CHLOSPA			1	1				2
CHRYTER			2					2
CIROSPA	6	1	3	4				14
CIRRSPA	2	4	24	41	19	8	2	100
CLYMCLY	1		4		1			6
CORBGIB			16	27	15	2		60
COROACU			1					1
COROANN	3	1	27	33	18	6		88
COROCOM				3				3
COROINS				1				1
CORORUN			10	15	5	2		32
COROSEX	2		8	11	7	4		32
CRANCRA		3	2	7	1	3	1	17
CYATCAR			15	22	19	4	3	63
CYMOTRU	1		1					2
DENTSPA			1					1
DEXASPI	1		5	5	4	1		16
DIALACU			3	7	7	1		18
DIASRUG			2					2
DIOPNEA			6	2	5	8		21
DIPLCIR	1							1
DIVADIV			6	2	1			9
DOSIEXO			5					5
DOSILUP					1			1
DRILFIL			6	14	5			25
EBALEDW			1					1
EBALTUM			2					2
ECHIPUS			2					2
EDWACLA			1		3			4
ENSIENS	1		6	1	1			9
EPITCLA	1		2					3
ERICPUN			2	5	3	3	1	14
ERVICAS	3		7	1				11
ETEOSPA	2							2
EUCLOER			1		1			2
EUCLPAL			20	7	6			33
EULAAUR			1					1
EUMISAN			8	3	5			16
EUNELON		1	6	10	1			18
EUNIVIT	1		9	2	3			15
EURYASP			1					1
EURYPUL	2	1		1				4
EXOGNAI			2					2
EXOGVER			6		2	1	1	10
GAFRMIN			2					2
GAMMFUC	2		3	1	1			7
GAMMLOC					1			1
GAMMMAC	4		14	3	1			22
GAMMSOP		1		3	1	1		6
GARIDEP			1					1
GAROSPA						1		1
GASTFRA	1							1
GASTSPI	11	3	6	3	2			25
GIBUMAG			1					1
GLYCCAP	8		10	1				19
GLYCROU			5					5
GLYCTRY	6	5	26	30	8	5		80
GLYCUNI			1	1	4	1		7
GONIERE			1					1
GONIGAL	9	7	10	6				32

	MARINE		TRANSITION	ESTUARINE				
	A1	A2	B1	B2A	I	II	B2B"	
	13 St.	8 St.	31 St.	43 St.	19 St.	13 St.	4 St.	TOTAL
GONIGRA	2		1					3
GYPTPRO			3		1			4
HAMINAV			1	2	3			6
HARMIMB			1	4				5
HARMIMP	1		16	3	11	3		34
HARMLJU	2		8	3	1	1		15
HARMLUN			2	2	1			5
HARMMAR			2	3		1		6
HARPANT	1		2					3
HARPLAE			3					3
HARPPEC			11	11	16	1		39
HEMINIT			5	30	2			37
HESIELO	3		1					4
HETEFIL		1	7	29	16	3	2	58
HETEMIC				15	1			16
HETEOER		1	9	7	6	1		24
HIATART	1		1					2
HIPPDEN			2					2
HYALBIL	1		10					11
HYALVIT					1			1
HYDRULV		1	1		1		1	4
INACCOM					1			1
INACDOR			3	2	3			8
IPHITEN	3	1	26	26	18	8	2	84
IPHITRI			1					1
JAERNOR	1							1
JASMELE			1					1
JASSMAR			1		1	1		3
JUJUSTR	1							1
KEFECIR			1					1
KELLSUB	1		1					2
LABIDIG			1					1
LAEVCRA			3					3
LANICON			14	22	10	4		50
LARVINS							1	1
LEPICAN			1	1	1			3
LEPICIN	1							1
LEPILON			4					4
LEPTGLA				2				2
LEPTINH		1	6	1	1			9
LEPTPEC	1	1	23	11	5			41
LEPTPIL				7				7
LEUCINC	1	1	5	3				10
LEUCRIC			1		1			2
LIOCARC			1		2	2		5
LIOCCOR			3	1				4
LIOCHOL	1		1					2
LIOCPUS			2	1				3
LIOCSPA			1					1
LIOCVER	1							1
LISTPIC	1		10	1	2			14
LOPHSTE			2	1		1		4
LORILAC		1	3	3		1		8
LUCIBOR			5	1	3	1		10
LUMBLAT	1		24	22	17	1		65
LUMBPAR	1	1						2
LUNAALD					1			1
LUTRLUT			13	2	7			22
LYGDMUR		1	9	14	6			30
LYONNOR				2	1			3
LYSIINE			2					2
LYSIMIN			1					1

	MARINE		TRANSITION	ESTUARINE				
	A1	A2	B1	B2A	I	II	B2B"	
	13 St.	8 St.	31 St.	43 St.	19 St.	13 St.	4 St.	TOTAL
MACRROS			1					1
MAEROTH	3	1	7					11
MAGEALL			2	1	2			5
MALACIL			7					7
MALAFUL					1		4	5
MANGCOA			1					1
MARPSAN	1		4	2	1	2		10
MEDICAP	7	2	29	21	11	2		72
MEDOLAN			2	4				6
MEGAAGI			2	1				3
MEGAVES		1	5	4	2			12
MELIGLA	1		3			2		6
MELIOBT	4		16	9	3	4		36
MELIPAL			17	22	19	7	1	66
MELTPAL				4				4
METAPEC			15	2	7			24
MICRABE	2							2
MICRCUM			1					1
MICRMAC			2			1		3
MICRMEC			1					1
MIDESPA			1					1
MIDEVER	1	1	19	14	16	2	1	54
MODISPA	2		3	2				7
MONIPAT			1					1
MONTFER			1					1
MUSCCOS	1							1
MYRIHEE	1		1	1				3
MYSEBID			3	1	2			6
MYSTPIC			4					4
MYTIGAL				1				1
MYXIINF				2	5			7
NASSARG			1					1
NASSINC		1	9	15	5			30
NASSRET	2	1	15	3	5		1	27
NEBABIP	2		3	2				7
NEMAUNI	1		15	5	3			24
NEMESPA	8		21	5		1		35
NEMESPB		1	26	24	16	4		71
NEMESPC	1		14	3	4	1		23
NEOAAFF			4	4	5	1		14
NEPTCIR	11	7	16	5	1			40
NEPTHOM	1	1	11	15	9	10	2	49
NERECAU							1	1
NERESUC			1					1
NOTHCON	1		2					3
NOTHGEO			1					1
NOTOLAT	9	1	29	30	8	1		78
NUCUNUC	2		14	6	10	1	1	34
NUDISPA	2		1					3
OLIGSPA	10	1	3	1	1			16
OLIGSPB		3	9	11	4	3	3	33
OPHELAU			2	1				3
OPHENEG		1						1
OPHIALB			1					1
OPHYSPA							1	1
ORCHMAS			2					2
ORCHNAN			3	2	1			6
OSTRSPA	5	2	15	6				28
OSTRSPB		1	16	3	8	1		29
OSTRSPC			11	2	1			14
OWENFUS			8	1	6			15
PAGUSPP	1		3	4	1			9

	MARINE		TRANSITION	ESTUARINE				
	A1	A2	B1	B2A	I	II	B2B"	
	13 St.	8 St.	31 St.	43 St.	19 St.	13 St.	4 St.	TOTAL
PANDALB			1	1	2	1		5
PARAELE	12	6	5	6				29
PARAFOR			5		1			6
PARAKOS	1		3					4
PARALAB		2						2
PARALYR	6		10	19	5	1		41
PARITYP	6	1	19	11	8	2		47
PARVEXI			5	8	8	1		22
PARVSCR			3		1			4
PECTKOR			3	1	3			7
PERILON	1		16	5	6			28
PHERMON			2					2
PHILAPE			8	2	2			12
PHILMON					1			1
PHOLSYN	1		5	1	1			8
PHORSPA	2		15	3	5			25
PHOTLOC				1				1
PHOTLON	9	2	20	6	7			44
PHTIMAR	7	1	18	12	15	5	2	60
PICNSPA			1		1			2
PILAVER			1	1	1			3
PINOPIS				1	1			2
PISILON	1		3					4
PISIREM	13	1	3					17
PISTCRI	1		16	20	15	3		55
PITARUD			1					1
PLATDUM						1		1
PLATSPA	2	1	4	2	1			10
PODAAGI			1					1
POECSER			11	4				15
POLYAPP	6		2					8
POLYARM			1					1
POLYCAE	4	3	25	23	16	4		75
POLYCIL	1			1	1			3
POLYHOP	1							1
POLYSPA	3	1	20	9	1			34
POMAMIC			2					2
POMAMIN				1				1
POMAPIC					1			1
POMASPA				1				1
PRAXAFF			1					1
PRIOCIR	1	1	12	1	4	1		20
PRIOMAL			7	1	2			10
PROCMAC			1					1
PROTKEF	10	3	14	3	1			31
PROTSPA	1		1					2
PSAMMIL	1		1					2
PSEUANT	1	1	23	13	12	2	1	53
PSEULIM	2		2					4
PSEUPHA	4							4
PYGOELE				1				1
RETUSPA			1		1			2
RISSLAB			1					1
SABEOCT					1			1
SABEPAV			3	2	7			12
SABESPI	4		13	1	2			20
SACCPAP	9	2						11
SCAINF			18	26	7			51
SCHINEG	2		1					3
SCHIRUD	1		4	3	1	1	1	11
SCOLARM	3	7	19	29	2	2		62
SCROPLA		1	2	13		1		17

	MARINE		TRANSITION	ESTUARINE				
	A1	A2	B1	B2A	I	II	B2B"	
	13 St.	8 St.	31 St.	43 St.	19 St.	13 St.	4 St.	TOTAL
SERPSPP	5		12	1	1			19
SIGASQU	1							1
SIGATEN			3					3
SIPHSTR				1				1
SIPUSPP			8		3			11
SOLEMAR		1	2	15	3			21
SOLETOG					2	1		3
SPHABOC		1		2				3
SPHABUL	3	1	11	1	2			18
SPHAHOO	1			1				2
SPHAHYS	1							1
SPHAMON	7		4	4				15
SPHATAY				1				1
SPIOBOM	4		6					10
SPIOCOS	4	1	24	35	18	4	3	89
SPIODEC	2	1	11	3				17
SPIONDE			1	1	1			3
SPISSOL	6		17	1	2			26
SPISSUB			5	3	4			12
STENMAR	2		5		1	1		9
STHEBOA			13	6	12	1		32
STRESHR				2		2		4
SYLLGAR	1							1
SYLLHYA	8	2	19	12	7	1		49
SYLLSPA			1					1
SYNCHAP			4	1	1			6
SYNCLON			1					1
SYNISPA	1		1			1		3
TELLDON		1	7	3	1	1		13
TELLFAB			3					3
TELLPUL			1					1
TELLPYG			1					1
TELLSER			1					1
TELLTEN	1	6	2	3				12
THARSPA	2		25	35	19	6	3	90
THRASPA	1		4		1			6
THROSPA			1					1
THYAFLE			1	1	1			3
TRYPLON	1		3					4
TUBIBEN		1	4	5	6	5	1	22
TURRTRI			1		2			3
UPOGTYP				20	1			21
UROTBRE	2		2					4
UROTELE	1		7	1				9
UROTGRI	6		1					7
VENEPUL	3		18	1	3			25
VENUCAS			5	1				6
VENUFAS			4					4
VENUSTR			10	3	6			19
VENUVER			2					2
VIRGMIR		2	9	31	8	3		53
XANTSPA	1							1
TOTAL	410	136	1985	1479	929	236	53	

Annex VI

Abundances of each species, in the affinity groups defined in Twinspan (for species codes see annex III).

	MARINE		TRANSITION	ESTUARINE				
	A1	A2	B1	B2A	I	II	B2B"	
	13 St.	8 St.	31 St.	43 St.	19 St.	13 St.	4 St.	TOTAL
ABRAALB	1	1	776	167	631	76		1652
ABRANIT				18	16	9		43
ACOESPA			1					1
ADYTPEL						1		1
AGLARUB			4					4
AKERSPA				2	5			7
ALVABEA	5							5
AMAETRI			4	13		1		18
AMPEBRE		2	47	56	2			107
AMPEDIA			107	10	190			307
AMPEREM			61	13	217	1		292
AMPESPI	1		12	1	13	243		270
AMPETEN	2		268	265	781	7		1323
AMPHCHI					1			1
AMPHGAM			2					2
AMPHLIN			4	1	3			8
AMPHNEA	4		12		4			20
AMPHNEG			16					16
AMPHSPE			10	1				11
AMPHSQA	4		81	3	1			89
ANAILIN	3	3	92	16	44	4	1	163
ANAIMUC	7	1	166	108	88	16	4	390
ANFISPA	10		2					12
ANTHSPA			52	15	8			75
ANTHSPB	1		1	1				3
ANTHSPC	2		16	12	2			32
ANTUSPA	5		43					48
AONIOXY	4	1	606	829	623	2	1	2066
AORATYP			184	7	10	10		211
AOTISPA			5	3	3	4		15
APHECLE	1							1
APHEOVA	2		14	5	6	4		31
APSELAT	3	3	1268	8				1282
APSETAL			489	52	261	3		805
ARCALAC	7		3					10
ARCTSPA			16					16
ARICFOE		3		3				6
ARMACIR			5					5
ASCISPP			4					4
ASTALON			18	13	7			38
ATELUND	1		28	1				30
ATYLGUT	1		18	14	3	3		39
ATYLSWA	3		1					4
ATYLVED	58		64					122
AUTOLAN			1	1	5			7
BARNCAN				1				1
BATHGUI	28							28
BHAWSPA	1							1
BITTRET	10		4					14
BODOSCO		2	12	8	5			27
BRANLAN			6					6
CALLSEP	1							1
CALYCHI	85	1	208	19	33			346
CAPICAP	65	2	24	2	5	20	15602	15720
CAPRACA	19	1	136	18		7		181
CARCMAE						1	1	2
CARDCAL	4							4
CARDPAU			19	40	54	6		119
CAULSPP	8	38	1281	752	639	57	8	2783
CERAEDU	4	23	5	65	2	4		103
CERASEM			5					5
CHAEANG			34	25	31	1	1	92

	MARINE		TRANSITION	ESTUARINE				
	A1	A2	B1	B2A	I	II	B2B"	
	13 St.	8 St.	31 St.	43 St.	19 St.	13 St.	4 St.	TOTAL
CHAEVAR					1			1
CHEISUN	5		113	80	28	5	1	232
CHLOSPA			7	1				8
CHRYTER			3					3
CIROSPA	8	1	3	6				18
CIRRSPA	2	13	392	1710	1463	81	12	3673
CLYMCLY	1		41		6			48
CORBGIB			27	68	88	4		187
COROACU			1					1
COROANN	7	3	2075	252	259	15		2611
COROCOM				5				5
COROINS				1				1
CORORUN			360	260	40	3		663
COROSEX	39		767	76	28	15		925
CRANCRA		3	2	11	2	4	1	23
CYATCAR			97	377	363	5	4	846
CYMOTRU	5		2					7
DENTSPA			1					1
DEXASPI	2		18	10	16	1		47
DIALACU			4	10	15	2		31
DIASRUG			2					2
DIOPNEA			12	2	7	13		34
DIPLCIR	1							1
DIVADIV			22	2	1			25
DOSIEXO			6					6
DOSILUP					1			1
DRILFIL			15	23	9			47
EBALEDW			1					1
EBALTUM			2					2
ECHIPUS			2					2
EDWACLA			1		7			8
ENSIENS	1		11	1	1			14
EPITCLA	1		3					4
ERICPUN			130	11	4	17	1	163
ERVICAS	31		9	1				41
ETEOSPA	2							2
EUCLOER			2		57			59
EUCLPAL			421	25	90			536
EULAAUR			2					2
EUMISAN			19	3	7			29
EUNELON		1	20	16	1			38
EUNIVIT	1		37	2	4			44
EURYASP			1					1
EURYPUL	4	2		1				7
EXOGNAI			4					4
EXOGVER			10		3	1	8	22
GAFRMIN			3					3
GAMMFUC	9		3	1	3			16
GAMMLOC					1			1
GAMMMAC	138		256	7	1			402
GAMMSOP		1		4	2	1		8
GARIDEP			1					1
GAROSPA						3		3
GASTFRA	1							1
GASTSPI	76	4	8	5	2			95
GIBUMAG			1					1
GLYCCAP	38		46	1				85
GLYCROU			19					19
GLYCTRY	14	20	106	95	28	5		268
GLYCUNI			1	1	5	1		8
GONIERE			1					1
GONIGAL	128	16	77	8				229

	MARINE		TRANSITION	ESTUARINE				
	A1	A2	B1	B2A	I	II	B2B"	
	13 St.	8 St.	31 St.	43 St.	19 St.	13 St.	4 St.	TOTAL
GONIGRA	3		3					6
GYPTPRO			5		1			6
HAMINAV			1	2	4			7
HARMIMB			5	5				10
HARMIMP	1		37	6	18	6		68
HARMLJU	13		46	4	1	1		65
HARMLUN			3	3	1			7
HARMMAR			3	4		1		8
HARPANT	1		21					22
HARPLAE			14					14
HARPPEC			92	49	88	2		231
HEMINIT			50	904	17			971
HESIELO	4		2					6
HETEFIL		2	25	226	114	5	2	374
HETEMIC				51	1			52
HETEOER		3	48	9	26	1		87
HIATART	1		5					6
HIPPDEN			4					4
HYALBIL	1		24					25
HYALVIT					1			1
HYDRULV		1	2		1		1	5
INACCOM					2			2
INACDOR			4	2	3			9
IPHITEN	4	1	471	301	505	47	6	1335
IPHITRI			1					1
JAERNOR	2							2
JASMELE			1					1
JASSMAR			8		5	3		16
JUJUSTR	8							8
KEFECIR			1					1
KELLSUB	1		1					2
LABIDIG			1					1
LAEVCRA			4					4
LANICON			50	125	52	16		243
LARVINS							5	5
LEPICAN			1	1	1			3
LEPICIN	3							3
LEPILON			8					8
LEPTGLA				2				2
LEPTINH		1	14	1	1			17
LEPTPEC	1	24	202	26	29			282
LEPTPIL				22				22
LEUCINC	1	6	12	3				22
LEUCRIC			1		2			3
LIOCARC			1		2	2		5
LIOCCOR			3	2				5
LIOCHOL	1		1					2
LIOCPUS			2	1				3
LIOCSPA			1					1
LIOCVER	1							1
LISTPIC	1		59	3	5			68
LOPHSTE			5	1		17		23
LORILAC		1	4	3		1		9
LUCIBOR			7	1	22	1		31
LUMBLAT	1		214	91	75	1		382
LUMBPAR	1	1						2
LUNAALD					1			1
LUTRLUT			20	5	12			37
LYGDMUR		1	153	178	24			356
LYONNOR				2	1			3
LYSIINE			2					2
LYSIMIN			1					1

	MARINE		TRANSITION	ESTUARINE				
	A1	A2	B1	B2A	I	II	B2B"	
	13 St.	8 St.	31 St.	43 St.	19 St.	13 St.	4 St.	TOTAL
MACRROS			1					1
MAEROTH	14	1	87					102
MAGEALL			7	3	2			12
MALACIL			46					46
MALAFUL					7		163	170
MANGCOA			1					1
MARPSAN	1		4	3	1	4		13
MEDICAP	34	3	1328	172	132	4		1673
MEDOLAN			3	6				9
MEGAAGI			6	1				7
MEGAVES		1	6	4	2			13
MELIGLA	32		13			2		47
MELIOBT	29		233	22	11	6		301
MELIPAL			226	442	1421	131	1	2221
MELTPAL				14				14
METAPEC			48	2	19			69
MICRABE	14							14
MICRCUM			1					1
MICRMAC			2			2		4
MICRMEC			4					4
MIDESPA			6					6
MIDEVER	1	2	198	105	57	8	1	372
MODISPA	3		3	2				8
MONIPAT			8					8
MONTFER			2					2
MUSCCOS	1							1
MYRIHEE	2		4	2				8
MYSEBID			7	1	3			11
MYSTPIC			6					6
MYTIGAL				1				1
MYXIINF				2	7			9
NASSARG			2					2
NASSINC		1	35	25	6			67
NASSRET	10	1	53	6	7		39	116
NEBABIP	3		4	2				9
NEMAUNI	1		48	5	3			57
NEMESPA	38		410	15		1		464
NEMESPB		1	107	69	102	9		288
NEMESPC	2		22	3	5	1		33
NEOAAFF			5	8	17	1		31
NEPTCIR	34	37	56	8	1			136
NEPTHOM	2	2	35	31	16	52	2	140
NERECAU							8	8
NERESUC			2					2
NOTHCON	1		2					3
NOTHGEO			1					1
NOTOLAT	50	1	673	300	40	2		1066
NUCUNUC	3		131	12	47	1	2	196
NUDISPA	5		1					6
OLIGSPA	73	4	21	2	1			101
OLIGSPB		9	62	128	13	15	92	319
OPHELAU			8	2				10
OPHENEG		1						1
OPHIALB			1					1
OPHYSPA							8	8
ORCHMAS			9					9
ORCHNAN			34	5	1			40
OSTRSPA	18	2	40	17				77
OSTRSPB		11	111	11	31	1		165
OSTRSPC			62	7	2			71
OWENFUS			45	6	16			67
PAGUSPP	1		9	5	1			16

	MARINE		TRANSITION	ESTUARINE				
	A1	A2	B1	B2A	I	II	B2B"	
	13 St.	8 St.	31 St.	43 St.	19 St.	13 St.	4 St.	TOTAL
PANDALB			1	1	2	1		5
PARAELE	114	80	16	12				222
PARAFOR			14		2			16
PARAKOS	1		8					9
PARALAB		9						9
PARALYR	66		33	116	14	1		230
PARITYP	28	1	1902	23	56	4		2014
PARVEXI			12	14	29	2		57
PARVSCR			4		1			5
PECTKOR			4	1	3			8
PERILON	1		54	6	25			86
PHERMON			2					2
PHILAPE			10	4	2			16
PHILMON					1			1
PHOLSYN	2		13	1	1			17
PHORSPA	2		77	8	23			110
PHOTLOC				2				2
PHOTLON	604	32	1754	15	12			2417
PHTIMAR	24	1	179	112	99	36	3	454
PICNSPA			1		1			2
PILAVER			1	1	1			3
PINOPIS				2	1			3
PISILON	1		6					7
PISIREM	195	1	10					206
PISTCRI	1		128	79	66	9		283
PITARUD			1					1
PLATDUM						1		1
PLATSPA	2	1	8	2	1			14
PODAAGI			2					2
POECSER			49	8				57
POLYAPP	105		10					115
POLYARM			220					220
POLYCAE	9	7	639	134	206	4		999
POLYCIL	1			1	2			4
POLYHOP	1							1
POLYSPA	19	3	224	19	1			266
POMAMIC			2					2
POMAMIN				1				1
POMAPIC					2			2
POMASPA				1				1
PRAXAFF			3					3
PRIOCIR	3	1	57	3	6	1		71
PRIOMAL			24	1	3			28
PROCMAC			1					1
PROTKEF	64	7	95	8	1			175
PROTSPA	1		1					2
PSAMMIL	3		1					4
PSEUANT	1	1	681	45	44	2	4	778
PSEULIM	2		4					6
PSEUPHA	9							9
PYGOELE				3				3
RETUSPA			2		1			3
RISSLAB			14					14
SABEOCT					1			1
SABEPAV			25	10	30			65
SABESPI	4		75	3	3			85
SACCPAP	44	11						55
SCAINF			159	480	21			660
SCHINEG	4		1					5
SCHIRUD	1		4	6	2	2	1	16
SCOLARM	16	587	175	519	4	3		1304
SCROPLA		1	4	16		1		22

	MARINE		TRANSITION	ESTUARINE				
	A1	A2	B1	B2A	I	II	B2B"	
	13 St.	8 St.	31 St.	43 St.	19 St.	13 St.	4 St.	TOTAL
SERPSPP	55		187	1	1			244
SIGASQU	1							1
SIGATEN			7					7
SIPHSTR				1				1
SIPUSPP			60		3			63
SOLEMAR		1	2	37	6			46
SOLETOG					2	1		3
SPHABOC		2		2				4
SPHABUL	10	1	74	6	2			93
SPHAHOO	2			1				3
SPHAHYS	2							2
SPHAMON	12		4	19				35
SPHATAY				1				1
SPIOBOM	5		14					19
SPIOCOS	6	1	844	4236	2084	8	8	7187
SPIODEC	2	1	33	3				39
SPIONDE			2	1	1			4
SPISSOL	29		71	1	2			103
SPISSUB			8	3	5			16
STENMAR	13		15		2	1		31
STHEBOA			26	6	22	1		55
STRESHR				7		5		12
SYLLGAR	1							1
SYLLHYA	13	11	262	31	14	1		332
SYLLSPA			1					1
SYNCHAP			8	1	1			10
SYNCLON			1					1
SYNISPA	4		1			1		6
TELLDON		1	18	3	1	1		24
TELLFAB			11					11
TELLPUL			1					1
TELLPYG			2					2
TELLSER			1					1
TELLTEN	6	27	8	3				44
THARSPA	3		1680	1907	1147	45	14	4796
THRASPA	1		8		1			10
THROSPA			1					1
THYAFLE			1	1	1			3
TRYPLON	1		7					8
TUBIBEN		9	42	19	576	227	1	874
TURRTRI			1		2			3
UPOGTYP				36	1			37
UROTBRE	21		2					23
UROTELE	3		83	1				87
UROTGRI	12		1					13
VENEPUL	19		245	1	10			275
VENUCAS			6	1				7
VENUFAS			6					6
VENUSTR			22	3	9			34
VENUVER			3					3
VIRGMIR		3	53	192	42	9		299
XANTSPA	1							1
TOTAL	2835	1063	27816	17307	13824	1367	16006	

Annex VII

Wet-weight biomass (mg) of each species, in the affinity groups defined in Twinspan (for species codes see annex III).

	MARINE		TRANSITION	ESTUARINE				
	A1	A2	B1	B2A	I	II	B2B"	
	13 St.	8 St.	31 St.	43 St.	19 St.	13 St.	4 St.	TOTAL
ABRAALB	22.1	12.9	42580.4	8957.3	57248.5	7099.7		115920.9
ABRANIT				1003.9	632.4	724.1		2360.4
ACOESPA			952.8					952.8
ADYTPEL						3.6		3.6
AGLARUB			1038.6					1038.6
AKERSPA				3.3	10.7			14
ALVABEA	16.8							16.8
AMAETRI			291.7	679.6		46.4		1017.7
AMPEBRE		5.0	117.5	141.5	5.0			269.0
AMPEDIA			149.8	14.0	261.8			425.6
AMPEREM			44.8	9.1	155.6	0.7		210.2
AMPESPI	1.1		13.2	1.1	14.3	275.4		305.1
AMPETEN	2.8		375.20	371.0	1088.2	9.8		1847.0
AMPHCHI					493.2			493.2
AMPHGAM			1.2					1.2
AMPHLIN			60.40	15.1	45.4			120.90
AMPHNEA	2.0		6.0		2.0			10.0
AMPHNEG			10.3					10.3
AMPHSPE			5.0	0.5				5.5
AMPHSQA	8.8		178.2	6.6	2.2			195.8
ANAILIN	19.2	19.2	625.40	158.5	336.10	25.6	6.4	1190.40
ANAIMUC	7.0	1.0	231.2	100.5	85.2	16.0	4.0	444.9
ANFISPA	5.0		1.0					6.0
ANTHSPA			26844.30	42068.7	17451.2			86364.20
ANTHSPB	57.1		259.1	18.3				334.5
ANTHSPC	25.0		167.0	1274.0	743.4			2209.4
ANTUSPA	4.5		139.5					144.0
AONIOXY	23.2	8.0	3030.3	4175.0	3232.5	10.2	5.1	10484.3
AORATYP			112.6	4.2	6.0	6.0		128.8
AOTISPA			3.0	1.8	1.8	2.4		9.0
APHECLE	0.6							0.6
APHEOVA	1.0		7.0	2.5	3.0	2.0		15.5
APSELAT	3.0	6.1	1254.3	8.0				1271.4
APSETAL			2004.9	213.2	1067.9	12.3		3298.3
ARCALAC	690.8		916.2					1607.0
ARCTSPA			17.6					17.6
ARICFOE		1083.4		176.9				1260.3
ARMACIR			4.4					4.4
ASCISPP			197.9					197.9
ASTALON			12.6	69.1	4.9			86.6
ATELUND	59.8		3164.1	59.8				3283.7
ATYLGUT	3.4		61.2	47.60	6.8	10.2		129.20
ATYLSWA	10.2		3.4					13.6
ATYLVED	160.3		251.4					411.7
AUTOLAN			0.9	0.9	4.5			6.3
BARNCAN				2878.9				2878.9
BATHGUI	350.9							350.9
BHAWSPA	7.3							7.3
BITTRET	8.8		7.3					16.1
BODOSCO		1.6	9.6	6.4	4.0			21.6
BRANLAN			1084.4					1084.4
CALLSEP	210.7							210.7
CALYCHI	788.3	1.2	6913.8	1828.80	1396.7			10928.80
CAPICAP	98.8	3.0	21.3	3.0	27.1	17.5	25757.4	25928.1
CAPRACA	13.3	0.7	94.6	12.6		4.9		126.1
CARCMAE						253.1	165.9	419.0
CARDCAL	106.8							106.8
CARDPAU			100408.7	150091.1	287353.9	18694		556547.7
CAULSPP	15.2	72.2	5374.8	2273.60	2440.7	96.8	5.2	10278.50
CERAEDU	36.5	155.5	361.4	669.9	25.7	6.8		1255.8
CERASEM			1.0					1.0
CHAEANG			74674.9	40341.6	62746.3	2648.6	6357.5	186768.9

	MARINE		TRANSITION	ESTUARINE				
	A1	A2	B1	B2A	I	II	B2B"	
	13 St.	8 St.	31 St.	43 St.	19 St.	13 St.	4 St.	TOTAL
CHAEVAR					412.2			412.2
CHEISUN	7.0		147.8	112.0	39.20	7.0	1.4	314.4
CHLOSPA			4.1	0.6				4.7
CHRYTER			4.5					4.5
CIROSPA	861.6	208.8	19.8	39.6				1129.8
CIRRSPA	4.0	86.5	2132.3	29307.2	20593.9	1170.0	132.8	53426.7
CLYMCLY	0.9		182.3		13.2			196.4
CORBGIB			5315.3	14207.2	27316.1	62.4		46901.0
COROACU			0.5					0.5
COROANN	3.5	1.5	1054.0	126.0	129.5	7.5		1322.0
COROCOM				39.3				39.3
COROINS				0.5				0.5
CORORUN			209.1	156.0	24.0	1.8		390.9
COROSEX	35.1		714.3	68.4	25.2	13.5		856.5
CRANCRA		711.5	34.0	2444.1	8.7	568.1	21.0	3787.4
CYATCAR			649.9	2472.6	2429.1	33.5	26.8	5611.9
CYMOTRU	29.5		11.8					41.3
DENTSPA			319.3					319.3
DEXASPI	6.6		53.5	33.0	57.8	3.3		154.2
DIALACU			38.3	271.9	498.70	55.8		864.70
DIASRUG			2.8					2.8
DIOPNEA			2119.0	841.0	629.3	10786.8		14376.1
DIPLCIR	0.1							0.1
DIVADIV			513.6	30.7	22.6			566.9
DOSIEXO			7253.1					7253.1
DOSILUP					1260.8			1260.8
DRILFIL			137.2	481.1	148.4			766.7
EBALEDW			315.8					315.8
EBALTUM			340.4					340.4
ECHIPUS			19.0					19.0
EDWACLA			104.2		729.4			833.6
ENSIENS	280.8		10278.7	482.9	17.6			11060.0
EPITCLA	871.1		501.5					1372.6
ERICPUN			89.9	7.7	2.8	11.9	0.7	113.0
ERVICAS	307.7		125.4	25.8				458.9
ETEOSPA	17.4							17.4
EUCLOER			36.3		577.3			613.6
EUCLPAL			5969.4	331.7	1607.9			7909.0
EULAAUR			3.8					3.8
EUMISAN			19.2	3.0	7.0			29.2
EUNELON		16.8	215.6	405.4	0.6			638.4
EUNIVIT	58.1		1205.4	71.2	133.6			1468.3
EURYASP			482.8					482.8
EURYPUL	5.2	2.6		1.3				9.1
EXOGNAI			0.4					0.4
EXOGVER			1.0		0.3	0.1	0.8	2.2
GAFRMIN			542.5					542.5
GAMMFUC	14.4		4.8	1.6	4.8			25.6
GAMMLOC					1.6			1.6
GAMMMAC	220.8		415.6	11.2	1.6			649.2
GAMMSOP		1.6		6.4	3.2	1.6		12.8
GARIDEP			293.0					293.0
GAROSPA						1.6		1.6
GASTFRA	88.4							88.4
GASTSPI	456.0	26.0	46.0	30.0	12.0			570.0
GIBUMAG			1100.0					1100.0
GLYCCAP	736.9		599.6	18.7				1355.2
GLYCROU			2507.1					2507.1
GLYCTRY	163.6	306.0	1927.5	1579.9	346.6	61.6		4385.2
GLYCUNI			38.7	755.2	4492.4	755.2		6041.5
GONIERE			99.1					99.1
GONIGAL	90.8	10.0	50.9	4.4				156.1

	MARINE		TRANSITION	ESTUARINE				
	A1	A2	B1	B2A	I	II	B2B"	
	13 St.	8 St.	31 St.	43 St.	19 St.	13 St.	4 St.	TOTAL
GONIGRA	4.7		20.3					25.0
GYPTPRO			107.9		21.6			129.5
HAMINAV			985.7	3820.1	1336.1			6141.9
HARMIMB			25.5	25.5				51.0
HARMIMP	7.6		281.2	45.6	136.8	45.6		516.8
HARMLJU	46.8		165.6	14.4	3.6	3.6		234.0
HARMLUN			15.3	15.3	5.1			35.7
HARMMAR			15.3	20.4		5.1		40.8
HARPANT	0.8		16.8					17.6
HARPLAE			11.2					11.2
HARPPEC			78.3	34.7	70.4	1.6		185.0
HEMINIT			98.1	1979.5	42.0			2119.6
HESIELO	0.4		0.2					0.6
HETEFIL		6.2	80.2	675.4	950.3	15.5	3.8	1731.4
HETEMIC				260.1	5.1			265.2
HETEOER		0.6	9.6	1.8	5.2	0.2		17.4
HIATART	3.5		10.2					13.7
HIPPDEN			2.0					2.0
HYALBIL	65.7		493.6					559.3
HYALVIT					5.6			5.6
HYDRULV		3.0	3.2		2.1		13.5	21.8
INACCOM					30.8			30.8
INACDOR			61.6	39.2	37.8			138.6
IPHITEN	3.6	0.9	423.9	271.8	452.70	42.30	5.4	1200.60
IPHITRI			2.6					2.6
JAERNOR	0.2							0.2
JASMELE			1.5					1.5
JASSMAR			4.0		2.5	1.5		8.0
JUJUSTR	84.0							84.0
KEFECIR			1.4					1.4
KELLSUB	1.1		0.3					1.4
LABIDIG			963.5					963.5
LAEVCRA			11668.5					11668.5
LANICON			1677.7	2907.0	804.0	395.9		5784.6
LARVINS							14.7	14.7
LEPICAN			2.3	1.0	483.7			487.0
LEPICIN	59.7							59.7
LEPILON			25.6					25.6
LEPTGLA				819.2				819.2
LEPTINH		141.1	2051.1	28.2	178.0			2398.4
LEPTPEC	1.5	36.0	304.8	39.0	43.5			424.8
LEPTPIL				33.0				33.0
LEUCINC	1.7	10.3	20.4	5.1				37.5
LEUCRIC			1.7		3.4			5.1
LIOCARC			5.7		4071.1	4123.6		8200.4
LIOCCOR			214.0	100.6				314.6
LIOCHOL	76.3		18.3					94.6
LIOCPUS			24.9	77.9				102.8
LIOCSPA			189.4					189.4
LIOCVER	997.2							997.2
LISTPIC	1.5		89.2	4.5	7.5			102.7
LOPHSTE			1718.1	769.1		19133.0		21620.2
LORILAC		685.6	12.6	7.2		40.7		746.1
LUCIBOR			137.0	3.6	790.4	3.3		934.3
LUMBLAT	80.5		11226.9	4374.4	4273.8	1.1		19956.7
LUMBPAR	21.3	0.6						21.9
LUNAALD					1200.0			1200.0
LUTRLUT			16265.1	17877.8	6638.7			40781.6
LYGDMUR		211.9	30882.0	39368.5	4980.0			75442.4
LYONNOR				5.8	4.9			10.7
LYSIINE			3.0					3.0
LYSIMIN			1.0					1.0

	MARINE		TRANSITION	ESTUARINE				
	A1	A2	B1	B2A	I	II	B2B"	
	13 St.	8 St.	31 St.	43 St.	19 St.	13 St.	4 St.	TOTAL
MACRROS			13.3					13.3
MAEROTH	26.6	1.9	174.8					203.3
MAGEALL			6.5	28.2	77.9			112.6
MALACIL			231.2					231.2
MALAFUL					31.9		123.30	155.20
MANGCOA			24.3					24.3
MARPSAN	16.3		2885.2	2393.1	565.4	2604.4		8464.4
MEDICAP	37.8	3.8	3371.0	884.70	797.7	5.2		5100.20
MEDOLAN			28.1	50.3				78.4
MEGAAGI			9.6	1.6				11.2
MEGAVES		390.4	1189.7	2536.1	959.1			5075.3
MELIGLA	75.6		23.4			3.6		102.6
MELIOBT	52.2		413.7	39.6	19.8	10.8		536.1
MELIPAL			5676.7	11749.2	33686.6	3151.8	2.9	54267.2
MELTPAL				16.8				16.8
METAPEC			28.4	1.2	11.4			41.0
MICRABE	1.6							1.6
MICRCUM			0.5					0.5
MICRMAC			1.8			1.8		3.6
MICRMEC			5.2					5.2
MIDESPA			5.4					5.4
MIDEVER	0.9	1.8	182.0	93.7	51.30	7.2	0.9	337.80
MODISPA	18.8		3959.8	4711.9				8690.5
MONIPAT			230.3					230.3
MONTFER			1.2					1.2
MUSCCOS	3.1							3.1
MYRIHEE	1.2		2.3	1.2				4.7
MYSEBID			9.1	0.9	5.0			15.0
MYSTPIC			56.8					56.8
MYTIGAL				241.4				241.4
MYXIINF				1253.8	2588.3			3842.1
NASSARG			167.4					167.4
NASSINC		56.6	3229.8	1488.3	831.8			5606.5
NASSRET	3842.4	3439.5	58132.3	7506.0	6623.6		45151.7	124695.5
NEBABIP	10.9		6.6	5.0				22.5
NEMAUNI	16.9		333.9	31.1	17.4			399.3
NEMESPA	69.5		600.6	22.5		1.5		694.1
NEMESPB		4.3	500.0	355.9	363.4	38.7		1262.3
NEMESPC	134.0		24982.3	191.4	1196.8	782.9		27287.4
NEOAAFF			279.9	217.9	254.3	15.2		767.3
NEPTCIR	1571.0	1688.3	2334.1	299.9	3.7			5897.0
NEPTHOM	79.0	4581.5	1973.6	2600.4	1892.4	4892.1	226.8	16245.8
NERECAU							22.4	22.4
NERESUC			226.8					226.8
NOTHCON	1.1		29.5					30.6
NOTHGEO			15.6					15.6
NOTOLAT	415.7	4.3	10286.8	3075.70	311.8	2.1		14096.40
NUCUNUC	9.4		25172.7	3782.9	13961.9	169.1	68.6	43164.6
NUDISPA	24.1		2.3					26.4
OLIGSPA	7.3	0.4	2.1	0.2	0.1			10.1
OLIGSPB		7.2	42.8	93.3	10.4	12.0	50.2	215.9
OPHELAU			5.4	1.4				6.8
OPHENEG		2.5						2.5
OPHIALB			248.1					248.1
OPHYSPA							0.8	0.8
ORCHMAS			11.1					11.1
ORCHNAN			50.8	7.5	1.5			59.8
OSTRSPA	174.8	19.4	436.50	164.9				795.60
OSTRSPB		15.4	148.4	15.4	43.4	1.4		224.0
OSTRSPC			68.2	7.7	2.2			78.1
OWENFUS			2356.8	384.0	1548.9			4289.7
PAGUSPP	228.5		586.5	1400.2	41.8			2257.0

	MARINE		TRANSITION	ESTUARINE				
	A1	A2	B1	B2A	I	II	B2B"	
	13 St.	8 St.	31 St.	43 St.	19 St.	13 St.	4 St.	TOTAL
PANDALB			152.7	247.8	347.4	15.4		763.3
PARAELE	16.4	8.0	1.6	1.2				27.2
PARAFOR			4.2		0.6			4.8
PARAKOS	3.5		28.0					31.5
PARALAB		0.9						0.9
PARALYR	22.5		16.0	45.2	5.6	0.4		89.7
PARITYP	14.0	0.5	922.6	11.5	28.0	2.0		978.6
PARVEXI			957.9	4260.7	7554.6	68.8		12842
PARVSCR			8.4		1.1			9.5
PECTKOR			45.0	23.6	120.2			188.8
PERILON	0.5		25.9	· 3.0	12.6			42.0
PHERMON			1066.2					1066.2
PHILAPE			1592.5	1769.5	13.4			3375.4
PHILMON					9.2			9.2
PHOLSYN	1.2		154.9	0.6	0.6			157.3
PHORSPA	16.4		536.6	50.4	91.7			695.1
PHOTLOC				1.8				1.8
PHOTLON	543.6	28.8	1560.8	13.5	9.9			2156.6
PHTIMAR	16.8	0.7	130.4	78.4	69.3	25.20	2.1	322.90
PICNSPA			0.5		0.5			1.0
PILAVER			11.0	11.0	11.0			33.0
PINOPIS				55.5	27.8			83.3
PISILON	75.6		149.7					225.3
PISIREM	94.60	0.2	0.9					95.70
PISTCRI	74.1		5693.4	4684.6	4163.8	180.6		14796.5
PITARUD			1349.8					1349.8
PLATDUM						41.5		41.5
PLATSPA	2.9	1.5	12.4	3.0	1.5			21.3
PODAAGI			1.0					1.0
POECSER			101.5	11.7				113.2
POLYAPP	40.7		1.0					41.7
POLYARM			22.8					22.8
POLYCAE	3.4	6.3	523.6	126.9	229.4	3.0		892.6
POLYCIL	0.3			0.3	0.6			1.2
POLYHOP	0.1							0.1
POLYSPA	56.2	8.1	1535.5	49	2.7			1651.5
POMAMIC			196.3					196.3
POMAMIN				120.9				120.9
POMAPIC					152.6			152.6
POMASPA				51.1				51.1
PRAXAFF			47.9					47.9
PRIOCIR	0.9	0.5	35.2	1.8	3.6	0.6		42.6
PRIOMAL			12.2	0.5	1.5			14.2
PROCMAC			930.3					930.3
PROTKEF	34.5	1.7	22.6	2.2	0.3			61.3
PROTSPA	0.1		0.1					0.2
PSAMMIL	6.0		1919.6					1925.6
PSEUANT	0.1	1.7	1172.8	78.4	83.5	2.3	0.4	1339.2
PSEULIM	0.2		0.4					0.6
PSEUPHA	25.9							25.9
PYGOELE				2.7				2.7
RETUSPA			3.4		1.4			4.8
RISSLAB			39.5					39.5
SABEOCT					1.8			1.8
SABEPAV			3416.1	1285.7	4540.8			9242.6
SABESPI	7.5		216.6	8.4	8.4			240.9
SACCPAP	7.7	1.1						8.8
SCAINF			944.3	2685.0	108.4			3737.7
SCHINEG	0.8		0.2					1.0
SCHIRUD	0.2		0.8	1.2	0.4	0.4	0.2	3.2
SCOLARM	195.2	5818.5	1645.2	4293.0	8.4	38.7		11999.0
SCROPLA		2034.9	3547.6	34858.7		2019.0		42460.2

	MARINE		TRANSITION	ESTUARINE				
	A1	A2	B1	B2A	I	II	B2B"	
	13 St.	8 St.	31 St.	43 St.	19 St.	13 St.	4 St.	TOTAL
SERPSPP	176.1		560.4	3.0	0.2			739.7
SIGASQU	94.1							94.1
SIGATEN			8.3					8.3
SIPHSTR				7.9				7.9
SIPUSPP			11525.0		388.8			11913.8
SOLEMAR		305.2	1963.3	136166.8	24939.9			163375.2
SOLETOG					14.5	1.0		15.5
SPHABOC		0.6		0.6				1.2
SPHABUL	3.0	0.1	7.4	0.6	0.2			11.3
SPHAHOO	5.6			2.8				8.4
SPHAHYS	0.2							0.2
SPHAMON	152.8		47.0	230.1				429.9
SPHATAY				0.1				0.1
SPIOBOM	11.8		20.0					31.8
SPIOCOS	42.8	8.0	5701.6	32496.1	19228.8	64.0	81.3	57622.6
SPIODEC	11.7	0.9	21.8	1.9				36.3
SPIONDE			0.8	0.4	0.4			1.6
SPISSOL	19638.6		26467.3	2854.9	4260.7			53221.5
SPISSUB			9669.4	2892.0	6161.7			18723.1
STENMAR	2.7		3.2		0.2	0.2		6.3
STHEBOA			924.1	417.2	958.5	19.8		2319.6
STRESHR				0.7		0.5		1.2
SYLLGAR	0.9							0.9
SYLLHYA	12.9	9.9	235.8	25.20	12.6	0.9		297.3
SYLLSPA			0.9					0.9
SYNCHAP			4.0	0.5	0.5			5.0
SYNCLON			0.5					0.5
SYNISPA	4.4		1.1			1.3		6.8
TELLDON		4.3	1098.1	1011.9	1.6	5.4		2121.3
TELLFAB			149.1					149.1
TELLPUL			323.9					323.9
TELLPYG			100.0					100.0
TELLSER			3690.2					3690.2
TELLTEN	505.2	2305.3	1000.8	173.2				3984.5
THARSPA	2.1		3491.5	3978.0	3840.4	101.3	14.7	11428.0
THRASPA	0.4		852.9		1.3			854.6
THROSPA			1.7					1.7
THYAFLE			0.9	0.6	1.2			2.7
TRYPLON	1.5		10.5					12.0
TUBIBEN		6.3	29.4	13.3	412.4	130.2	0.7	592.3
TURRTRI			435.8		1960.7			2396.5
UPOGTYP				50764.2	2033.2			52797.4
UROTBRE	29.0		2.8					31.8
UROTELE	2.1		60.0	0.7				62.8
UROTGRI	16.8		1.4					18.2
VENEPUL	36689.6		383354.0	3471.6	5032.5			428547.7
VENUCAS			5749.8	145.0				5894.8
VENUFAS			5806.5					5806.5
VENUSTR			42062.8	4954.3	14303.9			61321.0
VENUVER			24629.9					24629.9
VIRGMIR		523.8	13310.6	30803.2	5993.5	1571.4		52202.5
XANTSPA	96.2							96.2
fragments	334.3	2.9	3719.7	3825.4	1161.4	219.9	34.5	9298.1
TOTAL	74393.3	25135.3	1131317.9	760417.5	699252.6	83534.4	78303.9	

ENVIRONMENTAL STATUS OF A MULTIPLE USE ESTUARY, THROUGH THE ANALYSIS OF BENTHIC COMMUNITIES: THE SADO ESTUARY, PORTUGAL

SEPARATE APPENDIX

Thesis submitted for the Degree of Doctor of Philosophy

In the
University of Stirling

by

Ana M. J. Rodrigues

Department of Biological and Molecular Sciences
University of Stirling

January 1992

SEPARATE APPENDIX

This separate appendix gives the full data set concerning abundance, wet-weight biomass (mg) and ash-free dry weight biomass (mg), per species and per sampling station, presented in three separate files.

Table 1 gives the species names and code numbers, which are then used in the data files. These are shown in adapted Cornell condensed format, for simplification of reading and to avoid an excessive number of pages. For each sampling station, the data is presented by sequences of two sets of numbers, where the first, an integer number, identifies the species and the second, a real number, corresponds to the abundance or the biomass value.

For exemple, the first line of the abundance file shows:

```
St1 2   1.0  8   5.0 14   1.0 18   1.0 21   4.0 22   1.0 24   1.0 26   1.0 42   1.0 45  40.0
```

which reads as:
in the sampling station 1, the species with the code number 2 is represented by 1 individual, the species with code number 8 is represented by 5 specimens, species 14 and 18 are both represented by 1 specimen, species 21 by 4 individuals, ...

Table 1 - Species names and code numbers.

CODES		SPECIES NAME
2	ABRAALB	Abra alba
3	ABRANIT	Abra nitida
4	ACOESPA	Acoetes sp.
5	ADYTPEL	Adyte pellucida
6	AGLARUB	Aglaophamus rubella
7	AKERSPA	Akera sp.
8	ALVABEA	Alvania beani
9	AMAETRI	Amaena trilobata
10	AMPEBRE	Ampelisca brevicornis
11	AMPEDIA	Ampelisca diadema
12	AMPEREM	Ampelisca remora
13	AMPESPI	Ampelisca spinimana
14	AMPETEN	Ampelisca tenuicornis
15	AMPHCHI	Amphiura chiajei
16	AMPHGAM	Amphithoe gammaroides
17	AMPHLIN	Ampharete lindstroemi
18	AMPHNEA	Amphilochus neapolitanus
19	AMPHNEG	Amphithoe neglecta
20	AMPHSPE	Amphilochus spencebatei
21	AMPHSQA	Amphipholis squamata
22	ANAILIN	Anaitides lineata
23	ANAIMUC	Anaitides mucosa
24	ANFISPA	Amphipod sp. indet.
25	ANTHSPA	Anthozoa spA
26	ANTHSPB	Anthozoa spB
27	ANTHSPC	Anthozoa spC
28	ANTUSPA	Anthuridae sp.
29	AONIOXY	Aonides oxycephala
30	AORATYP	Aora typica
31	AOTISPA	Aoridae sp.
32	APHECLE	Apherusa clevei
33	APHEOVA	Apherusa ovalipes
34	APSELAT	Apseudes latreilli
35	APSETAL	Apseudes talpa
36	ARCALAC	Arca lactea
37	ARCTSPA	Arcturella sp.
38	ARICFOE	Orbinia (=Aricia) foetida
39	ARMACIR	Armandia cirrosa
40	ASCISPP	Ascidian sp. indet.
41	ASTALON	Astacilla longicorns
42	ATELUND	Atelecyclus undecimdentatus
43	ATYLGUT	Atylus guttatus
44	ATYLSWA	Atylus swammerdami
45	ATYLVED	Atylus vedlomensis
46	AUTOLAN	Autolytus cf. langerhansi
47	BARNCAN	Barnea candida
48	BATHGUI	Bathyporeia guilliamsoniana
49	BHAWSPA	Bhawania cf goodei
50	BITTRET	Bittium reticulatum
51	BODOSCO	Bodotria scorpioides
52	BRANLAN	Branchiostoma lanceolatum
53	CALLSEP	Callochiton septenvalvis
54	CALYCHI	Calyptraea chinensis
55	CAPICAP	Capitella capitata
56	CAPRACA	Caprella cf. acanthifera
57	CARCMAE	Carcinus maenas
58	CARDCAL	Cardita calyculata
59	CARDPAU	Cardium paucicostatum
60	CAULSPP	Caulleriella sp.
61	CERAEDU	Cerastoderma edule
62	CERASEM	Ceradocus semiserratus
63	CHAEANG	Chaetopleura angulata
64	CHAEVAR	Chaetopterus variopedatus
65	CHEISUN	Cheirocratus sundevalli
66	CHLOSPA	Flabelligeridae sp.
67	CHRYTER	Chrysallida terebelum
68	CIROSPA	Cirolanidae sp.
69	CIRRSPA	Cirriformia sp.
70	CLYMCLY	Clymenura clypeata
71	CORBGIB	Corbula gibba
72	COROACU	Corophium acutum
73	COROANN	Corophium annulatum
74	COROCOM	Corophium "complexe"
75	COROINS	Corophium insidiosum
76	CORORUN	Corophium runcicorne
77	COROSEX	Corophium sextonae
78	CRANCRA	Crangon crangon
79	CYATCAR	Cyathura carinata
80	CYMOTRU	Cymodoce truncata
81	DENTSPA	Dentalium sp.
82	DEXASPI	Dexamine spinosa
83	DIALACU	Dialychone cf. acustica
84	DIASRUG	Diastylis rugosa
85	DIOPNEA	Diopatra neapolitana
86	DIPLCIR	Diplosyllis cirrosa
87	DIVADIV	Divaricella divaricata
88	DOSIEXO	Dosinia exoleta
89	DOSILUP	Dosinia lupinus
90	DRILFIL	Drilonereis filum
91	EBALEDW	Ebalia edwardsi
92	EBALTUM	Ebalia tumefacta
93	ECHIPUS	Echinociamus pusillus
94	EDWACLA	Edwarsia claparedii
95	ENSIENS	Ensis ensis
96	EPITCLA	Epitonium clathratulum
97	ERICPUN	Ericthonius puntactus
98	ERVICAS	Ervilia castanea
99	ETEOSPA	Eteone sp.
100	EUCLOER	Euclymene oerstedi
101	EUCLPAL	Euclymene palermitana
102	EULAAUR	Eulalia viridis aurea
103	EUMISAN	Eumida sanguinea
104	EUNELON	Eunereis longissima
105	EUNIVIT	Eunice vittata
106	EURYASP	Eurynome aspera
107	EURYPUL	Eurydice pulchra
108	EXOGNAI	Exogone naidina
109	EXOGVER	Exogone verrugera
110	GAFRMIN	Gafrarium minimum
111	GAMMFUC	Gammarella fucicola
112	GAMMLOC	Gammarus locusta
113	GAMMMAC	Gammaropsis maculata
114	GAMMSOP	Gammaropsis sophiae
115	GARIDEP	Gari depressa
116	GAROSPA	Gammaropsis sp.
117	GASTFRA	Gastrana fragilis
118	GASTSPI	Gastrosaccus spinifer
119	GIBUMAG	Gibbula magnum
120	GLYCCAP	Glycera capitata
121	GLYCROU	Glycera rouxii
122	GLYCTRY	Glycera tridactyla (=convoluta)
123	GLYCUNI	Glycera unicornis
124	GONIERE	Goniada eremita
125	GONIGAL	Goniadella galaica
126	GONIGRA	Goniadella gracilis
127	GYPTPRO	Gyptis propinquos
128	HAMINAV	Haminea navicula
129	HARMIMB	Harmothoë imbricata
130	HARMIMP	Harmothoë cf. impar
131	HARMLJU	Harmothoë ljungmani
132	HARMLUN	Harmothöe lunulata
133	HARMMAR	Harmothöe marphysae

Table 1 (continued).

CODES		SPECIES NAME
134	HARPANT	Harpinia antennaria
135	HARPLAE	Harpinia laevis
136	HARPPEC	Harpinia pectinata
137	HEMINIT	Hemilepton nitidum
138	HESIELO	Hesionura elongata
139	HETEFIL	Heteromastus filiformis
140	HETEMIC	Heteromysis microps
141	HETEOER	Heterotanais oerstedi
142	HIATART	Hiatella arctica
143	HIPPDEN	Hippomedon denticulatus
144	HYALBIL	Hyalinoecia bilineata
145	HYALVIT	Onoba vitrea
146	HYDRULV	Hydrobia ulvae
147	INACCOM	Inachus communisimus
148	INACDOR	Inachus dorsettensis
149	IPHITEN	Iphinoë tenella
150	IPHITRI	Iphinoë trispinosa
151	JAERNOR	Jaera nordmani
152	JASMELE	Jasmineira elegans
153	JASSMAR	Jassa marmorata
154	JUJUSTR	Jujubinus strigosus
155	KEFECIR	Kefersteinia cirrata
156	KELLSUB	Kellia suborbicularis
157	LABIDIG	Labidoplax digitata
158	LAEVCRA	Laevicardium crassum
159	LANICON	Lanice conchilega
160	LARVINS	Insect larvae
161	LEPICAN	Lepidochiton cancellatus
162	LEPICIN	Lepidochitona cinerea
163	LEPILON	Lepidepecreum longicorne
164	LEPTGLA	Laeonereis glauca
165	LEPTINH	Leptosynapta inhaerens
166	LEPTPEC	Leptocheirus pectinatus
167	LEPTPIL	Leptocheirus pilosus
168	LEUCINC	Leucothöe incisa
169	LEUCRIC	Leucothöe richiardii
170	LIOCARC	Liocarcinus arcuatus
171	LIOCCOR	Liocarcinus corrugatus
172	LIOCHOL	Liocarcinus holsatus
173	LIOCPUS	Liocarcinus pusilus
174	LIOCSPA	Liocarcinus sp.
175	LIOCVER	Liocarcinus cf. vernalis
176	LISTPIC	Listriella picta
177	LOPHSTE	Lopha stentina
178	LORILAC	Loripes lacteus
179	LUCIBOR	Lucinoma borealis
180	LUMBLAT	Lumbrinereis latreilli
181	LUMBPAR	Lumbrinereis paradoxa
182	LUNAALD	Natica alderi
183	LUTRLUT	Lutraria lutraria
184	LYGDMUR	Lygdamis murata
185	LYONNOR	Lyonsia norvegica
186	LYSIINE	Lysianassa inesperata
187	LYSIMIN	Lysidice ninetta
188	MACRROS	Macropodia rostrata
189	MAEROTH	Maera othonis
190	MAGEALL	Magelona alleni
191	MALACIL	Malacoceros ciliata
192	MALAFUL	Malacoceros (=Scolelepis) fuliginosus
193	MANGCOA	Mangelia coarctata
194	MARPSAN	Marphysa sanguinea
195	MEDICAP	Mediomastus capensis
196	MEDOLAN	Medorippe lanata
197	MEGAAGI	Megaluropus agilis
198	MEGAVES	Megalomma vesiculosum
199	MELIGLA	Melita gladiosa
200	MELIOBT	Melita obtusata
201	MELIPAL	Melinna palmata
202	MELTPAL	Melita palmata
203	METAPEC	Metaphoxus pectinatus
204	MICRABE	Microphtalmus cf. aberrans
205	MICRCUM	Microjassa cumbrensis
206	MICRMAC	Microprotopus maculatus
207	MICRMEC	Microspio mecznikowianus
208	MIDESPA	Microdeutopus cf. stationis
209	MIDEVER	Microdeutopus versiculatus
210	MODISPA	Modiolus sp.
211	MONIPAT	Monia patelliformis
212	MONTFER	Montacuta ferruginosa
213	MUSCCOS	Musculus costulatus
214	MYRIHEE	Myriochele heeri
215	MYSEBID	Mysella bidentata
216	MYSTPIC	Mysta picta
217	MYTIGAL	Mytilus galloprovincialis
218	MYXIINF	Myxicola infundibulum
219	NASSARG	Nassarius argenteus
220	NASSINC	Nassarius incrassatus
221	NASSRET	Nassarius reticulatus
222	NEBABIP	Nebalia bipes
223	NEMAUNI	Nematonereis unicornis
224	NEMESPA	Nemertea spA
225	NEMESPB	Nemertea spB
226	NEMESPC	Nemertea spC
227	NEOAAFF	Neoamphitrite affinis
228	NEPTCIR	Nepthys cirrosa
229	NEPTHOM	Nepthys hombergii
230	NERECAU	Neanthes caudata
231	NERESUC	Neanthes succinea
232	NOTHCON	Nothria conchilega
233	NOTHGEO	Nothria geophiliformis
234	NOTOLAT	Notomastus latericeus
235	NUCUNUC	Nucula nucleus
236	NUDISPA	Nudibranch sp. indet.
237	OLIGSPA	Tubificidae spA
238	OLIGSPB	Tubificidae spB
239	OPHELAU	Ophelia laubieri
240	OPHENEG	Ophelia neglecta
241	OPHIALB	Ophiura albida
242	OPHYSPA	Ophyotrocha sp.
243	ORCHMAS	Orchomene massiliensis
244	ORCHNAN	Orchomene nana
245	OSTRSPA	Ostracod spA
246	OSTRSPB	Ostracod spB
247	OSTRSPC	Ostracod spC
248	OWENFUS	Owenia fusiformis
249	PAGUSPP	Pagurus sp.
250	PANDALB	Pandora albida
251	PARAELE	Parapionosyllis elegans
252	PARAFOR	Paragnathia formica
253	PARAKOS	Paranaitis kosteriensis
254	PARALAB	Parapionosyllis labronica
255	PARALYR	Paradoneis lyra
256	PARITYP	Pariambus typicus
257	PARVEXI	Parvicardium exiguum
258	PARVSCR	Parvicardium scriptum
259	PECTKOR	Lagis koreni
260	PERILON	Perioculodes longimanus
261	PHERMON	Pherusa monolifer
262	PHILAPE	Philine aperta
263	PHILMON	Philoceras monacanthus
264	PHOLSYN	Pholoë synophthalmica
265	PHORSPA	Phoronis sp.

Table 1 (continued).

CODES		SPECIES NAME
266	PHOTLOC	Photis longicaudata
267	PHOTLON	Photis longipes
268	PHTIMAR	Phtisica marina
269	PICNSPA	Pycnogonide sp. indet.
270	PILAVER	Pilargis verrucosa
271	PINOPIS	Pinnotheres pisum
272	PISILON	Pisidia longicornis
273	PISIREM	Pisione remota
274	PISTCRI	Pista cristata
275	PITARUD	Pitaria rudis
276	PLATDUM	Platynereis dumerilii
277	PLATSPA	Platyhelminthes sp. indet.
278	PODAAGI	Podarke agilis
279	POECSER	Poecilochaetus serpens
280	POLYAPP	Polygordius appendiculatus
281	POLYARM	Polydora armata
282	POLYCAE	Polydora caeca
283	POLYCIL	Polydora ciliata
284	POLYHOP	Polydora hoplura
285	POLYSPA	Polycirrus sp.
286	POMAMIC	Pomatoschistus microps
287	POMAMIN	Pomatoschistus minutus
288	POMAPIC	Pomatoschistus pictus
289	POMASPA	Pomatoschistus sp.
290	PRAXAFF	Praxillella affinis
291	PRIOCIR	Prionospio cirrifera
292	PRIOMAL	Prionospio malmgreni
293	PROCMAC	Processa macropthalma
294	PROTKEF	Protodorvillea kefersteini
295	PROTSPA	Protomystides sp.
296	PSAMMIL	Psammechinus miliaris
297	PSEUANT	Pseudopolydora antennata
298	PSEULIM	Pseudomystides limbata
299	PSEUPHA	Pseudoprotella phasma
300	PYGOELE	Pygospio elegans
301	RETUSPA	Retusa sp.
302	RISSLAB	Rissoa labiosa
303	SABEOCT	Sabellides octocirrata
304	SABEPAV	Sabella pavonina
305	SABESPI	Sabellaria spinulosa
306	SACCPAP	Saccocirrus papillocercus
307	SCAINF	Scalibregma inflatum
308	SCHINEG	Schistomeringos neglecta
309	SCHIRUD	Schistomeringos rudolphi
310	SCOLARM	Scoloplos armiger
311	SCROPLA	Scrobicularia plana
312	SERPSPP	Serpulidae spp
313	SIGASQU	Sigalion squamosum
314	SIGATEN	Sigambra tentaculata
315	SIPHSTR	Siphonoecetes striatus
316	SIPUSPP	Sipunculids sp. indet.
317	SOLEMAR	Solen marginatus
318	SOLETOG	Solemya togata
319	SPHABOC	Sphaeroma cf. bocqueti
320	SPHABUL	Sphaerosyllis bulbosa
321	SPHAHOO	Sphaeroma hookeri
322	SPHAHYS	Sphaerosyllis hystrix
323	SPHAMON	Sphaeroma monodi
324	SPHATAY	Sphaerosyllis taylori
325	SPIOBOM	Spiophanes bombyx
326	SPIOCOS	Spiochaetopterus costarum
327	SPIODEC	Spio decoratus Bobretzki
328	SPIONDE	Spionidae sp.
329	SPISSOL	Spisula solida
330	SPISSUB	Spisula subtruncata
331	STENMAR	Stenothöe marina
332	STHEBOA	Sthenelais boa
333	STRESHR	Streblospio shrubsolii
334	SYLLGAR	Syllis cf. garciae
335	SYLLHYA	Syllis hyalina
336	SYLLSPA	Syllis sp.
337	SYNCHAP	Synchelidium haplocheles
338	SYNCLON	Synchelidium longidigitatum
339	SYNISPA	Synisoma sp.
340	TELLDON	Tellina donacina
341	TELLFAB	Tellina fabula
342	TELLPUL	Tellina pulchella
343	TELLPYG	Tellina pygmaea
344	TELLSER	Tellina serrata
345	TELLTEN	Tellina tenuis
346	THARSPA	Tharyx sp.
347	THRASPA	Thracia sp.
348	THROSPA	Trochidae sp.
349	THYAFLE	Thyasira flexuosa
350	TRYPLON	Tryphosites longipes
351	TUBIBEN	Tubificoides benedeni
352	TURRTRI	Turritella triplicata
353	UPOGTYP	Upogebia cf typica
354	UROTBRE	Urothoë brevicornis
355	UROTELE	Urothöe elegans
356	UROTGRI	Urothöe grimaldii
357	VENEPUL	Venerupis pullastra
358	VENUCAS	Venus casina
359	VENUFAS	Venus fasciata
360	VENUSTR	Venus striatula
361	VENUVER	Venus verrucosa
362	VIRGMIR	Virgularia mirabilis
363	XANTSPA	Xantho sp.

DATA FILES, IN CORNELL CONDENSED FORMAT (Adapted)

Sado Estuary. Subtidal macrofauna abundance data, ind.0.1m^{-2}

```
(I5,10(I4,F8.1))
   100
 St 1 2   1.0 8   5.0 14  1.0 18  1.0 21  4.0 22  1.0 24  1.0 26  1.0 42  1.0 45  40.0
 50  10.0 53  1.0 54  84.0 55  65.0 56  17.0 61  1.0 77  34.0 80  5.0 98  2.0 111  8.0
 113  54.0 118  1.0 122  1.0 125  5.0 126  1.0 131  5.0 149  1.0 151  2.0 154  8.0 162  3.0
 180  1.0 189  12.0 194  1.0 195  9.0 199  32.0 209  1.0 213  1.0 221  9.0 222  2.0 224  11.0
 229  2.0 234  8.0 235  2.0 236  1.0 237  1.0 245  1.0 251  1.0 253  1.0 255  12.0 256  1.0
 264  2.0 267  20.0 268  2.0 272  1.0 273  1.0 274  1.0 277  1.0 280  1.0 282  5.0 291  3.0
 294  12.0 296  3.0 299  2.0 305  1.0 312  23.0 321  2.0 329  8.0 335  1.0 339  4.0 347  1.0
 357  17.0 363  1.0
 St 2 13  1.0 18  3.0 24  7.0 34  1.0 36  6.0 45  17.0 49  1.0 54  1.0 58  4.0 69  1.0
 77  5.0 86  1.0 96  1.0 105  1.0 113  81.0 118  5.0 120  8.0 125  1.0 130  1.0 142  1.0
 144  1.0 149  2.0 156  1.0 189  1.0 195  4.0 200  1.0 210  2.0 223  1.0 224  5.0 228  1.0
 234  1.0 235  1.0 237  12.0 245  1.0 251  2.0 255  6.0 268  9.0 273  18.0 280  72.0 285  1.0
 294  3.0 295  1.0 298  1.0 299  1.0 306  2.0 312  7.0 320  3.0 322  2.0 323  2.0 331  3.0
 334  1.0 335  2.0
 St.3 34  1.0 68  1.0 113  1.0 125  48.0 204  8.0 224  2.0 228  2.0 237  3.0 251  2.0 267
29.0
 268  1.0 273  8.0 294  3.0 299  1.0 306  1.0 323  2.0 345  6.0
 St.4 14  1.0 22  1.0 23  4.0 56  2.0 65  2.0 69  1.0 73  4.0 82  2.0 118  10.0 120  15.0
 122  1.0 126  2.0 149  1.0 195  1.0 200  11.0 224  11.0 226  2.0 228  3.0 234  11.0 236  4.0
 237  3.0 245  8.0 251  4.0 256  11.0 265  1.0 267  540.0 268  3.0 273  10.0 280  1.0 282  2.0
 285  16.0 294  3.0 297  1.0 299  5.0 306  3.0 323  2.0 325  2.0 326  1.0 329  2.0 331  10.0
 335  2.0 355  3.0 356  3.0
 St.5 13  4.0 21  10.0 22  3.0 23  2.0 24  2.0 25  15.0 28  8.0 29  2.0 34  1.0 36  3.0
 45  29.0 54  57.0 56  9.0 60  3.0 61  1.0 70  8.0 73  38.0 77  5.0 88  1.0 102  2.0
 105  3.0 106  1.0 113  125.0 120  12.0 126  3.0 130  6.0 131  3.0 135  4.0 142  5.0 146  2.0
 156  1.0 166  2.0 176  3.0 180  5.0 183  2.0 189  5.0 193  1.0 195  32.0 199  9.0 200  2.0
 209  2.0 210  1.0 211  8.0 220  8.0 221  1.0 224  9.0 228  3.0 234  34.0 235  5.0 243  1.0
 249  6.0 256  1.0 264  3.0 265  2.0 267  431.0 285  13.0 291  1.0 294  1.0 295  1.0 296  1.0
 305  10.0 312  88.0 316  22.0 327  2.0 329  1.0 335  8.0 336  1.0 357  27.0 358  2.0 359  1.0
 St.6 2  3.0 10  13.0 14  2.0 22  1.0 23  6.0 30  2.0 31  5.0 33  4.0 34  718.0 41  1.0
 43  1.0 55  5.0 56  18.0 69  2.0 76  1.0 82  5.0 88  1.0 97  25.0 101  34.0 109  5.0
 122  6.0 149  22.0 168  1.0 170  1.0 178  1.0 180  1.0 195  13.0 221  6.0 222  1.0 229  4.0
 233  1.0 234  16.0 245  1.0 260  2.0 267  10.0 268  27.0 294  1.0 304  1.0 325  4.0 327  2.0
 340  1.0 341  3.0 345  7.0 347  3.0 357  1.0 360  2.0
 St.7 34  1.0 68  1.0 98  1.0 118  25.0 120  1.0 228  14.0 237  4.0 251  2.0 256  3.0 267
5.0
 273  13.0 294  1.0 306  1.0 327  1.0 329  2.0 354  1.0
 St.8 24  2.0 68  2.0 118  21.0 120  2.0 125  1.0 138  2.0 210  1.0 224  3.0 228  2.0 234
1.0
 237  1.0 251  9.0 255  1.0 273  32.0 284  1.0 298  1.0 306  7.0 323  1.0 335  1.0 356  3.0
 St.9 23  1.0 28  4.0 29  1.0 36  1.0 44  3.0 45  1.0 68  1.0 70  1.0 95  1.0 98  28.0
 99  1.0 118  5.0 120  5.0 125  37.0 131  8.0 195  2.0 222  1.0 224  4.0 234  8.0 237  5.0
 245  5.0 251  4.0 255  3.0 256  3.0 260  1.0 265  1.0 267  1.0 273  12.0 277  1.0 280  3.0
 283  1.0 294  11.0 305  1.0 306  1.0 312  16.0 320  2.0 323  2.0 325  1.0 327  1.0 329  7.0
 335  2.0 357  1.0
 St.10 48  28.0 61  2.0 99  1.0 107  3.0 118  2.0 120  2.0 125  8.0 189  1.0 221  1.0 224
1.0
 228  1.0 232  1.0 234  1.0 237  3.0 251  1.0 267  1.0 273  1.0 294  1.0 329  7.0 350  1.0
 354  20.0 356  1.0
 St.11 23  1.0 32  1.0 33  2.0 43  1.0 60  3.0 65  1.0 68  1.0 73  2.0 113  2.0 118  1.0
```

```
122   7.0 134   1.0 138   1.0 168   1.0 172   1.0 195   5.0 200   16.0 228   2.0 234   1.0 237   2.0
251   10.0 256   9.0 267   5.0 268   1.0 273   72.0 280   21.0 282   1.0 294   1.0 305   1.0 306   22.0
312   2.0 313   1.0 323   1.0 325   1.0 326   1.0 329   3.0 335   1.0 356   1.0
 St.12 2   8.0  6   4.0  23   6.0  27   1.0  29   5.0  34   3.0  35   1.0  39   3.0  45   2.0  54   1.0
60   15.0  73  154.0  79   1.0  92   1.0  98   1.0 101   1.0 118   1.0 120   8.0 122   1.0 125   8.0
138   2.0 144   5.0 149   3.0 155   1.0 158   2.0 163   1.0 166   17.0 183   1.0 195   6.0 207   4.0
209   5.0 210   1.0 224  120.0 225   3.0 226   1.0 228   2.0 234   1.0 237   3.0 246   1.0 251   6.0
256  847.0 262   3.0 267  565.0 268   1.0 273   7.0 274   3.0 277   3.0 280   7.0 282   1.0 285   5.0
294   22.0 297   52.0 310   7.0 316   1.0 320   7.0 325   1.0 326   8.0 329   27.0 335   6.0 340   4.0
346   2.0 357   5.0
 St.13 2   91.0  4   1.0  14   2.0  21   2.0  23   4.0  29   15.0  35   16.0  39   1.0  45   2.0  54   23.0
55   2.0  56   3.0  59   1.0  60   19.0  65   4.0  69   3.0  70   21.0  71   1.0  73   93.0  79   3.0
82   1.0  88   2.0  90   2.0  92   1.0  95   1.0  96   1.0  98   1.0 101   9.0 109   1.0 111   1.0
119   1.0 132   1.0 134   4.0 136   17.0 141   9.0 149   77.0 157   1.0 158   1.0 165   1.0 166   6.0
171   1.0 180   4.0 183   2.0 184   1.0 190   5.0 191   2.0 195   87.0 199   2.0 200   6.0 203   1.0
209   4.0 221   5.0 224   4.0 225   7.0 226   4.0 229   2.0 234   2.0 235   10.0 238   2.0 241   1.0
245   2.0 246   23.0 247   7.0 248   3.0 252   1.0 255   6.0 256   3.0 259   2.0 260   3.0 265   14.0
267   12.0 268   8.0 282   1.0 285   1.0 292   1.0 297   3.0 307   2.0 312   3.0 316   5.0 326   8.0
329   2.0 330   2.0 332   4.0 337   2.0 344   1.0 346   82.0 347   2.0 349   1.0 357   1.0 358   1.0
360   4.0
 St.14 2   21.0  14   14.0  21   1.0  22   1.0  23   2.0  29   8.0  35   88.0  42   3.0  45   2.0  54   6.0
60  104.0  65   8.0  69   48.0  71   2.0  73   75.0  85   3.0  90   2.0 101   3.0 103   2.0 105   8.0
108   2.0 113   1.0 120   4.0 130   1.0 131   1.0 133   1.0 134   17.0 148   1.0 149   6.0 158   1.0
159   1.0 161   1.0 174   1.0 176   4.0 180   13.0 194   1.0 195   66.0 200   4.0 201   23.0 203   14.0
223   6.0 224   8.0 225   1.0 226   2.0 234   8.0 235   16.0 245   6.0 246   1.0 249   2.0 251   1.0
256   60.0 257   2.0 260   4.0 265   3.0 267   5.0 274   1.0 279   1.0 282   8.0 291   17.0 297   13.0
307   2.0 314   3.0 316   5.0 326   3.0 329   3.0 330   1.0 335   7.0 346  292.0 351   15.0 357   19.0
358   1.0 360   4.0
 St.15 2   8.0  14   1.0  22   4.0  23   4.0  25   1.0  29   3.0  34   3.0  43   2.0  45   2.0  60   6.0
61   1.0  68   1.0  73   58.0 103   2.0 105   2.0 118   1.0 121   1.0 122   11.0 124   1.0 125   2.0
144   1.0 149   8.0 163   2.0 166   10.0 195   15.0 200   20.0 206   1.0 224   16.0 228   4.0 234   5.0
237   7.0 244   1.0 245   7.0 247   2.0 256  329.0 260   1.0 267  602.0 273   1.0 280   3.0 294
27.0
297   29.0 310   6.0 323   1.0 326   1.0 327   5.0 329   7.0 343   2.0 350   2.0 354   1.0
 St.16 2   61.0  12   1.0  14   9.0  18   1.0  22   27.0  23   4.0  25   7.0  29   18.0  33   1.0  34  105.0
35   8.0  42   6.0  51   2.0  54   7.0  55   2.0  60   68.0  65   3.0  69   5.0  71   3.0  73   47.0
79   4.0  87   8.0  95   5.0  96   2.0  98   1.0 101   23.0 103   6.0 104   2.0 109   1.0 121   2.0
122   4.0 130   1.0 141   4.0 144   1.0 149   22.0 159   10.0 166   12.0 173   1.0 178   2.0 179   1.0
180   3.0 183   2.0 191   2.0 195   99.0 196   1.0 198   1.0 200   19.0 201   16.0 203   6.0 208   6.0
215   1.0 219   2.0 221   1.0 223   1.0 224   12.0 225   4.0 228   6.0 229   1.0 234   29.0 238   14.0
246   16.0 247   25.0 248   1.0 258   2.0 260   8.0 262   1.0 265   7.0 267   2.0 274   2.0 277   1.0
279   8.0 282   13.0 291   9.0 292   1.0 297   87.0 305   5.0 310   7.0 312   1.0 320   2.0 326  195.0
327   6.0 332   2.0 340   1.0 341   3.0 346   59.0 355   22.0 357   7.0 358   1.0 360   1.0
 St.17 21   5.0  22   3.0  23   7.0  28   11.0  29   9.0  40   2.0  42   4.0  45   1.0  54   4.0  56   6.0
60   16.0  63   1.0  69   3.0  77   10.0  98   1.0 113   5.0 118   2.0 122   12.0 125   1.0 130   2.0
141   1.0 149   3.0 180   14.0 183   1.0 189   2.0 191   6.0 195   38.0 200   17.0 209   3.0 210   1.0
216   1.0 220   1.0 221   1.0 223   1.0 224   19.0 225   4.0 228   5.0 234   28.0 243   8.0 245   2.0
251   4.0 265   1.0 267   23.0 268   1.0 272   3.0 279   1.0 282  101.0 285   41.0 294   2.0 297
18.0
305   35.0 310   9.0 312   48.0 320   2.0 326   16.0 327   1.0 329   1.0 331   4.0 346   3.0 357   14.0
 St.18 2  177.0  11   4.0  12   1.0  14   7.0  23   24.0  29   29.0  34   1.0  35   1.0  43   1.0  54   3.0
55   5.0  60   18.0  61   1.0  69   13.0  70   3.0  73   30.0  76   6.0  85   1.0  87   8.0 101   69.0
109   1.0 122   2.0 127   2.0 143   3.0 149   33.0 171   1.0 179   3.0 183   2.0 195   90.0 201   5.0
212   2.0 220   1.0 221   7.0 225   3.0 226   2.0 229   2.0 234   36.0 235   7.0 246   20.0 247   5.0
248   15.0 256   4.0 265   6.0 274   1.0 279   16.0 282   5.0 285   1.0 291   1.0 292   3.0 294   1.0
297   3.0 307   1.0 310   2.0 325   1.0 326   14.0 327   4.0 330   1.0 335   3.0 345   1.0 346   6.0
351   20.0 360   1.0
 St.19 2   13.0  14   1.0  18   2.0  21   4.0  22   2.0  23   16.0  27   7.0  29   58.0  33   1.0  42   4.0
```

```
45   1.0 51   1.0 54   6.0 56   2.0 60   21.0 63   2.0 65   10.0 69   9.0 71   1.0 73   17.0
76   1.0 77   5.0 83   1.0 87   1.0 101   11.0 104   1.0 108   2.0 113   2.0 121   14.0 125   1.0
130   4.0 144   1.0 149   10.0 159   3.0 166   2.0 169   1.0 173   1.0 180   17.0 183   2.0 184   1.0
191   19.0 194   1.0 195   94.0 198   2.0 200   3.0 209   2.0 216   3.0 220   1.0 221   1.0 222   2.0
223   4.0 225   3.0 226   1.0 228   7.0 234   19.0 235   1.0 238   5.0 245   3.0 250   1.0 262   1.0
265   23.0 267   4.0 274   2.0 277   1.0 279   1.0 281   220.0 282   99.0 285   19.0 292   1.0 294
1.0
297   76.0 305   10.0 307   1.0 310   30.0 312   6.0 325   4.0 326   18.0 329   1.0 331   3.0 332   1.0
335   18.0 346   14.0 357   3.0 359   1.0
 St.20 2   34.0 10   9.0 12   1.0 14   23.0 22   5.0 23   7.0 29   7.0 35   1.0 54   1.0 55   7.0
 60   64.0 69   8.0 73   36.0 76   24.0 79   1.0 94   1.0 101   13.0 103   5.0 109   1.0 122   11.0
 137   12.0 143   1.0 149   39.0 159   4.0 166   6.0 168   3.0 171   1.0 176   1.0 179   1.0 190   2.0
 195   35.0 201   17.0 205   1.0 206   1.0 209   6.0 216   1.0 221   1.0 223   1.0 224   1.0 225   4.0
 226   1.0 227   1.0 229   5.0 234   80.0 245   1.0 246   16.0 247   6.0 248   15.0 256   9.0 258   1.0
 265   2.0 268   1.0 279   2.0 282   15.0 292   13.0 297   7.0 310   8.0 325   2.0 326   56.0 327   6.0
 329   2.0 332   1.0 341   5.0 346   39.0 347   2.0 355   2.0 357   2.0 362   2.0
 St.21 2   30.0 14   2.0 20   5.0 21   11.0 23   14.0 27   1.0 29   11.0 34   131.0 35   6.0 45   1.0
 51   4.0 60   7.0 68   1.0 71   1.0 73   174.0 76   1.0 77   1.0 83   2.0 93   1.0 98   3.0
 101   9.0 120   7.0 121   1.0 122   5.0 125   36.0 130   2.0 131   1.0 144   5.0 149   10.0 163   4.0
 165   2.0 166   28.0 183   2.0 186   1.0 195   56.0 200   1.0 203   1.0 209   10.0 214   4.0 224   27.0
 225   1.0 226   1.0 228   6.0 234   27.0 238   10.0 245   2.0 246   1.0 252   3.0 255   3.0 256   322.0
 265   2.0 267   24.0 270   1.0 273   2.0 274   27.0 277   3.0 282   7.0 285   2.0 292   3.0 294   22.0
 297   11.0 305   1.0 310   6.0 320   20.0 323   1.0 326   66.0 329   1.0 335   8.0 338   1.0 340   6.0
 346   9.0 350   4.0 357   57.0
 St.22 2   28.0 11   1.0 14   11.0 17   1.0 20   1.0 21   8.0 22   1.0 23   4.0 25   1.0 28   1.0
 29   5.0 34   3.0 35   9.0 42   4.0 45   4.0 51   2.0 54   10.0 56   13.0 60   36.0 62   5.0
 69   21.0 73   127.0 76   2.0 113   3.0 120   3.0 122   2.0 130   3.0 135   1.0 136   2.0 149   14.0
 166   9.0 176   9.0 179   1.0 180   8.0 183   2.0 186   1.0 194   1.0 195   120.0 200   10.0 201   3.0
 203   2.0 209   2.0 223   2.0 224   2.0 225   1.0 229   1.0 234   3.0 235   4.0 246   3.0 247   1.0
 255   6.0 256   157.0 260   7.0 265   6.0 267   16.0 282   6.0 291   5.0 297   23.0 312   3.0 326   1.0
 329   4.0 332   2.0 335   3.0 346   281.0 351   3.0 357   44.0 362   1.0
 St.23 2   67.0 17   1.0 23   10.0 27   1.0 29   17.0 30   3.0 35   17.0 41   2.0 60   29.0 65   1.0
 69   24.0 73   2.0 79   12.0 82   7.0 83   6.0 85   3.0 97   1.0 100   57.0 109   2.0 122   4.0
 139   18.0 148   1.0 149   35.0 159   7.0 179   19.0 180   6.0 183   2.0 190   1.0 195   50.0 201
94.0
 209   2.0 218   2.0 221   1.0 223   1.0 225   4.0 227   1.0 229   4.0 234   9.0 235   5.0 248   1.0
 255   1.0 257   2.0 259   1.0 265   15.0 268   3.0 274   1.0 282   15.0 291   2.0 297   6.0 301   1.0
 304   12.0 312   1.0 318   1.0 326   86.0 332   2.0 346   6.0 351   8.0 357   7.0 362   11.0
 St.24 2   34.0 23   3.0 55   18.0 60   12.0 73   1.0 76   2.0 85   1.0 122   1.0 149   3.0 179   1.0
 201   5.0 226   1.0 229   13.0 234   2.0 268   1.0 274   5.0 282   1.0 297   1.0 310   1.0 318   1.0
 332   1.0 340   1.0 346   2.0 351   44.0
 St.25 2   13.0 11   38.0 12   5.0 13   8.0 14   19.0 18   1.0 21   6.0 22   15.0 27   6.0 29   8.0
 35   40.0 42   1.0 45   1.0 54   4.0 55   2.0 60   96.0 65   2.0 69   9.0 73   55.0 79   1.0
 84   1.0 87   1.0 88   1.0 90   2.0 101   1.0 105   2.0 110   1.0 113   1.0 127   1.0 130   1.0
 136   14.0 139   2.0 141   1.0 149   3.0 159   4.0 163   1.0 166   1.0 180   10.0 189   9.0 194   1.0
 195   12.0 197   1.0 201   1.0 203   6.0 224   3.0 225   2.0 226   1.0 227   2.0 235   25.0 247   1.0
 256   8.0 260   1.0 262   1.0 264   1.0 265   1.0 268   1.0 274   2.0 282   50.0 285   6.0 291   5.0
 297   194.0 305   1.0 307   3.0 312   1.0 316   13.0 326   7.0 332   2.0 335   4.0 346   220.0 360
2.0
 362   1.0
 St.26 55 14496.0 57   1.0 60   4.0 63   1.0 69   4.0 79   1.0 109   8.0 146   1.0 149   5.0 192
144.0
 221   39.0 230   8.0 235   2.0 242   8.0 268   1.0 297   4.0 346   4.0
 St.27 2   78.0 11   23.0 12   46.0 14   36.0 22   2.0 23   2.0 29   23.0 35   42.0 54   8.0 56   3.0
 59   1.0 60   12.0 63   8.0 65   23.0 69   2.0 71   4.0 73   43.0 79   17.0 101   4.0 103   1.0
 122   1.0 127   2.0 136   23.0 139   4.0 148   1.0 149   4.0 159   2.0 180   3.0 195   12.0 201   84.0
 203   3.0 209   4.0 223   2.0 225   2.0 234   2.0 235   18.0 256   1.0 257   1.0 259   1.0 260   3.0
 262   1.0 265   1.0 268   1.0 282   72.0 291   1.0 297   81.0 305   2.0 326   5.0 332   1.0 335   1.0
```

```
346 37.0 351 4.0
 St.28 2 19.0 11 24.0 17 2.0 18 1.0 20 1.0 21 13.0 23 1.0 25 27.0 27 1.0 28 1.0
29 76.0 35 14.0 41 3.0 42 2.0 45 9.0 54 29.0 60 77.0 63 5.0 65 6.0 66 7.0
69 75.0 73 85.0 77 1.0 79 2.0 88 1.0 101 3.0 104 5.0 105 9.0 113 20.0 120 1.0
122 1.0 125 2.0 130 4.0 131 8.0 136 4.0 141 12.0 144 1.0 148 2.0 149 2.0 176 9.0
180 17.0 189 39.0 195 154.0 200 6.0 201 1.0 203 3.0 209 14.0 223 3.0 224 9.0 225
11.0
226 2.0 228 1.0 232 1.0 234 10.0 235 1.0 246 1.0 252 1.0 253 1.0 255 4.0 260 11.0
264 6.0 274 16.0 282 5.0 285 2.0 291 7.0 293 1.0 294 5.0 297 3.0 307 4.0 309 1.0
312 14.0 314 2.0 316 8.0 320 4.0 327 1.0 329 1.0 332 2.0 335 17.0 346 23.0 355 1.0
357 3.0 359 3.0 361 2.0
 St.29 2 6.0 11 11.0 14 18.0 22 6.0 23 8.0 29 64.0 35 1.0 39 1.0 42 1.0 51 1.0
54 2.0 60 135.0 63 1.0 65 1.0 69 12.0 71 1.0 73 30.0 79 27.0 81 1.0 85 2.0
90 2.0 95 1.0 103 1.0 105 7.0 115 1.0 120 1.0 122 4.0 130 2.0 131 2.0 136 3.0
149 3.0 166 11.0 180 20.0 184 1.0 195 49.0 198 1.0 200 1.0 201 7.0 203 2.0 209 11.0
223 1.0 224 5.0 225 12.0 226 1.0 228 1.0 232 1.0 234 9.0 246 3.0 248 1.0 252 8.0
255 3.0 256 11.0 260 2.0 262 1.0 265 1.0 267 3.0 268 1.0 274 1.0 282 13.0 285 2.0
298 1.0 305 1.0 307 10.0 326 4.0 327 3.0 329 1.0 332 2.0 335 13.0 346 84.0 352 1.0
355 4.0 360 2.0 362 3.0
 St.30 2 35.0 11 2.0 14 11.0 23 5.0 29 26.0 33 2.0 35 1.0 60 114.0 63 2.0 65 1.0
68 1.0 69 7.0 71 3.0 73 18.0 79 3.0 95 2.0 101 9.0 103 1.0 118 2.0 122 6.0
136 1.0 149 46.0 159 4.0 166 3.0 168 4.0 180 2.0 195 36.0 201 2.0 203 2.0 209 1.0
225 7.0 226 1.0 229 3.0 234 59.0 236 1.0 238 2.0 246 6.0 247 7.0 248 6.0 253 1.0
256 1.0 260 3.0 265 1.0 267 1.0 268 1.0 274 2.0 279 9.0 282 2.0 285 2.0 297 4.0
307 2.0 310 12.0 317 1.0 326 44.0 327 1.0 346 102.0 355 3.0 360 3.0 362 4.0
 St.31 68 2.0 107 1.0 118 4.0 120 1.0 228 2.0 273 3.0
 St.32 29 1.0 107 2.0 118 2.0 125 1.0 181 1.0 189 1.0 220 1.0 221 1.0 228 3.0 229
2.0
240 1.0 291 1.0 310 1.0 335 1.0 345 3.0
 St.33 2 2.0 29 10.0 35 1.0 42 1.0 54 5.0 60 10.0 67 2.0 111 1.0 120 7.0 122 2.0
131 1.0 144 1.0 176 1.0 180 3.0 189 1.0 195 3.0 220 1.0 221 3.0 223 2.0 224 1.0
228 3.0 234 5.0 245 1.0 272 1.0 282 2.0 285 2.0 291 1.0 294 1.0 297 1.0 307 1.0
310 1.0 312 3.0 316 1.0 323 1.0 329 3.0 335 4.0 346 2.0 357 35.0
 St.34 2 19.0 12 1.0 22 1.0 29 15.0 33 2.0 38 3.0 60 15.0 68 1.0 95 1.0 111 1.0
122 3.0 125 1.0 149 1.0 195 33.0 200 2.0 227 1.0 229 1.0 234 4.0 268 1.0 274 1.0
279 2.0 282 1.0 294 2.0 310 123.0 326 11.0 327 1.0 330 1.0 335 4.0 340 1.0 346 24.0
362 5.0
 St.35 2 29.0 7 2.0 10 9.0 12 5.0 14 13.0 23 1.0 29 52.0 55 1.0 60 62.0 66 1.0
68 3.0 69 7.0 73 3.0 76 3.0 79 3.0 90 1.0 122 4.0 136 1.0 141 3.0 149 1.0
159 1.0 168 1.0 180 1.0 184 1.0 190 3.0 195 12.0 201 2.0 225 2.0 228 1.0 229 1.0
234 21.0 238 2.0 244 3.0 248 6.0 256 2.0 274 4.0 279 2.0 297 1.0 310 41.0 326 55.0
332 1.0 335 7.0 340 1.0 346 74.0 362 19.0
 St.36 2 52.0 11 1.0 12 2.0 14 39.0 22 6.0 23 7.0 29 15.0 35 9.0 45 1.0 55 1.0
56 1.0 59 7.0 60 55.0 63 10.0 71 2.0 73 180.0 76 7.0 77 1.0 79 6.0 82 1.0
85 3.0 90 6.0 101 35.0 122 4.0 123 1.0 136 6.0 139 3.0 149 29.0 166 11.0 168 2.0
180 2.0 184 3.0 195 7.0 201 25.0 203 2.0 223 1.0 225 2.0 226 1.0 229 1.0 234 6.0
235 17.0 238 2.0 244 32.0 245 3.0 246 8.0 247 2.0 255 3.0 256 79.0 259 1.0 260 4.0
262 1.0 264 1.0 265 7.0 267 3.0 268 5.0 275 1.0 282 8.0 297 11.0 307 1.0 326 44.0
330 1.0 332 2.0 346 79.0
 St.37 2 8.0 11 3.0 20 1.0 21 3.0 29 67.0 34 1.0 37 15.0 41 10.0 45 6.0 54 13.0
60 47.0 71 1.0 73 84.0 79 1.0 95 1.0 98 1.0 104 9.0 105 3.0 113 1.0 120 1.0
122 1.0 130 2.0 131 12.0 135 9.0 141 12.0 144 6.0 166 3.0 180 16.0 191 9.0 195 44.0
200 1.0 203 1.0 209 22.0 223 8.0 224 28.0 225 4.0 226 2.0 228 6.0 234 12.0 238 4.0
245 2.0 249 1.0 255 3.0 257 1.0 260 1.0 264 2.0 267 7.0 274 25.0 282 9.0 285 3.0
291 1.0 294 4.0 297 2.0 298 3.0 305 1.0 307 1.0 309 1.0 312 3.0 316 5.0 320 2.0
329 9.0 331 1.0 335 37.0 340 1.0 346 58.0 357 8.0 359 1.0
 St.38 2 12.0 12 1.0 14 4.0 17 1.0 22 2.0 29 54.0 34 138.0 35 3.0 45 2.0 51 1.0
60 40.0 69 2.0 71 1.0 73 24.0 76 1.0 79 3.0 84 1.0 91 1.0 101 3.0 110 2.0
```

```
113   1.0 121   1.0 122   1.0 144   2.0 149   8.0 166   19.0 180   4.0 183   1.0 189   2.0 195   5.0
201   1.0 225   6.0 229   9.0 234   6.0 238   2.0 255   3.0 256   36.0 260   1.0 267   26.0 268   2.0
274   9.0 282   1.0 285   1.0 307   1.0 310   1.0 312   3.0 320   2.0 326   10.0 329   4.0 331   6.0
335   5.0 337   2.0 346   54.0 357   2.0 362   10.0
 St.39 2  116.0 11   8.0 12   5.0 14   5.0 22   8.0 23   5.0 25   2.0 29   34.0 30   7.0 33   3.0
 35  16.0 54   1.0 59   1.0 60   30.0 63   2.0 64   1.0 69   16.0 71   2.0 73   5.0 77   6.0
 79  15.0 82   7.0 94   1.0 101   6.0 109   1.0 111   3.0 122   6.0 123   1.0 127   1.0 130   1.0
 136   7.0 139   11.0 149   32.0 159   1.0 169   2.0 170   1.0 176   1.0 180   4.0 183   1.0 195   40.0
 201   25.0 209   3.0 220   2.0 221   2.0 225   14.0 226   1.0 229   1.0 234   2.0 235   9.0 246   2.0
 256   2.0 260   5.0 265   3.0 268   3.0 274   1.0 277   1.0 282   2.0 283   2.0 291   2.0 292   2.0
 326   23.0 346   66.0 351   520.0
  St.40 2   97.0 11  118.0 12  137.0 13   2.0 14   23.0 18   1.0 22   6.0 23   15.0 25   2.0 29
28.0
 33   1.0 35   26.0 54   4.0 59   2.0 60   31.0 63   2.0 69  163.0 71   1.0 73   3.0 77   12.0
 79  26.0 83   2.0 101   46.0 103   1.0 130   4.0 136   2.0 139   2.0 149   58.0 165   1.0 180   3.0
 183   4.0 190   1.0 195   4.0 198   1.0 201  386.0 203   1.0 215   2.0 221   2.0 225   11.0 226   1.0
 228   1.0 235   4.0 246   6.0 248   1.0 257   2.0 259   1.0 260   9.0 264   1.0 265   2.0 268   8.0
 274   1.0 282   2.0 304   2.0 307   1.0 326  242.0 330   1.0 331   2.0 332   2.0 340   1.0 346  113.0
 351   1.0 360   2.0 362   1.0
  St.41 2  108.0 11   5.0 12   16.0 13   2.0 14   11.0 18   1.0 23   3.0 29   42.0 35   38.0 59   2.0
 60   6.0 63   3.0 69  199.0 71   2.0 73   1.0 79   6.0 83   1.0 103   1.0 122   3.0 123   1.0
 130   1.0 136   4.0 139   9.0 149   35.0 159   3.0 180   2.0 182   1.0 183   1.0 195   4.0 201   56.0
 209   1.0 225   15.0 226   2.0 234   4.0 235   8.0 246   2.0 257   6.0 263   1.0 265   2.0 268   1.0
 282   1.0 326   62.0 330   1.0 332   2.0 346   62.0 351   27.0
  St.42 2   30.0 11   4.0 12   10.0 22   4.0 23   4.0 29   22.0 35   1.0 51   1.0 54   2.0 60   89.0
 69  116.0 73   5.0 79   9.0 95   1.0 139   1.0 149   9.0 180   2.0 195   5.0 201   69.0 218   1.0
 225   5.0 234   1.0 238   1.0 246   3.0 248   1.0 255   5.0 256   15.0 274   3.0 282   1.0 292   1.0
 310   1.0 326   3.0 329   1.0 335   2.0 346   99.0
  St.43 2   9.0 10   21.0 12   4.0 14   51.0 21   2.0 22   5.0 23   11.0 29   12.0 34   3.0 37   1.0
 54   3.0 56   2.0 60   75.0 61   1.0 63   2.0 65   4.0 69   1.0 71   1.0 73   60.0 79   1.0
 95   1.0 101   1.0 113   1.0 122   3.0 130   1.0 137   2.0 139   1.0 141   1.0 149   19.0 159   4.0
 166   8.0 172   1.0 176   4.0 180   2.0 183   1.0 184   1.0 191   7.0 195   33.0 197   5.0 200   4.0
 201   1.0 203   1.0 209   7.0 216   1.0 221   1.0 222   1.0 224   23.0 225   7.0 228   4.0 229   1.0
 234   47.0 245   2.0 247   5.0 248   1.0 252   1.0 255   1.0 267   2.0 268   1.0 269   1.0 274   1.0
 279   5.0 282   15.0 285   2.0 297   17.0 307   1.0 310   22.0 323   1.0 327   2.0 328   2.0 329   1.0
 335   3.0 346   19.0 350   1.0 355   50.0 357   3.0 362   1.0
  St.44 2   10.0 10   2.0 14   4.0 22   3.0 29   19.0 31   2.0 41   2.0 46   4.0 54   1.0 60   24.0
 65   5.0 69   6.0 73   17.0 76   31.0 79   14.0 83   1.0 85   1.0 101   31.0 122   4.0 128   1.0
 130   1.0 136   1.0 141   1.0 149   30.0 153   5.0 159   4.0 166   18.0 179   1.0 180   1.0 183   2.0
 192   7.0 195   4.0 201   56.0 203   1.0 209   16.0 215   1.0 221   1.0 225   5.0 229   2.0 234   11.0
 237   1.0 246   11.0 247   2.0 248   5.0 256   18.0 267   1.0 268   30.0 269   1.0 274   3.0 282   3.0
 304   6.0 310   3.0 317   2.0 318   1.0 326  115.0 332   1.0 346   40.0 347   1.0 349   1.0 352   1.0
 362   11.0
  St.45 2   1.0 18   1.0 21   4.0 28   22.0 29   4.0 35   3.0 40   2.0 42   2.0 52   6.0 54   2.0
 56   43.0 60   12.0 65   12.0 69   15.0 71   3.0 73   31.0 113   82.0 122   11.0 125   1.0 130   4.0
 131   18.0 141   3.0 144   1.0 152   1.0 166   3.0 176   19.0 180   11.0 189   29.0 195   18.0 199
 2.0
 200  136.0 209   16.0 220   8.0 221   2.0 224   35.0 225   5.0 226   2.0 234   59.0 244   1.0 251
 3.0
 253   6.0 260   1.0 268   2.0 272   2.0 274   26.0 278   2.0 282   3.0 285   26.0 286   1.0 294   4.0
 304   1.0 307   6.0 308   1.0 310   6.0 312   14.0 320   4.0 326   5.0 329   3.0 335   18.0 357   1.0
  St.46 2   4.0 14   3.0 22   4.0 23   4.0 34  140.0 41   1.0 44   1.0 56   2.0 60   4.0 69   1.0
 73   1.0 76   1.0 78   1.0 100   2.0 101   80.0 109   1.0 122   5.0 125   2.0 128   1.0 130   1.0
 149   9.0 150   1.0 159   1.0 165   1.0 166   1.0 184   1.0 195   13.0 200   1.0 221   5.0 225   1.0
 234   44.0 245   2.0 256   6.0 268   10.0 279   3.0 285   1.0 310   3.0 325   2.0 340   3.0 347   1.0
 356   1.0 360   1.0
  St.47 2   39.0 16   2.0 19   16.0 22   2.0 26   1.0 29   24.0 30  182.0 33   6.0 34   2.0 35   14.0
 41   2.0 43   5.0 50   4.0 54   1.0 56   7.0 60   8.0 63   1.0 65   1.0 67   1.0 69   5.0
```

```
72 1.0 78 1.0 80 2.0 82 7.0 83 1.0 85 2.0 87 3.0 97 105.0 101 42.0 122 1.0
125 17.0 149 17.0 153 8.0 159 5.0 179 1.0 180 8.0 183 1.0 188 1.0 191 1.0 195 87.0
201 8.0 209 14.0 215 5.0 221 16.0 224 8.0 225 3.0 227 1.0 228 1.0 231 2.0 234 22.0
235 5.0 237 11.0 239 1.0 248 3.0 251 2.0 258 1.0 261 1.0 268 97.0 291 8.0 294 2.0
301 2.0 302 14.0 304 23.0 307 2.0 310 23.0 311 2.0 326 11.0 332 1.0 339 1.0 340 2.0
346 14.0 348 1.0 357 13.0
St.48 22 1.0 28 1.0 29 2.0 60 3.0 111 1.0 117 1.0 120 4.0 122 1.0 125 6.0 166
1.0
176 1.0 181 1.0 195 9.0 200 1.0 214 2.0 224 1.0 228 1.0 234 13.0 249 1.0 251 3.0
256 1.0 268 7.0 273 3.0 282 1.0 285 2.0 305 1.0 310 3.0 312 7.0 320 5.0 325 1.0
326 1.0 335 3.0 346 1.0 356 2.0 357 1.0
St.49 27 1.0 29 1.0 60 2.0 61 1.0 65 2.0 73 1.0 118 1.0 122 3.0 125 5.0 138 1.0
195 4.0 204 6.0 228 3.0 234 6.0 237 39.0 251 75.0 255 31.0 267 1.0 268 1.0 273 19.0
280 7.0 294 28.0 306 1.0 308 1.0 309 1.0 310 5.0 323 2.0 326 3.0 356 2.0
St.50 10 45.0 12 1.0 14 30.0 22 2.0 29 7.0 41 10.0 54 1.0 59 3.0 60 23.0 69 29.0
71 1.0 73 4.0 76 7.0 79 9.0 83 1.0 97 4.0 118 1.0 122 3.0 136 1.0 137 11.0
141 1.0 149 2.0 165 1.0 168 1.0 184 1.0 185 1.0 195 9.0 225 3.0 228 1.0 234 12.0
256 3.0 268 11.0 274 3.0 279 3.0 282 4.0 304 1.0 307 2.0 310 18.0 315 1.0 317 2.0
326 105.0 346 29.0 362 1.0
St.51 2 27.0 3 15.0 12 9.0 14 61.0 21 1.0 22 2.0 29 1.0 35 3.0 54 1.0 59 10.0
60 10.0 65 1.0 69 10.0 71 6.0 73 32.0 76 3.0 77 1.0 79 1.0 97 1.0 101 2.0
118 1.0 132 1.0 136 7.0 139 7.0 145 1.0 149 20.0 159 1.0 166 2.0 195 2.0 201 1.0
209 2.0 229 2.0 235 7.0 246 1.0 248 7.0 256 4.0 265 1.0 267 1.0 270 1.0 297 2.0
303 1.0 330 2.0 346 12.0 360 1.0 362 3.0
St.52 2 4.0 14 3.0 17 1.0 23 3.0 29 18.0 35 3.0 43 1.0 55 4.0 59 4.0 60 63.0
63 4.0 65 3.0 69 23.0 71 5.0 77 1.0 79 8.0 82 1.0 94 5.0 112 1.0 118 1.0
122 1.0 123 1.0 128 2.0 131 1.0 136 1.0 139 7.0 140 1.0 149 37.0 180 3.0 195 2.0
200 1.0 201 17.0 203 2.0 209 4.0 225 7.0 235 5.0 238 1.0 250 1.0 256 11.0 257 2.0
260 1.0 268 9.0 274 1.0 282 18.0 294 1.0 297 1.0 304 2.0 307 2.0 326 1.0 330 1.0
346 41.0 357 2.0
St.53 2 3.0 11 15.0 12 2.0 14 144.0 22 2.0 29 54.0 35 1.0 54 6.0 59 1.0 60 11.0
63 2.0 65 1.0 69 3.0 71 1.0 73 26.0 77 1.0 79 33.0 89 1.0 90 1.0 103 1.0
128 1.0 130 1.0 136 3.0 139 2.0 141 10.0 149 14.0 166 2.0 180 15.0 184 11.0 185 1.0
201 14.0 209 8.0 220 1.0 225 4.0 227 10.0 252 2.0 257 1.0 267 2.0 274 8.0 282 4.0
297 1.0 305 1.0 307 1.0 326 26.0 329 1.0 332 2.0 335 1.0 346 37.0 362 6.0
St.54 2 92.0 11 14.0 12 7.0 14 98.0 18 1.0 22 1.0 23 1.0 29 84.0 35 103.0 41 3.0
54 13.0 59 1.0 60 53.0 65 5.0 69 224.0 71 4.0 73 3.0 79 10.0 90 3.0 101 1.0
105 1.0 122 1.0 130 4.0 136 7.0 139 1.0 149 4.0 176 4.0 180 7.0 195 17.0 200 8.0
201 13.0 209 1.0 218 2.0 234 10.0 235 5.0 249 1.0 258 1.0 260 1.0 267 3.0 268 11.0
274 1.0 282 11.0 297 4.0 307 6.0 326 2.0 332 2.0 335 1.0 346 20.0 352 1.0 360 2.0
St.55 2 9.0 11 12.0 12 15.0 14 46.0 18 1.0 22 15.0 23 1.0 29 28.0 35 12.0 55 1.0
59 9.0 60 8.0 61 1.0 63 2.0 65 6.0 69 23.0 71 7.0 73 4.0 79 50.0 85 1.0
103 3.0 104 1.0 130 2.0 136 3.0 141 2.0 148 1.0 149 10.0 166 1.0 180 1.0 183 1.0
184 1.0 201 368.0 203 1.0 209 1.0 220 1.0 221 1.0 225 2.0 226 1.0 235 1.0 246 3.0
260 4.0 274 3.0 282 25.0 297 1.0 304 1.0 307 1.0 316 1.0 326 227.0 332 2.0 335 1.0
337 1.0 346 59.0
St.56 2 5.0 13 3.0 23 2.0 29 3.0 35 1.0 59 2.0 60 11.0 69 26.0 73 1.0 79 32.0
122 4.0 146 1.0 149 64.0 161 1.0 180 2.0 201 20.0 209 1.0 225 4.0 227 1.0 234 1.0
235 1.0 244 1.0 248 1.0 259 1.0 262 1.0 268 1.0 274 2.0 288 2.0 291 1.0 326 1.0
332 1.0 346 17.0 351 13.0
St.57 2 35.0 13 50.0 22 4.0 23 5.0 35 2.0 43 1.0 59 3.0 60 18.0 73 7.0 77 1.0
131 1.0 139 1.0 149 21.0 195 3.0 201 16.0 225 1.0 229 9.0 256 3.0 291 1.0 333 1.0
346 24.0 351 51.0
St.58 2 2.0 5 1.0 13 4.0 14 2.0 30 10.0 33 4.0 35 1.0 43 2.0 55 2.0 60 5.0
79 1.0 82 1.0 85 5.0 97 2.0 109 1.0 130 1.0 149 16.0 170 1.0 199 1.0 206 2.0
229 2.0 268 20.0 276 1.0 297 1.0 335 1.0 339 1.0 346 2.0 351 109.0
St.59 2 5.0 12 4.0 13 4.0 14 102.0 22 1.0 29 78.0 35 1.0 59 2.0 60 50.0 63 3.0
69 241.0 71 5.0 73 14.0 79 29.0 83 1.0 90 2.0 105 1.0 136 2.0 139 4.0 141 1.0
```

```
149   18.0 166   6.0 180   8.0 195   3.0 201   13.0 203   1.0 209   2.0 225   9.0 234   2.0 256   2.0
267   1.0 268   3.0 274   10.0 282   12.0 285   1.0 297   8.0 307   2.0 316   1.0 326   1.0 335   5.0
346   16.0 357   1.0 360   2.0 362   1.0
 St.60 2   9.0  7   5.0 11   4.0 12   4.0 14  149.0 23   7.0 25   2.0 29   84.0 35   17.0 54   5.0
59   3.0 60  106.0 63   1.0 69   19.0 70   6.0 71   3.0 73   79.0 77   4.0 79   23.0 90   2.0
94   1.0 101   4.0 105   2.0 113   1.0 130   1.0 136   9.0 139   11.0 141   4.0 149   57.0 159   3.0
180   9.0 184   1.0 195   1.0 198   1.0 201   22.0 203   12.0 209   7.0 218   1.0 225   10.0 227   4.0
229   2.0 246   3.0 255   4.0 256   1.0 260   5.0 267   1.0 268   8.0 274   8.0 282   3.0 297   2.0
307   8.0 317   2.0 326  266.0 332   3.0 335   2.0 346  310.0
 St.61 2   2.0 13  165.0 23   2.0 59   1.0 60   1.0 69   33.0 73   1.0 79   1.0 122   1.0 149   2.0
194   1.0 201   35.0 225   5.0 238   5.0 256   1.0 282   1.0 346   9.0
 St.62 2   1.0 14   2.0 31   1.0 85   1.0 180   1.0 201   1.0 227   1.0 229   2.0
 St.63 2   23.0 11   2.0 14   12.0 22   1.0 23   1.0 29   12.0 35   20.0 59   5.0 60   22.0 63   6.0
65   1.0 69  106.0 71   17.0 73   7.0 79   10.0 130   1.0 136   11.0 137   2.0 139   13.0 180   3.0
201   9.0 209   2.0 223   1.0 229   1.0 235   2.0 238   9.0 256   3.0 268   3.0 274   3.0 282   52.0
297   12.0 316   1.0 320   1.0 326   33.0 332   2.0 346   77.0 360   1.0
 St.64 2   13.0 12   1.0 14   53.0 15   1.0 17   1.0 22   1.0 23   3.0 29   24.0 33   1.0 59   2.0
60   7.0 63   1.0 65   2.0 69   46.0 71   4.0 73   15.0 76   2.0 78   2.0 79   16.0 85   1.0
90   1.0 130   1.0 136   8.0 139   6.0 149   18.0 159   3.0 180   3.0 183   1.0 184   1.0 201   9.0
203   1.0 220   1.0 225   6.0 227   1.0 255   2.0 257   2.0 268   5.0 274   1.0 282   39.0 304   2.0
317   2.0 326  238.0 328   1.0 332   2.0 346   35.0 360   1.0 362   1.0
 St.65 13   21.0 23   1.0 31   1.0 60   1.0 69   6.0 78   2.0 85   1.0 122   1.0 149   2.0 200   1.0
201   1.0 225   1.0 229   3.0 238   9.0 346   4.0
 St.66 2   2.0 13   1.0 14   35.0 22   2.0 25   1.0 29   18.0 33   1.0 35   1.0 43   1.0 59   2.0
60   45.0 63   1.0 65   7.0 69   40.0 71   1.0 73   5.0 77   1.0 79   30.0 90   1.0 105   1.0
130   1.0 137  127.0 139   7.0 140   6.0 141   1.0 148   1.0 149   16.0 166   2.0 180   7.0 185   1.0
195   2.0 201   29.0 209   1.0 220   1.0 223   1.0 225   1.0 234   1.0 256   1.0 260   1.0 267   1.0
274   8.0 282   8.0 285   1.0 297   7.0 307   1.0 326  153.0 332   1.0 335   2.0 346   68.0 355   1.0
362   1.0
 St.67 23   1.0 27   1.0 118   1.0 122   1.0 125   17.0 175   1.0 228   3.0 245   3.0 251   1.0 255
13.0
267   2.0 273   3.0 294   1.0 306   6.0 308   3.0 310   8.0 335   1.0 346   2.0
 St.68 2   1.0 22   1.0 68   1.0 78   1.0 104   1.0 251   1.0 345   1.0
 St.69 2   35.0 14   3.0 29   5.0 41   1.0 63   1.0 69   9.0 76   7.0 82   1.0 87   1.0 101   2.0
118   2.0 122   2.0 137   1.0 139   5.0 141   1.0 149   2.0 183   1.0 194   1.0 195   11.0 201   6.0
223   1.0 229   4.0 234   25.0 247   4.0 249   2.0 256   1.0 268   3.0 274   1.0 283   1.0 297   3.0
307   2.0 310   2.0 326   27.0 346   8.0 360   1.0 362   4.0
 St.70 2   33.0 9   4.0 14   17.0 22   1.0 23   11.0 29   37.0 34   2.0 35   1.0 54   1.0 59   4.0
60   74.0 61   1.0 69   7.0 71   2.0 73   4.0 76   1.0 79   5.0 90   1.0 101   2.0 103   1.0
122   3.0 128   1.0 131   1.0 136   1.0 137   31.0 139   1.0 148   1.0 149   18.0 159   1.0 166   3.0
168   1.0 179   1.0 180   6.0 184   4.0 195   20.0 201   53.0 203   1.0 221   2.0 225   8.0 227   2.0
229   1.0 234   3.0 235   6.0 238   9.0 246   4.0 247   3.0 256   2.0 260   1.0 265   1.0 274   4.0
279   1.0 282   3.0 291   3.0 292   1.0 307   16.0 310   7.0 326  236.0 329   1.0 330   1.0 337   1.0
345   1.0 346  182.0 353   2.0 360   1.0
 St.71 11   1.0 14   10.0 23   2.0 27   4.0 29   11.0 43   5.0 54   1.0 60   16.0 69   11.0 73   7.0
76   3.0 77   2.0 78   1.0 79   18.0 82   1.0 103   1.0 105   1.0 122   6.0 125   1.0 132   2.0
137   1.0 149   8.0 159   9.0 167   1.0 180   3.0 195   4.0 200   1.0 201   1.0 209   2.0 224   4.0
228   1.0 234   48.0 257   1.0 262   3.0 265   2.0 268   6.0 274   4.0 282   19.0 285   4.0 297   5.0
307   1.0 326   65.0 332   1.0 335   3.0 346   7.0 362   11.0
 St.72 2   3.0 12   4.0 14   22.0 22   1.0 23   15.0 29   4.0 35   2.0 47   1.0 59   8.0 60   26.0
63   1.0 65   1.0 69  119.0 71   11.0 73   9.0 79   31.0 114   1.0 122   1.0 136   20.0 137   30.0
139   10.0 140   2.0 149   34.0 159   2.0 161   1.0 180   4.0 195   5.0 196   1.0 198   1.0 201   16.0
220   1.0 225   7.0 229   1.0 235   1.0 238   15.0 246   6.0 250   1.0 255   5.0 256   1.0 271   2.0
274   1.0 282   7.0 297   3.0 326   41.0 346  222.0 353   2.0
 St.73 2   1.0 12   1.0 14   1.0 60   1.0 78   1.0 85   1.0 114   1.0 136   2.0 149   1.0 170   1.0
268   1.0 326   2.0 351   17.0
 St.74 11   1.0 14   3.0 23   5.0 25   2.0 29   12.0 51   2.0 60   45.0 69  161.0 71   1.0 73   1.0
79   17.0 90   1.0 103   1.0 122   1.0 137   21.0 139   7.0 149   35.0 180   1.0 184   1.0 194   2.0
```

```
197   1.0 201  47.0 218   1.0 220   4.0 225   3.0 255   2.0 260   1.0 267   1.0 274   1.0 282   1.0
326  85.0 346  31.0 362   1.0
 St.75 2   1.0 12   1.0 14   5.0 23   14.0 25   1.0 27   6.0 29   4.0 35   1.0 51   2.0 60   21.0
61   1.0 69   45.0 73   2.0 79   15.0 83   2.0 101   6.0 104   1.0 114   2.0 122   6.0 133   1.0
136   2.0 137   2.0 139   2.0 149   10.0 159   1.0 180   1.0 198   1.0 201   46.0 220   1.0 221   1.0
225   4.0 255   8.0 266   2.0 267   9.0 274   4.0 282   1.0 311   1.0 317   1.0 326   10.0 335   1.0
340   1.0 346   30.0 351   1.0 353   1.0 357   1.0 362   2.0
 St.76 2   2.0 12   1.0 14   17.0 23   4.0 29   11.0 60   42.0 63   2.0 65   1.0 69   136.0 71   3.0
73   1.0 76   1.0 79   22.0 90   1.0 118   2.0 122   2.0 136   1.0 137   62.0 139   12.0 140   3.0
149   13.0 159   1.0 180   1.0 195   5.0 201   91.0 220   2.0 225   5.0 244   2.0 255   1.0 256   2.0
267   2.0 282   2.0 297   3.0 307   3.0 326   7.0 346   149.0 353   1.0 358   1.0 362   1.0
 St.77 2   3.0 11   2.0 12   3.0 14   25.0 23   6.0 25   1.0 29   51.0 33   1.0 35   1.0 46   1.0
59   5.0 60   25.0 63   1.0 65   2.0 69   47.0 71   13.0 73   6.0 77   3.0 79   46.0 82   1.0
97   2.0 114   2.0 123   2.0 136   4.0 137   15.0 139   15.0 141   8.0 147   2.0 148   1.0 149   31.0
159   21.0 179   2.0 180   4.0 184   8.0 201   9.0 209   1.0 218   1.0 220   1.0 223   1.0 225   4.0
229   2.0 255   2.0 257   13.0 262   1.0 267   3.0 268   7.0 271   1.0 274   20.0 282   8.0 291   1.0
297   1.0 304   5.0 305   2.0 320   1.0 326   719.0 332   1.0 335   2.0 346   94.0 353   1.0 362   8.0
 St.78 23   4.0 55   1.0 60   2.0 65   1.0 69   8.0 78   1.0 79   1.0 139   1.0 149   1.0 192   3.0
201   1.0 238   9.0 326   2.0 346   8.0 351   1.0
 St.79 11   1.0 14   6.0 22   4.0 23   7.0 25   3.0 29   26.0 30   3.0 46   1.0 56   2.0 59   2.0
60   31.0 63   2.0 65   4.0 69   22.0 71   6.0 73   5.0 77   2.0 79   60.0 82   1.0 83   1.0
97   2.0 101   5.0 122   4.0 128   1.0 129   1.0 136   2.0 137   5.0 139   12.0 140   1.0 141   1.0
149   21.0 159   17.0 166   1.0 173   1.0 180   20.0 184   76.0 198   1.0 201   6.0 209   16.0 210
1.0
220   3.0 225   1.0 226   1.0 234   1.0 251   2.0 257   6.0 260   1.0 264   1.0 268   33.0 274   24.0
282   45.0 297   7.0 304   9.0 309   3.0 317   2.0 326   256.0 332   1.0 335   1.0 346   134.0 351
1.0
353   2.0 362   22.0
 St.80 2   8.0 3   1.0 11   6.0 12   4.0 13   2.0 14   39.0 23   1.0 27   1.0 29   22.0 51   3.0
59   5.0 60   30.0 63   4.0 65   1.0 69   121.0 71   17.0 73   37.0 76   1.0 79   21.0 83   1.0
87   1.0 130   1.0 136   18.0 139   6.0 149   26.0 159   3.0 180   2.0 194   1.0 201   28.0 209   5.0
225   1.0 229   1.0 238   2.0 257   1.0 268   2.0 282   10.0 297   5.0 326   36.0 346   39.0
 St.81 14   1.0 18   1.0 20   1.0 22   1.0 23   4.0 25   1.0 29   11.0 43   7.0 46   1.0 56   3.0
60   23.0 69   11.0 71   1.0 73   263.0 77   34.0 79   1.0 82   4.0 85   1.0 93   1.0 98   1.0
113   10.0 118   1.0 122   7.0 125   7.0 130   2.0 139   11.0 149   13.0 159   5.0 165   2.0 166   41.0
168   2.0 180   7.0 184   44.0 196   2.0 209   70.0 220   10.0 224   45.0 228   4.0 234   39.0 239
7.0
262   1.0 267   16.0 268   3.0 274   2.0 282   179.0 285   79.0 294   2.0 297   25.0 305   4.0 309
1.0
310   6.0 320   23.0 326   10.0 331   1.0 335   74.0 337   2.0 354   1.0 361   1.0
 St.82 2   10.0 10   1.0 17   1.0 29   20.0 54   1.0 56   1.0 61   1.0 63   4.0 69   4.0 71   2.0
73   1.0 79   3.0 82   1.0 90   1.0 122   3.0 137   110.0 139   15.0 140   7.0 180   4.0 184   6.0
195   16.0 200   4.0 201   1.0 220   2.0 225   1.0 226   1.0 234   2.0 238   5.0 239   2.0 267   1.0
268   2.0 282   2.0 307   26.0 310   1.0 326   518.0 335   7.0 346   131.0 353   2.0
 St.83 2   4.0 9   4.0 21   6.0 22   1.0 23   2.0 29   17.0 35   38.0 45   1.0 54   13.0 60   63.0
65   6.0 69   2.0 71   1.0 73   17.0 101   5.0 104   2.0 105   2.0 111   1.0 113   2.0 120   2.0
122   1.0 130   1.0 132   2.0 136   9.0 137   1.0 166   3.0 176   8.0 177   4.0 180   17.0 184   3.0
195   59.0 198   1.0 209   4.0 220   1.0 221   1.0 223   14.0 224   16.0 225   2.0 227   1.0 228   2.0
234   43.0 235   9.0 245   2.0 246   1.0 257   1.0 267   1.0 282   15.0 285   14.0 291   1.0 292   2.0
297   8.0 305   2.0 307   44.0 310   1.0 317   1.0 326   15.0 330   3.0 332   5.0 335   27.0 346   82.0
355   1.0
 St.84 2   10.0 10   4.0 14   12.0 23   10.0 29   1.0 34   19.0 35   1.0 43   1.0 59   10.0 60   14.0
69   7.0 70   9.0 73   21.0 76   316.0 87   1.0 101   66.0 122   2.0 136   3.0 137   2.0 139   1.0
149   28.0 159   2.0 165   3.0 166   4.0 178   1.0 183   1.0 195   19.0 201   30.0 221   2.0 223   1.0
225   1.0 229   6.0 234   17.0 245   4.0 246   6.0 247   1.0 256   5.0 267   1.0 268   4.0 279   2.0
290   3.0 307   5.0 310   7.0 311   2.0 326   250.0 337   2.0 342   1.0 346   16.0 360   2.0 362   29.0
 St.85 2   9.0 3   1.0 11   3.0 14   26.0 23   14.0 29   32.0 34   6.0 35   2.0 59   5.0 60   26.0
61   1.0 69   20.0 71   1.0 73   45.0 76   41.0 79   1.0 87   1.0 90   3.0 104   3.0 122   1.0
```

```
136   1.0 139   3.0 159   3.0 178   1.0 180   1.0 183   4.0 195   2.0 201   17.0 209   1.0 221   3.0
223   1.0 224   2.0 225   2.0 227   4.0 229   2.0 234   30.0 238   1.0 256   3.0 259   1.0 268   6.0
277   1.0 307   6.0 310   1.0 311   1.0 317   7.0 326   100.0 346   76.0 360   1.0 362   15.0
 St.86 2   2.0 14   2.0 60   10.0 68   1.0 69   1.0 71   1.0 98   1.0 107   1.0 122   3.0 125   3.0
195   1.0 224   2.0 228   3.0 234   2.0 238   1.0 245   2.0 251   1.0 282   1.0 285   1.0 294   4.0
307   1.0 310   67.0 317   1.0 346   11.0
 St.87 2   2.0 29   90.0 60   2.0 69   82.0 71   4.0 73   1.0 104   1.0 122   2.0 137   72.0 139
9.0
140   3.0 167   3.0 180   3.0 195   10.0 200   1.0 225   1.0 234   1.0 238   58.0 255   5.0 282   3.0
297   2.0 307   66.0 310   21.0 317   1.0 326   75.0 335   1.0 346   34.0 353   3.0
 St.88 14   3.0 23   2.0 29   4.0 54   1.0 60   46.0 61   2.0 69   55.0 71   1.0 73   1.0 78   2.0
79   13.0 122   1.0 133   1.0 137   30.0 139   12.0 149   1.0 159   11.0 178   1.0 200   1.0 201   47.0
225   5.0 255   3.0 282   1.0 312   1.0 326   12.0 346   43.0 351   12.0 353   3.0 362   8.0
 St.89 2   2.0 14   6.0 23   26.0 25   1.0 29   2.0 31   1.0 35   1.0 43   2.0 51   1.0 60   34.0
61   1.0 69   50.0 71   1.0 73   2.0 76   3.0 79   2.0 83   3.0 85   1.0 103   1.0 122   5.0
136   1.0 139   1.0 149   7.0 159   6.0 170   1.0 184   2.0 200   2.0 201   212.0 209   1.0 225   1.0
229   1.0 250   1.0 268   5.0 297   1.0 309   2.0 326   3.0 346   4.0 351   7.0
 St.90 2   1.0 23   1.0 61   3.0 69   18.0 71   2.0 78   1.0 79   1.0 85   1.0 116   3.0 122   1.0
123   1.0 139   1.0 159   2.0 200   1.0 201   70.0 229   2.0 257   2.0 326   2.0
 St.91 14   1.0 22   2.0 23   11.0 27   2.0 29   37.0 30   3.0 33   2.0 41   1.0 55   1.0 56   10.0
59   2.0 60   28.0 61   1.0 69   30.0 71   1.0 73   11.0 79   52.0 82   6.0 83   1.0 104   1.0
122   7.0 139   2.0 141   1.0 149   90.0 159   3.0 180   3.0 184   10.0 195   1.0 201   4.0 209   19.0
220   1.0 223   1.0 225   3.0 234   3.0 255   5.0 256   5.0 260   2.0 268   43.0 274   3.0 289   1.0
297   1.0 310   2.0 317   1.0 326   195.0 335   2.0 346   46.0 351   4.0 362   4.0
 St.92 22   1.0 29   1.0 55   1.0 60   2.0 79   2.0 97   1.0 139   1.0·192   4.0 209   1.0 229   1.0
238   4.0 268   2.0 326   4.0 346   2.0
 St.93 55 1104.0 160   5.0 192   12.0 229   1.0 238   79.0 309   1.0 326   2.0
 St.94 13   1.0 23   3.0 57   1.0 59   1.0 60   17.0 63   1.0 65   1.0 69   17.0 71   2.0 73   2.0
83   2.0 85   1.0 122   1.0 149   1.0 159   5.0 178   1.0 195   1.0 200   1.0 201   3.0 209   1.0
225   2.0 229   2.0 238   1.0 246   1.0 274   3.0 282   1.0 309   2.0 311   1.0 346   4.0 362   6.0
 St.96 22   2.0 23   1.0 55   1.0 56   1.0 60   32.0 61   16.0 69   4.0 73   3.0 114   1.0 118   1.0
122   9.0 125   3.0 141   3.0 149   1.0 165   1.0 166   24.0 168   6.0 184   1.0 195   2.0 198   1.0
209   2.0 225   1.0 228   5.0 238   7.0 246   11.0 251   24.0 256   1.0 267   31.0 268   1.0 277   1.0
282   5.0 285   3.0 294   1.0 310   190.0 320   1.0 326   1.0 335   10.0 340   1.0 345   3.0 362   1.0
 St.97 14   1.0 18   5.0 22   1.0 23   10.0 29   3.0 35   4.0 41   1.0 51   1.0 54   4.0 56   24.0
60   32.0 65   23.0 69   120.0 71   1.0 73   259.0 77   710.0 79   26.0 103   1.0 104   1.0 122   1.0
129   5.0 141   5.0 149   35.0 159   4.0 165   5.0 166   1.0 180   17.0 184   98.0 187   1.0 198   1.0
201   1.0 203   1.0 220   4.0 224   19.0 225   7.0 235   1.0 246   4.0 256   21.0 257   7.0 260   2.0
268   13.0 274   8.0 279   1.0 282   5.0 285   2.0 286   1.0 297   6.0 305   2.0 310   18.0 320   4.0
326   6.0 335   6.0 346   9.0
 St.98 14   2.0 23   5.0 29   51.0 43   1.0 54   1.0 56   2.0 60   25.0 63   2.0 65   8.0 69   29.0
71   3.0 73   9.0 74   2.0 77   42.0 79   49.0 97   3.0 101   2.0 113   4.0 122   3.0 130   4.0
137   28.0 141   1.0 149   5.0 159   2.0 166   1.0 171   2.0 180   9.0 184   61.0 195   1.0 209   7.0
220   1.0 225   1.0 234   2.0 246   1.0 255   2.0 257   1.0 268   1.0 274   2.0 282   3.0 309   1.0
311   1.0 317   1.0 326   56.0 335   1.0 346   56.0 353   1.0 362   6.0
 St.99 2   2.0 14   2.0 23   1.0 29   5.0 60   2.0 69   40.0 73   2.0 76   1.0 122   2.0 125   1.0
137   1.0 149   1.0 159   2.0 195   2.0 200   3.0 220   1.0 229   1.0 234   8.0 245   2.0 249   1.0
274   1.0 282   1.0 285   3.0 297   4.0 307   4.0 310   32.0 326   240.0 346   2.0 362   9.0
 St.100 2   4.0 14   2.0 22   1.0 29   49.0 35   38.0 43   1.0 54   1.0 60   29.0 63   1.0 65   6.0
69  113.0 71   1.0 73   6.0 79   1.0 104   1.0 122   1.0 129   2.0 131   2.0 136   1.0 137   26.0
139   3.0 149   4.0 166   1.0 180   5.0 184   3.0 195   15.0 200   1.0 201   2.0 210   1.0 215   1.0
217   1.0 220   4.0 225   4.0 234   14.0 235   2.0 249   1.0 251   1.0 255   1.0 257   1.0 282   7.0
307   78.0 310   2.0 311   1.0 317   1.0 323   1.0 326   680.0 332   1.0 346   38.0 353   2.0 362   1.0
 St.101 2   10.0 14   1.0 20   1.0 21   6.0 23   2.0 29   21.0 35   188.0 43   1.0 54   6.0 60   87.0
61   1.0 63   2.0 65   9.0 69   11.0 73   55.0 90   1.0 105   1.0 113   2.0 118   1.0 122   1.0
133   2.0 136   10.0 137   33.0 139   3.0 149   8.0 159   1.0 166   1.0 176   1.0 177   1.0 180   10.0
195   26.0 200   2.0 201   1.0 203   3.0 209   1.0 215   1.0 223   1.0 225   4.0 228   1.0 234   5.0
235   12.0 238   21.0 246   1.0 255   1.0 256   2.0 261   1.0 282   4.0 297   7.0 305   1.0 307   72.0
```

```
309   1.0 314   2.0 320   4.0 326  47.0 332   1.0 346  94.0 358   1.0 362   2.0
 St.102 3  16.0 14   1.0 43   1.0 63   2.0 69  11.0 73   3.0 136  18.0 137   1.0 139   2.0 149
2.0
229   6.0 256   2.0 326   3.0 349   1.0 351   1.0 362  10.0
 St.103 2   1.0 11   2.0 14  15.0 20   1.0 29  12.0 35   5.0 43   2.0 65   5.0 69  49.0 71   2.0
73   9.0 79   7.0 101   3.0 122   2.0 130   1.0 139  30.0 149   5.0 164   1.0 176   3.0 180   4.0
184   1.0 195   2.0 209  11.0 225   3.0 234   3.0 256   1.0 262   1.0 268   1.0 307  33.0 310   3.0
317   1.0 326  17.0 335   1.0 346 119.0
 St.104 38   1.0 69   4.0 78   1.0 125   1.0 195   1.0 228   4.0 234   1.0 251   3.0 294   2.0 310
66.0
311   1.0
 St.105 14   1.0 23   4.0 26   1.0 29 103.0 31   3.0 41   1.0 54   1.0 56   2.0 59   3.0 60  40.0
65  13.0 69  24.0 71   9.0 73   5.0 77   6.0 79  30.0 83   1.0 97   1.0 113   2.0 139   4.0
149  16.0 159  16.0 177   1.0 180   9.0 184  11.0 198   1.0 201   1.0 209  31.0 218   1.0 224   4.0
225   2.0 226   1.0 229   1.0 235   1.0 255   3.0 257   2.0 268   2.0 274   7.0 282  19.0 285   2.0
294   2.0 297   6.0 305   3.0 309   2.0 310   5.0 311   1.0 317   3.0 326  33.0 332   1.0 346  35.0
362   1.0
 St.106 10   2.0 34   1.0 51   2.0 60   2.0 61   1.0 69   4.0 122   8.0 125   2.0 228   7.0 245   1.0
251  30.0 254   3.0 267   1.0 294   4.0 310 240.0 317   1.0 327   1.0 345  14.0 351   9.0
 St.107 3   1.0 13   2.0 23   1.0 29   2.0 31   1.0 59   1.0 61   1.0 69   2.0 73   2.0 76   1.0
77   7.0 85   2.0 130   1.0 141   1.0 159   5.0 200   3.0 229  16.0 310   2.0 326   2.0 333   4.0
351   6.0
 St.108 29  18.0 51   2.0 60   5.0 69  32.0 79   1.0 122   4.0 137   4.0 140   1.0 159   1.0 166
2.0
195   8.0 200   7.0 222   1.0 234  16.0 245   8.0 251   2.0 282   2.0 307   7.0 310  44.0 311   2.0
326  75.0 327   1.0 346  10.0 362   1.0
 St.109 2   1.0 9   1.0 29  38.0 60   3.0 69  35.0 85   1.0 137  66.0 139   4.0 140   5.0 149
2.0
166   1.0 167   3.0 195  10.0 220   1.0 222   1.0 225   1.0 234  11.0 238   2.0 245   3.0 255   6.0
282   1.0 287   1.0 307  21.0 310  10.0 311   2.0 326  23.0 346  16.0 353   2.0 362   9.0
 St.110 2   2.0 9   3.0 14   1.0 29   9.0 60   9.0 61   5.0 63   3.0 65   3.0 69 100.0 73   3.0
76   5.0 77   3.0 90   2.0 104   1.0 137  23.0 167   2.0 184   1.0 195   3.0 196   1.0 201   2.0
220   1.0 223   1.0 234  25.0 249   1.0 274   2.0 282   1.0 297   2.0 307  43.0 310   6.0 326  23.0
335   1.0 346   7.0 362   2.0
 St.111 2   4.0 3   1.0 9   3.0 10   1.0 11   1.0 14  18.0 21   1.0 23   7.0 29  15.0 42   1.0
43   2.0 59   6.0 60   9.0 61   9.0 63   1.0 69  12.0 73  27.0 76  82.0 77   2.0 83   1.0
85   1.0 90   3.0 101   5.0 104   1.0 122  13.0 136   1.0 137  15.0 139  11.0 140   1.0 149   8.0
159   2.0 166   4.0 178   1.0 196   3.0 201  41.0 225   3.0 227   1.0 234  29.0 235   1.0 255   2.0
268   3.0 274   1.0 297   1.0 307   6.0 310   8.0 317   3.0 326  73.0 346  61.0 353   1.0 362  11.0
 St.112 2   1.0 14   6.0 25   1.0 29  11.0 59   3.0 60   9.0 61   2.0 63   1.0 65   1.0 69  32.0
71   1.0 73   1.0 76   2.0 79   1.0 90   1.0 122   1.0 139   8.0 149   2.0 196   1.0 201   2.0
234   3.0 274   5.0 307   9.0 310  13.0 311   2.0 317   9.0 326 243.0 346   8.0 362  27.0
 St.113 2   2.0 11   1.0 14   5.0 23   1.0 29  70.0 35   2.0 43   1.0 60   4.0 63   2.0 65   1.0
69 146.0 71   3.0 73   3.0 90   3.0 104   1.0 133   2.0 137  21.0 140   2.0 149   2.0 201   1.0
220   1.0 229   1.0 255   3.0 270   1.0 274   1.0 277   1.0 282   1.0 285   1.0 307  44.0 310   3.0
326 612.0 346  16.0 353   1.0 362   4.0
 St.114 2   2.0 29   2.0 60   1.0 69  11.0 71   1.0 90   1.0 137   1.0 139   1.0 140   2.0 164   1.0
184   1.0 229   1.0 234   2.0 307   4.0 310   1.0 311   1.0 323   1.0 326  99.0 346   1.0 353   1.0
362   3.0
 St.115 60   1.0 69   1.0 78   1.0 118   1.0 122   1.0 125   2.0 228   3.0 238   1.0 251  11.0 273
1.0
282   1.0 306   4.0 310  27.0 345   1.0
 St.116 14   2.0 23   3.0 25   5.0 29   2.0 60  28.0 61  32.0 69  29.0 71   1.0 73   2.0 74   1.0
76   1.0 77   1.0 78   1.0 79   7.0 122   1.0 137   1.0 139   2.0 149   1.0 159   1.0 184   1.0
229   4.0 245   1.0 255   1.0 257   1.0 267   1.0 326   2.0 333   6.0 362   3.0
 St.117 31   1.0 60   2.0 69   3.0 77   4.0 97   6.0 199   1.0 229   1.0 268   1.0 326   2.0 362
1.0
```

```
St.118 51   1.0 61   3.0 69   26.0 71   6.0 78   2.0 137   42.0 140   2.0 333   1.0 346   31.0 353
1.0
362   3.0
St.119 29   2.0 60   7.0 61   2.0 68   1.0 69   6.0 73   1.0 78   3.0 97   1.0 120   1.0 122   2.0
166   1.0 180   1.0 200   2.0 209   1.0 234   2.0 251   3.0 285   2.0 300   3.0 310   4.0 311   1.0
323   1.0 326   6.0 327   1.0 345   1.0
St.121 69   3.0 71   1.0 125   1.0 139   1.0 229   1.0 310   8.0
St.122 9   2.0 14   1.0 29   20.0 54   1.0 59   1.0 60   11.0 63   1.0 65   3.0 69   12.0 71   1.0
73   2.0 76   5.0 132   1.0 137   62.0 139   33.0 140   3.0 159   1.0 166   8.0 180   2.0 202   2.0
209   3.0 234   5.0 238   14.0 255   26.0 282   1.0 307   23.0 310   7.0 311   1.0 319   1.0 326   70.0
328   1.0 346   69.0 353   3.0
St.123 34   2.0 38   2.0 54   1.0 60   2.0 61   1.0 122   1.0 125   2.0 178   1.0 228   3.0 238
1.0
245   1.0 310   44.0 319   2.0 345   5.0 362   2.0
St.124 14   3.0 29   5.0 60   13.0 61   1.0 65   13.0 69   73.0 71   1.0 73   32.0 77   1.0 90   2.0
104   4.0 122   7.0 129   1.0 137   75.0 139   11.0 140   8.0 159   1.0 167   7.0 180   1.0 202   1.0
203   1.0 209   3.0 220   1.0 225   2.0 234   3.0 235   1.0 238   10.0 251   3.0 255   26.0 257   1.0
285   1.0 307   48.0 310   4.0 324   1.0 326   28.0 346   79.0 353   4.0 362   3.0
St.125 69   56.0 167   2.0 310   1.0 353   1.0
St.126 3   8.0 69   1.0 229   2.0 250   1.0 362   2.0
St.127 55   1.0 60   1.0 61   5.0 122   1.0 125   5.0 139   2.0 146   1.0 228   12.0 237   4.0 251
11.0
254   6.0 282   1.0 297   1.0 306   7.0 310   19.0
St.128 29   1.0 60   1.0 69   15.0 73   1.0 75   1.0 125   1.0 139   2.0 201   1.0 202   1.0 228
2.0
310   33.0 321   1.0 345   1.0
St.129 2   1.0 14   3.0 22   2.0 25   2.0 29   19.0 30   1.0 51   1.0 56   1.0 59   1.0 60   7.0
61   3.0 65   2.0 73   14.0 74   2.0 76   100.0 77   15.0 78   1.0 79   2.0 83   3.0 113   1.0
114   1.0 122   3.0 123   1.0 139   7.0 149   1.0 159   45.0 180   1.0 201   26.0 209   6.0 214   2.0
225   1.0 229   5.0 234   20.0 237   2.0 255   1.0 257   1.0 265   5.0 274   2.0 307   12.0 310   16.0
311   1.0 317   3.0 346   18.0 362   1.0
St.130 14   10.0 23   1.0 29   11.0 60   19.0 65   4.0 69   46.0 71   2.0 73   30.0 76   1.0 77
1.0
78   1.0 90   2.0 104   2.0 122   1.0 137   24.0 139   6.0 140   5.0 159   2.0 166   2.0 167   4.0
180   4.0 209   2.0 225   2.0 229   1.0 234   1.0 238   11.0 255   4.0 307   18.0 317   1.0 319   1.0
326   2.0 346   42.0 353   2.0 362   2.0
St.131 21   2.0 54   8.0 60   18.0 61   1.0 63   1.0 65   6.0 69   15.0 122   3.0 131   1.0 137
3.0
159   2.0 225   4.0 234   2.0 245   1.0 285   4.0 307   4.0 310   36.0 311   1.0 330   1.0 362   2.0
St.132 29   1.0 54   2.0 65   2.0 69   17.0 71   1.0 73   2.0 129   1.0 137   8.0 139   4.0 159
1.0
202   10.0 209   2.0 224   3.0 234   1.0 255   12.0 307   2.0 320   6.0 323   16.0 353   1.0
St 133 9   1.0 14   2.0 56   7.0 65   4.0 69   1.0 73   2.0 77   3.0 79   2.0 97   9.0 130   4.0
133   1.0 139   3.0 149   1.0 153   3.0 159   4.0 177   17.0 194   3.0 209   7.0 224   1.0 235   1.0
255   1.0 268   13.0 274   1.0 282   1.0 331   1.0
0
```

Sado Estuary. Subtidal macrofauna wet-weight biomass data, mg.0.1m^{-2}

```
(I5,8(I4,F8.2))
  100
 St.1 2  22.10  8  16.80 14   1.40 18    .50 21   8.80 22   6.40 24    .50 26  57.10
42  59.80 45  99.10 50   8.80 53 210.70 54 786.90 55  98.80 56  11.90 61   7.10
77  30.60 80  29.50 98  25.70 111  12.80 113  86.40 118   6.00 122   4.70 125   1.40
126   1.10 131  18.00 149    .90 151    .20 154  84.00 162  59.70 180  80.50 189  22.80
194  16.30 195   6.10 199  75.60 209    .90 213   3.10 221 1813.00 222   8.40 224  29.00
229  79.00 234  53.10 235   9.10 236   1.50 237    .10 245   9.70 251    .10 253   3.50
255   2.90 256    .50 264   1.20 267  18.00 268   1.40 272  75.60 273    .30 274  74.10
277   1.40 280    .40 282   1.20 291    .90 294   5.50 296   6.00 299   5.80 305   4.10
312  29.50 321   5.60 32919230.00 335    .90 339   4.40 347    .40 35736688.20 363  96.20
 St.2 13   1.10 18   1.50 24   3.50 34   1.00 36 690.30 45  57.80 49   7.30 54   1.40
58 106.80 69   3.70 77   4.50 86    .10 96 871.10 105  58.10 113 129.60 118  30.00
120  26.40 125    .80 130   7.60 142   3.50 144  65.70 149   1.80 156   1.10 189   1.90
195   7.30 200   1.80 210  17.50 223  16.90 224   7.50 228   2.40 234  32.60 235    .30
237   1.20 245   9.70 251    .20 255   1.60 268   6.30 273  10.40 280  33.20 285    .40
294   1.40 295    .10 298    .10 299   2.90 306    .50 312 106.00 320    .30 322    .20
323  20.40 331    .60 334    .90 335   1.80
 St.3 34   1.00 68   6.60 113   1.60 125  32.70 204   1.00 224   3.00 228 472.60 237    .30
251   1.20 267  26.10 268    .70 273   2.20 294   2.40 299   2.90 306   1.40 323  20.40
345 505.20
 St.4 14   1.40 22   6.40 23   4.00 56   1.40 65   2.80 69    .30 73   2.00 82   6.60
118  60.00 120 556.10 122  43.50 126   3.60 149    .90 195    .10 200  19.80 224  16.50
226 134.00 228    .30 234  50.90 236  22.60 237    .30 245  77.80 251    .40 256   5.50
265  10.90 267 486.00 268   2.10 273    .70 280    .10 282   1.20 285  50.40 294    .90
297    .10 299  14.30 306    .40 323   2.40 325   7.60 326   5.10 329  73.00 331   2.10
335   1.80 355   2.10 356   4.20
 St.5 13   4.40 21  22.00 22  19.20 23   2.00 24   1.00 25 232.10 28  26.40 29  14.90
34   1.00 36 916.20 45 132.40 54 1358.90 56   6.30 60   7.40 61 314.30 70  46.10
73  19.00 77   4.50 88   1.60 102   3.80 105  66.60 106 482.80 113 206.00 120 353.90
126  20.30 130  45.60 131  10.80 135   3.20 142  10.20 146   3.20 156    .30 166   3.00
176   4.50 180 178.50 183   8.90 189  19.00 193  24.30 195  28.50 199  16.20 200   3.60
209   1.80 210 3907.30 211 230.30 220 1495.30 221 1599.20 224  13.50 228 219.70 234 662.30
235 410.80 243   1.20 249 435.60 256    .50 264    .50 265   7.60 267 387.90 285  28.50
291    .30 294    .10 295    .10 296 1919.60 305  19.80 312 392.50 316 3428.30 327   4.90
329  64.60 335   7.20 336    .90 35714213.60 358 3219.20 359 1146.20
 St.6 2  15.30 10  32.50 14   2.80 22   6.40 23   6.00 30   1.20 31   3.00 33   2.00
34 704.80 41    .70 43   3.40 55   1.60 56  12.60 69   4.50 76    .60 82  16.50
88 3471.30 97  17.50 101 357.20 109    .50 122   8.10 149  19.80 168   1.70 170   5.70
178    .20 180  19.00 195  16.80 221 4519.60 222   2.50 229 707.10 233  15.60 234 417.00
245   9.70 260   1.00 267   9.00 268  18.90 294    .20 304   3.30 325   6.10 327   1.60
340  22.70 341  47.30 345 1000.40 347   7.50 357   1.30 360 4301.90
 St.7 34   1.00 68   6.60 98  14.80 118 150.00 120    .90 228 131.30 237    .40 251    .20
256   1.50 267   4.50 273   1.90 294    .10 306    .70 327   3.30 329  39.90 354   1.40
 St.8 24   1.00 68 417.60 118 126.00 120   2.30 125    .50 138    .20 210   1.30 224   4.50
228   9.30 234   4.50 237    .10 251    .90 255    .10 273   8.90 284    .10 298    .10
306   1.00 323  22.30 335    .90 356   4.20
 St.9 23   1.00 28   3.60 29   7.90 36    .50 44  10.20 45   3.40 68   6.60 70    .90
95 280.80 98 267.20 99   6.20 118  30.00 120  53.00 125  33.40 131  28.80 195   3.00
222   2.50 224   6.00 234  33.90 237    .50 245  48.50 251   4.40 255    .30 256   1.50
260    .50 265   5.50 267    .90 273  14.20 277   1.50 280   1.20 283    .30 294  15.30
305    .50 306   1.10 312   9.70 320   2.20 323  44.60 325    .40 327   8.40 329  54.90
335   3.80 357    .60
 St.10 48 350.90 61  27.50 99  11.20 107   3.90 118  12.00 120  39.70 125   2.40 189   1.90
```

221 2029.40 224 1.50 228 438.70 232 1.10 234 .10 237 .30 251 .10 267 .90
273 1.10 294 .10 329 225.70 350 1.50 354 27.60 356 1.40
St.11 23 1.00 32 .60 33 1.00 43 3.40 60 5.70 65 1.40 68 6.60 73 1.00
113 3.20 118 6.00 122 38.90 134 .80 138 .10 168 1.70 172 76.30 195 4.40
200 28.80 228 127.90 234 12.00 237 .20 251 1.00 256 4.50 267 4.50 268 .70
273 40.30 280 3.00 282 .10 294 .10 305 .10 306 1.90 312 9.90 313 94.10
323 22.30 325 2.10 326 5.70 329 15.10 335 .90 356 1.40
St.12 2 49.20 6 1038.60 23 6.00 27 12.50 29 7.70 34 3.00 35 4.10 39 2.20
45 6.80 54 .50 60 22.50 73 77.00 79 6.70 92 81.20 98 12.50 101 .80
118 6.00 120 22.20 122 6.80 125 3.30 138 .20 144 5.60 149 2.70 155 1.40
158 33.60 163 3.20 166 25.50 183 4.30 195 4.40 207 5.20 209 4.50 210 1.30
224 171.50 225 12.90 226 67.00 228 1.90 234 .10 237 .30 246 1.40 251 .60
256 400.10 262 19.10 267 450.80 268 .70 273 .50 274 .80 277 2.20 280 .70
282 1.10 285 11.90 294 3.60 297 58.10 310 250.90 316 6.00 320 .70 325 1.50
326 37.50 329 812.80 335 5.40 340 8.70 346 3.00 357 24.90
St.13 2 6328.00 4 952.80 14 2.80 21 4.40 23 4.00 29 59.10 35 65.60 39 1.10
45 6.80 54 961.00 55 3.30 56 2.10 59 7773.10 60 132.20 65 5.60 69 4.90
70 58.50 71 328.20 73 46.50 79 20.10 82 3.30 88 3503.50 90 63.00 92 259.20
95 5669.70 96 472.00 98 2.50 101 19.40 109 .10 111 1.60 119 1100.00 132 5.10
134 3.20 136 13.60 141 1.80 149 69.30 157 963.50 15811484.10 165 1.20 166 9.00
171 50.60 180 78.60 183 2965.80 184 478.20 190 2.70 191 6.10 195 190.60 199 3.60
200 10.80 203 .60 209 3.60 221 4269.60 224 6.00 225 30.10 226 267.90 229 29.10
234 5.10 235 2062.30 238 1.60 241 248.10 245 19.40 246 32.20 247 7.70 248 86.60
252 .30 255 3.60 256 1.50 259 .20 260 1.50 265 226.60 267 10.80 268 5.60
282 .60 285 .80 292 .10 297 6.40 307 16.70 312 4.80 316 354.00 326 80.50
329 984.00 330 1335.50 332 49.40 337 1.00 344 3690.20 346 500.90 347 498.70 349 .90
357 2306.40 358 842.10 360 9606.30
St.14 2 1202.60 14 19.60 21 2.20 22 6.40 23 2.00 29 23.90 35 360.80 42 179.40
45 6.80 54 1124.10 60 324.80 65 11.20 69 303.90 71 412.40 73 37.50 85 3.70
90 4.80 101 29.10 103 2.00 105 37.20 108 .20 113 1.60 120 6.40 130 7.60
131 3.60 133 5.10 134 13.60 148 15.40 149 5.40 158 150.80 159 12.70 161 2.30
174 189.40 176 6.00 180 504.00 194 1955.30 195 61.10 200 7.20 201 332.60 203 8.00
223 16.00 224 12.00 225 4.30 226 359.90 234 24.40 235 3629.60 245 58.20 246 1.40
249 68.50 251 .10 256 30.00 257 250.30 260 2.00 265 3.90 267 4.50 274 42.90
279 2.30 282 8.80 291 12.00 297 21.50 307 2.00 314 5.10 316 380.50 326 24.20
329 2278.70 330 1005.80 335 6.30 346 347.10 351 10.50 35763540.20 358 842.10 360 5482.30
St.15 2 123.20 14 1.40 22 25.60 23 4.00 25 3605.50 29 3.90 34 3.00 43 6.80
45 6.80 60 10.40 61 13.40 68 6.60 73 29.00 103 2.00 105 6.10 118 6.00
121 227.70 122 52.50 124 99.10 125 .20 144 .10 149 7.20 163 6.40 166 15.00
195 18.10 200 36.00 206 .90 224 24.00 228 634.50 234 18.30 237 .70 244 1.50
245 67.90 247 2.20 256 164.50 260 .50 267 581.70 273 .10 280 .30 294 7.40
297 69.10 310 121.10 323 22.30 326 3.50 327 4.00 329 71.90 343 100.00 350 3.00
354 1.40
St.16 2 1711.10 12 2.80 14 12.60 18 .50 22 151.60 23 4.00 2517606.40 29 175.20
33 .50 34 105.00 35 32.80 42 358.50 51 1.60 54 189.30 55 11.00 60 207.20
65 4.20 69 14.60 71 190.30 73 23.50 79 26.80 87 75.80 95 4246.30 96 29.50
98 9.80 101 495.70 103 6.20 104 6.90 109 .10 121 788.50 122 157.10 130 7.60
141 .80 144 49.70 149 19.80 159 86.70 166 18.00 173 12.60 178 4.90 179 51.60
180 110.30 183 68.70 191 18.60 195 541.50 196 15.00 198 7.50 200 34.20 201 560.30
203 3.60 208 5.40 215 .40 219 167.40 221 1928.90 223 1.30 224 24.40 225 17.20
228 65.20 229 16.50 234 260.90 238 4.40 246 22.40 247 27.50 248 251.50 258 3.80
260 4.00 262 4.00 265 58.30 267 1.80 274 135.40 277 4.10 279 13.50 282 9.40
291 7.90 292 2.00 297 226.20 305 14.00 310 27.30 312 3.00 320 .20 326 1023.80
327 1.70 332 13.10 340 7.20 341 41.30 346 152.20 355 15.40 35711675.00 358 842.10
360 1548.90
St.17 21 11.00 22 19.20 23 7.00 28 36.30 29 30.80 40 98.90 42 239.20 45 3.40
54 4.10 56 4.20 60 37.90 63 2030.10 69 2.30 77 9.00 98 25.20 113 8.00
118 12.00 122 125.10 125 .10 130 15.20 141 .20 149 2.70 180 1014.30 183 28.30

```
189   3.80 191   54.60 195   50.10 200   30.60 209    2.70 210   51.20 216    7.70 220   16.40
221   26.20 223    5.10 224   28.50 225   17.20 228  246.60 234 1843.50 243    9.90 245   19.40
251     .40 265    9.10 267   20.70 268     .70 272   53.10 279    4.60 282   67.10 285  127.80
294     .40 297   26.50 305   91.50 310   59.70 312   63.40 320     .20 326  113.00 327     .50
329 1396.80 331     .80 346    2.10 357 1208.40
 St.18  223383.70  11    5.60  12     .70  14    9.80  23   27.90  29  138.40  34    1.00  35    4.10
 43    3.40  54    2.30  55     .90  60   16.50  61    1.80  69   10.20  70    7.80  73   15.00
 76    3.60  85    1.40  87  314.60 101  810.00 109     .10 122    5.50 127   63.40 143    1.50
 149   29.70 171   66.70 179   37.10 183  921.20 195   94.60 201  228.00 212    1.20 220   98.60
 221  552.30 225   12.90 226 9249.10 229  291.80 234  185.10 235 2394.30 246   28.00 247    5.50
 248   79.90 256    2.00 265   18.20 274    2.30 279   41.00 282    7.20 285    3.80 291     .40
 292    2.60 294     .10 297    3.30 307    1.70 310   16.50 325     .80 326   76.80 327    3.80
 330 1383.70 335    2.70 345     .40 346    7.80 351   14.00 360 1929.20
  St.19  2  612.20  14    1.40  18    1.00  21    8.80  22  124.50  23   68.30  27  116.30  29  279.10
  33     .50  42 1228.90  45    3.40  51     .80  54  207.50  56    1.40  60   21.40  6312515.80
  65   14.00  69    5.60  71  548.10  73    8.50  76     .60  77    4.50  83    4.40  87   48.40
  101   24.50 104    1.50 108     .20 113    3.20 121  287.60 125     .10 130   30.40 144    1.70
  149    9.00 159  686.70 166    3.00 169    1.70 173   12.30 180  286.10 183  790.20 184  319.80
  191   66.90 194   19.60 195   96.10 198   11.00 200    5.40 209    1.80 216   30.10 220  103.60
  221   21.40 222    1.60 223   11.90 225   77.70 22610958.40 228  137.60 234  268.00 235  149.00
  238    4.00 245   29.10 250  152.70 262  697.90 265   78.90 267    3.60 274  416.70 277    1.70
  279    5.40 281   22.80 282   54.50 285   50.40 292     .20 294     .10 297  112.60 305   54.00
  307    3.30 310  121.00 312    8.60 325    7.70 326  115.40 329 2020.40 331     .60 332    3.50
  335   16.20 346   11.80 357 4964.40 359  197.00
   St.20  2  635.30  10   22.50  12     .70  14   32.20  22   32.00  23    7.00  29.   53.60  35    4.10
   54   33.50  55    2.90  60  873.80  69   29.90  73   18.00  76   14.40  79    6.70  94  104.20
   101  269.00 103    5.00 109     .10 122  697.90 137   25.80 143     .50 149   35.10 159   27.20
   166    9.00 168    5.10 171   96.70 176    1.50 179   15.90 190    3.80 195   60.40 201  501.80
   205     .50 206     .90 209    5.40 216    9.00 221   22.60 223    3.50 224    1.50 225   17.20
   226   67.00 227  154.20 229   37.00 234  710.00 245    9.70 246   22.40 247    6.60 248  965.70
   256    4.50 258    1.90 265   39.70 268     .70 279    1.50 282   32.40 292    4.40 297   37.60
   310    7.60 325     .50 326  363.50 327     .50 329   28.60 332  175.70 341   60.50 346   91.10
   347  345.00 355    1.40 357    2.70 362 3381.60
    St.21  2  545.90  14    2.80  20    2.50  21   24.20  23   23.00  27   12.50  29   34.40  34  131.00
    35   24.60  45    3.40  51    3.20  60    7.40  68    6.60  71   44.30  73   87.00  76     .60
    77     .90  83    6.00  93    9.50  98   30.90 101   75.40 120   15.00 121  669.60 122   56.70
    125   27.30 130   15.20 131    3.60 144  178.90 149    9.00 163   12.80 165  134.00 166   42.00
    183   44.20 186    1.50 195  170.20 200    1.80 203     .60 209    9.00 214    2.30 224   54.00
    225    4.30 226  145.80 228   92.20 234   91.90 238    8.00 245   19.40 246    1.40 252     .90
    255    1.50 256  161.00 265    4.90 267   21.60 270   11.00 273     .30 274  163.90 277    4.40
    282    1.40 285    3.70 292    1.90 294    5.50 297   30.90 305     .60 310  131.10 320    2.00
    323    1.20 326  451.10 329    1.50 335    7.20 338     .50 340  685.60 346    8.70 350    6.00
    357 1935.80
     St.22   2  591.30  11    1.40  14   15.40  17     .90  20     .50  21   17.60  22    6.40  23    4.00
     25    4.60  28     .90  29   55.90  34    3.00  35   36.90  42  739.50  45   13.60  51    1.60
     54  291.30  56    9.10  60  126.10  62    1.00  69   41.60  73   63.50  76    1.20 113    4.80
     120   24.70 122   24.90 130   22.80 135     .80 136    1.60 149   12.60 166   13.50 176   13.50
     179    2.60 180  424.40 183   16.80 186    1.50 194  597.80 195  157.20 200   18.00 201   31.50
     203    1.20 209    1.80 223    9.90 224    3.00 225    4.30 229     .50 234    7.70 235  174.60
     246    4.20 247    1.10 255    2.80 256   78.50 260    3.50 265   30.60 267   14.40 282    4.50
     291    1.70 297   36.20 312    8.70 326   13.50 329 5292.80 332  220.20 335    2.70 346  627.80
     351    2.10 357******** 362     .20
      St.23   2  742.70  17   17.80  23   10.00  27  730.90  29  212.90  30    1.80  35   69.70  41    1.40
      60   45.70  65    1.40  69  166.00  73    1.00  79   80.40  82   44.00  83  175.20  85   70.40
      97     .70 100  577.30 109     .20 122   95.70 139  203.50 148    7.00 149   31.50 159   39.70
      179  785.60 180  659.20 183  577.10 190   66.60 195  387.50 201 3252.80 209    1.80 218  453.80
      221 1398.10 223    3.40 225   17.20 227   15.20 229   35.30 234  101.60 235   33.50 248  606.70
      255     .40 257   24.80 259   23.60 265   34.60 268    2.10 274  163.60 282   17.30 291    1.20
```

297 14.00 301 1.40 304 252.30 312 .20 318 5.20 326 723.50 332 28.10 346 3.80
351 5.60 357 82.50 362 687.90
St.24 2 1719.40 23 3.00 55 14.50 60 3.50 73 .50 76 1.20 85 374.00 122 .40
149 2.70 179 3.30 201 24.50 226 782.90 229 512.00 234 2.10 268 .70 274 1.50
282 .30 297 .60 310 .40 318 1.00 332 19.80 340 5.40 346 1.10 351 30.80
St.25 2 833.20 11 53.20 12 3.50 13 8.80 14 26.60 18 .50 21 13.20 22 42.10
St.26 13.20 29 48.50 35 164.00 42 59.80 45 3.40 54 142.80 55 1.50 60 407.80
65 2.80 69 7.00 73 27.50 79 6.70 84 1.40 87 3.40 88 1.10 90 8.10
101 3.50 105 160.60 110 537.10 113 1.60 127 1.30 130 7.60 136 11.20 139 2.30
141 .20 149 2.70 159 32.10 163 3.20 166 1.50 180 1272.90 189 17.10 194 312.50
195 12.10 197 1.60 201 10.50 203 3.60 224 4.50 225 8.60 226 67.00 227 58.50
235 2670.40 247 1.10 256 4.00 260 .50 262 .90 264 146.90 265 6.30 268 .70
274 2.60 282 35.90 285 16.20 291 2.50 297 272.20 305 .30 307 17.70 312 1.00
316 3585.40 326 41.00 332 4.40 335 3.60 346 654.00 360 2095.40 362 180.40
27 5521833.60 57 165.90 60 .80 63 6357.50 69 7.60 79 6.70 109 .80 146 13.50
149 4.50 192 106.80 22145151.70 230 22.40 235 68.60 242 .80 268 .70 297 .40
346 7.20
St.27 2 378.40 11 32.20 12 32.20 14 50.40 22 12.80 23 2.00 29 117.30 35 172.20
54 401.20 56 2.10 59 4828.40 60 22.80 6316240.80 65 32.80 69 11.80 71 1436.00
73 21.50 79 113.90 101 37.20 103 1.00 122 15.30 127 43.20 136 22.30 139 12.40
148 15.40 149 3.60 159 311.40 180 144.30 195 15.60 201 2231.80 203 1.80 209 3.60
223 14.00 225 4.30 234 13.20 235 5679.90 256 .50 257 54.90 259 23.60 260 1.50
262 245.60 265 6.30 268 .70 282 64.80 291 .60 297 137.70 305 5.60 326 40.00
332 42.20 335 .90 346 25.90 351 2.80
St.28 2 472.00 11 33.60 17 41.80 18 .50 20 .50 21 28.60 23 1.00 25 417.80
27 12.50 28 3.30 29 366.10 35 57.40 41 2.10 42 119.60 45 30.60 54 726.10
60 550.70 63 6714.50 65 8.40 66 4.10 69 226.90 73 42.50 77 .90 79 13.40
88 275.60 101 48.70 104 5.60 105 500.70 113 32.00 120 2.80 122 5.90 125 1.00
130 30.40 131 28.80 136 3.20 141 2.40 144 47.60 148 30.80 149 1.80 176 13.50
180 1113.80 189 74.10 195 203.50 200 10.80 201 17.00 203 1.80 209 12.60 223 44.20
224 13.50 225 32.60 226 134.00 228 1.40 232 19.30 234 719.90 235 224.50 246 1.40
252 .30 253 3.50 255 2.70 260 4.40 264 6.00 274 1565.70 282 7.00 285 4.50
291 3.20 293 930.30 294 1.30 297 2.80 307 40.80 309 .20 312 17.00 314 1.80
316 2625.70 320 .40 327 .10 329 13.40 332 1.90 335 15.30 346 144.80 355 .70
357 9.00 359 3148.80 36117133.60
St.29 2 274.80 11 15.40 14 25.20 22 38.40 23 8.00 29 326.40 35 4.10 39 1.10
42 59.80 51 .80 54 247.00 60 369.30 63 20.80 65 1.40 69 80.80 71 42.50
73 15.00 79 180.90 81 319.30 85 841.00 90 30.80 95 101.30 103 1.00 105 233.80
115 293.00 120 11.10 122 61.20 130 15.20 131 7.20 136 3.20 149 2.70 166 16.50
180 1010.30 184 211.90 195 305.00 198 390.40 200 1.80 201 161.70 203 1.20 209 9.90
223 7.00 224 7.50 225 45.70 226 67.00 228 42.50 232 10.20 234 59.40 246 4.20
248 64.00 252 2.40 255 1.20 256 .50 260 1.00 262 161.30 265 6.30 267 2.70
268 7.70 274 196.80 282 11.70 285 327.10 298 .10 305 2.80 307 55.00 326 32.00
327 2.70 329 1895.00 332 84.40 335 11.70 346 129.00 352 435.80 355 2.80 360 4082.70
362 523.80
St.30 2 2379.50 11 2.80 14 15.40 23 5.00 29 164.10 33 1.00 35 4.10 60 198.40
63 113.10 65 1.40 68 6.60 69 26.30 71 1215.90 73 9.00 79 20.10 95 107.70
101 71.00 103 1.00 118 12.00 122 77.10 136 .80 149 41.40 159 26.70 166 4.50
168 6.80 180 134.30 195 668.90 201 63.10 203 1.20 209 .90 225 30.10 226 282.80
229 18.60 234 333.50 236 2.30 238 1.60 246 8.40 247 7.70 248 653.10 253 3.50
256 .50 260 1.50 265 .50 267 .90 268 .70 274 18.70 279 13.20 282 5.00
285 2.40 297 10.90 307 56.30 310 61.20 317 1025.70 326 325.60 327 .20 346 143.90
355 2.10 360 4163.90 362 1493.80
St.31 68 417.60 107 1.30 118 24.00 120 14.10 228 91.00 273 9.60
St.32 29 8.00 107 2.60 118 14.00 125 .10 181 .60 189 1.90 220 56.60 221 3439.50
228 243.90 229 4581.50 240 2.50 291 .50 310 40.00 335 .90 345 208.10
St.33 2 91.30 29 51.00 35 4.10 42 59.80 54 432.50 60 19.00 67 3.00 111 1.60
120 130.20 122 45.60 131 3.60 144 22.40 176 1.50 180 211.80 189 1.90 195 3.90

```
220 243.00 221 6358.50 223  14.00 224   1.50 228 127.50 234  33.00 245   9.70 272  32.20
282   1.80 285   5.40 291    .60 294    .30 297   1.70 307   5.50 310   5.10 312   9.00
316 231.60 323   1.20 32911012.40 335   3.60 346   1.40 357********
 St.34  2 1408.20  12    .70  22   6.40  29 178.70  33   1.00  38 176.90  60  15.80  68   6.60
 95 482.90 111   1.60 122  57.60 125    .10 149    .90 195  36.80 200   3.60 227 111.50
229   4.20 234  38.80 268    .70 274  51.70 279   2.30 282   1.60 294    .40 310 1698.90
326  65.30 327    .10 330 919.70 335   3.60 340 818.10 346  38.10 362 2874.80
 St.35  2 2278.10   7   3.30  10  22.50  12   3.50  14  18.20  23   1.00  29 265.20  55   1.50
 60 226.80  66    .60  68  19.80  69  41.30  73   1.50  76   1.80  79  20.10  90  15.40
122  61.20 136    .80 141    .60 149    .90 159  10.00 168   1.70 180  48.10 184 211.90
190  28.20 195 254.80 201  46.20 225   8.60 228  42.50 229 113.40 234 138.60 238   1.60
244   4.50 248 384.00 256   1.00 274 144.00 279   4.00 297   1.70 310 209.10 326 440.00
332  42.20 335   3.60 340 188.70 346 181.90 362 3317.40
 St.36  2 923.60  11   1.40  12   1.40  14  54.60  22  38.40  23   7.00  29  69.20  35  36.90
 45   3.40  55    .10  56    .70 5940201.80  60  28.50 6334784.00  71 431.10  73  90.00
 76   4.20  77    .90  79  40.20  82   3.30  85  11.40  90  15.10 101 919.40 122  54.20
123  38.70 136   4.80 139   2.70 149  26.10 166  16.50 168   3.40 180 190.00 184  96.40
195   5.60 201 1073.40 203   1.20 223  38.70 225   8.60 226 3077.50 229 137.90 234  23.60
235 3488.80 238   1.60 244  47.80 245  77.60 246   4.20 247   2.20 255    .60 256  39.50
259  21.20 260   2.00 262 350.80 264    .30 265  39.40 267   2.70 268   3.50 275 1349.80
282   5.90 297   8,60 307   2.50 326 314.00 330 1734.70 332  33.90 346  34.60
 St.37  2 108.20  11   4.20  20    .50  21   6.60  29 341.70  34    .50  37  16.50  41   7.00
 45  20.40  54 149.80  60 345.80  71 114.00  73  42.00  79   6.70  95 102.60  98   9.20
104 151.20 105 100.20 113   1.60 120  11.10 122  15.30 130  15.20 131  43.20 135   7.20
141   2.40 144 134.40 166   4.50 180 769.60 191  45.00 195 297.30 200   1.80 203    .60
209  14.50 223  56.00 224  40.80 225  17.20 226 186.70 228 255.00 234  79.20 238   3.20
245  19.40 249  82.40 255   1.20 257  61.30 260    .50 264   1.20 267   6.30 274 1675.90
282   5.50 285 101.20 291    .60 294   1.20 297   3.40 298    .30 305   2.80 307   5.50
309    .20 312   9.00 316 913.50 320    .20 329 267.00 331    .20 335  33.30 340 122.10
346  40.60 357 511.60 359 1314.50
 St.38  2 225.30  12    .70  14   5.60  17  17.70  22  12.80  29 273.10  34 138.00  35  12.30
 45   6.80  51    .80  60 163.70  69   5.30  71  22.90  73  12.00  76    .60  79  20.10
 84   1.40  91 315.80 101  38.40 110   5.40 113   1.60 121 533.70 122  23.60 144  30.80
149   7.20 166  28.50 180 126.60 183 4231.90 189   3.80 195   2.60 201   2.20 225  25.80
229 226.00 234 325.60 238   1.60 255   1.60 256  18.00 260    .50 267  23.40 268   1.40
274 139.70 282    .10 285   1.40 307   1.20 310   1.60 312   1.40 320    .20 326  78.50
329 291.50 331   1.20 335   4.50 337   1.00 346 197.20 357  55.80 362 5985.00
 St.39  219823.70  11  11.20  12   3.50  14   7.00  22  51.20  23   5.00  25 5973.80  29 173.40
 30   4.20  33   1.50  35  65.60  54  11.70 5913862.10  60 256.60  63 1931.90  64 412.20
 69  94.40  71 323.00  73   2.50  77   5.40  79 100.50  82   7.20  94 104.20 101  55.80
109    .10 111   4.80 122  15.30 123 1471.60 127  21.60 130   7.60 136   5.60 139 107.30
149  28.80 159  10.00 169   3.40 170 4060.90 176   1.50 180 192.40 183 442.30 195 318.10
201 577.50 209   2.70 220 483.10 221 4245.80 225  31.20 226 164.30 229 113.40 234  13.20
235 3836.80 246   2.80 256   1.00 260   2.50 265  18.90 268   2.10 274  36.00 277   1.50
282   1.80 283    .60 291   1.20 292   1.00 326 184.00 346 485.30 351 373.20
 St.40  2 9223.40  11 161.00  12  99.60  13   2.20  14  32.20  18    .50  22  38.40  23  16.00
 25 7949.00  29 118.00  33    .50  35 106.60  54 100.70 5923208.20  60 191.80  63 2082.00
 69 794.70  71 164.10  73   1.50  77  10.80  79 174.20  83  76.00 101 549.10 103   1.00
130  30.40 136   1.60 139   6.00 149  52.20 165 178.00 180 563.60 183 4886.10 190  11.30
195   3.40 198 568.70 201 9265.50 203    .60 215   3.60 221  63.30 225  21.10 226 171.10
228   3.70 235 1129.50 246   8.40 248 212.70 257 681.40 259  73.00 260   4.60 264    .60
265  19.30 268   5.60 274  45.70 282   1.80 304 904.30 307   2.20 326 4014.60 330 1934.30
331    .20 332  54.20 340   1.60 346 640.50 351    .70 360 2634.40 362 1925.50
 St.41  213835.30  11   7.00  12  11.20  13   2.20  14  15.40  18    .50  23   3.00  29 214.20
 35 155.80  59 3232.70  60  57.60  63 5997.40  69 2706.50  71 569.50  73    .50  79  40.20
 83  27.90 103   1.00 122  45.90 123 755.20 130   7.60 136   3.20 139  27.90 149  31.50
159  30.00 180  96.20 182 1200.00 183 265.00 195   5.20 201 1293.60 209    .90 225  44.50
226 464.50 234  26.40 235 3019.40 246   2.80 257 2227.00 263   9.20 265  12.60 268    .70
```

282 .90 326 496.00 330 1498.40 332 84.40 346 520.80 351 18.90
St.42 2 2034.20 11 5.60 12 7.00 22 25.60 23 4.00 29 112.20 35 4.10 51 .80
54 31.90 60 660.90 69 1325.40 73 2.50 79 60.30 95 17.60 139 3.10 149 8.10
180 96.20 195 6.50 201 1593.90 218 426.90 225 21.50 234 6.60 238 .80 246 4.20
248 64.00 255 2.00 256 7.50 274 108.00 282 .90 292 .50 310 5.10 326 24.00
329 2942.50 335 1.80 346 616.40
St.43 2 171.30 10 52.50 12 2.80 14 71.40 21 4.40 22 32.00 23 11.00 29 61.20
34 3.00 37 1.10 54 61.40 56 1.40 60 409.90 61 29.60 63 181.10 65 5.60
69 9.40 71 46.00 73 30.00 79 6.70 95 51.10 101 9.30 113 1.60 122 45.90
130 7.60 137 2.90 139 3.10 141 .20 149 17.10 159 40.00 166 12.00 172 18.30
176 6.00 180 96.20 183 10.90 184 211.90 191 35.00 195 42.90 197 8.00 200 7.20
201 23.10 203 .60 209 6.30 216 10.00 221 2008.80 222 2.50 224 34.50 225 30.10
228 170.00 229 113.40 234 477.80 245 19.40 247 5.50 248 64.00 252 .30 255 .40
267 1.80 268 .70 269 .50 274 36.00 279 10.00 282 13.50 285 5.40 297 28.90
307 5.50 310 190.60 323 22.30 327 1.80 328 .80 329 18.70 335 2.70 346 81.00
350 1.50 355 36.90 357 180.90 362 174.60
St.44 2 498.50 10 5.00 14 5.60 22 19.20 29 103.50 31 1.20 41 1.40 46 3.60
54 43.10 60 15.50 65 7.00 69 33.90 73 8.50 76 18.60 79 93.80 83 6.90
85 137.40 101 867.40 122 21.40 128 .90 130 7.60 136 .80 141 .20 149 27.00
153 2.50 159 192.90 166 27.00 179 3.50 180 .10 183 68.90 192 31.90 195 4.30
201 1134.90 203 .60 209 14.40 215 1.40 221 783.60 225 21.50 229 833.50 234 78.20
237 .10 246 15.40 247 2.20 248 153.50 256 9.00 267 .90 268 21.00 269 .50
274 249.80 282 8.50 304 2089.00 310 3.30 317 3804.10 318 9.30 326 2582.20 332 2.90
346 25.20 347 1.30 349 1.20 352 157.40 362 237.00
St.45 2 37.60 18 .50 21 8.80 28 72.60 29 20.40 35 12.30 40· 99.00 42 119.60
52 1084.40 54 3.20 56 29.60 60 61.70 65 16.80 69 137.20 71 30.00 73 15.50
113 131.20 122 168.30 125 .70 130 30.40 131 64.80 141 .60 144 22.40 152 1.50
166 4.50 176 29.20 180 529.10 189 55.10 195 23.40 199 3.60 200 239.10 209 14.40
220 428.30 221 3728.40 224 52.50 225 21.50 226 52.20 234 1090.40 244 1.50 251 .30
253 21.00 260 .50 268 1.40 272 64.40 274 936.00 278 1.00 282 2.70 285 70.20
286 94.70 294 1.20 304 142.20 307 33.00 308 .20 310 30.60 312 42.00 320 .40
326 40.00 329 17.20 335 16.20 357 136.80
St.46 2 99.80 14 4.20 22 25.60 23 4.00 34 140.00 41 .70 44 3.40 56 1.40
60 75.80 69 22.90 73 .50 76 .60 78 18.60 100 36.30 101 1492.00 109 .10
122 76.50 125 1.40 128 985.70 130 7.60 149 8.10 150 2.60 159 10.00 165 141.10
166 1.50 184 211.90 195 16.90 200 1.80 221 3030.30 225 4.30 234 290.40 245 19.40
256 3.00 268 7.00 279 6.00 285 2.70 310 15.30 325 3.40 340 89.00 347 1.70
356 1.40 360 3303.00
St.47 2 255.00 16 1.20 19 10.30 22 12.80 26 259.10 29 122.40 30 111.40 33 3.00
34 2.00 35 57.40 41 1.40 43 17.00 50 7.30 54 .90 56 4.80 60 15.20
63 2030.10 65 1.40 67 1.50 69 29.50 72 .50 78 15.40 80 11.80 82 17.20
83 27.90 85 841.00 87 7.30 97 72.40 101 390.60 122 15.30 125 11.90 149 15.30
153 4.00 159 50.00 179 29.80 180 384.80 183 4.30 188 13.30 191 5.00 195 113.10
201 184.80 209 12.60 215 7.70 22124861.20 224 12.00 225 12.90 227 15.20 228 42.50
231 226.80 234 145.20 235 49.50 237 1.10 239 .70 248 192.00 251 .20 258 2.70
261 533.10 268 66.00 291 4.80 294 .60 301 3.40 302 39.50 304 3270.60 307 11.00
310 117.30 311 2030.00 326 88.00 332 42.20 339 1.10 340 162.80 346 9.80 348 1.70
357 52.40
St.48 22 6.40 28 .90 29 10.20 60 5.70 111 1.60 117 88.40 120 44.40 122 15.30
125 4.20 166 1.50 176 1.50 181 21.30 195 11.70 200 1.80 214 1.20 224 1.50
228 42.50 234 85.80 249 228.50 251 .30 256 .50 268 4.90 273 .60 282 .90
285 5.40 305 2.80 310 15.30 312 21.00 320 .50 325 1.70 326 8.00 335 2.70
346 .70 356 2.80 357 .80
St.49 27 12.50 29 5.10 60 3.80 61 1.90 65 2.80 73 .50 118 6.00 122 45.90
125 3.50 138 .10 195 5.20 204 .60 228 127.50 234 142.80 237 3.90 251 7.50
255 12.40 267 .90 268 .70 273 3.80 280 2.80 294 8.40 306 .10 308 .20
309 .20 310 25.50 323 20.40 326 24.00 356 2.80
St.50 10 114.00 12 .70 14 42.00 22 12.80 29 67.10 41 67.00 54 3.70 59 8860.60

60 24.60 69 936.20 71 27.30 73 2.00 76 4.20 79 7.00 83 20.80 97 2.80
118 6.00 122 5.10 136 .80 137 19.50 141 .20 149 1.80 165 28.20 168 1.70
184 137.10 185 3.60 195 442.60 225 12.90 228 2.40 234 72.60 256 1.50 268 7.70
274 132.80 279 3.40 282 13.40 304 5.90 307 37.20 310 70.50 315 7.90 317 3218.60
326 464.40 346 19.00 362 1.40

St.51 2 1312.20 3 607.50 12 6.30 14 85.40 21 2.20 22 153.80 29 5.10 35 12.30
54 13.40 5931694.80 60 19.00 65 1.40 69 59.00 71 1609.30 73 16.00 76 1.80
77 .90 79 6.70 97 .70 101 89.10 118 6.00 132 5.10 136 5.60 139 21.70
145 5.60 149 18.00 159 10.00 166 3.00 195 2.60 201 23.10 209 1.80 229 226.80
235 1403.60 246 1.40 248 448.00 256 2.00 265 6.30 267 .90 270 11.00 297 3.40
303 1.80 330 1699.50 346 8.40 360 3370.40 362 523.80

St.52 2 253.40 14 4.20 17 15.10 23 3.00 29 91.80 35 12.30 43 3.40 55 25.00
5919018.50 60 250.60 6312259.90 65 4.20 69 135.70 71 1409.60 77 .90 79 53.60
82 3.30 94 521.00 112 1.60 118 6.00 122 15.30 123 755.20 128 1020.90 131 3.60
136 .80 139 55.00 140 5.10 149 33.30 180 144.30 195 12.10 200 1.80 201 392.70
203 1.20 209 3.60 225 30.10 235 1454.90 238 .80 250 188.30 256 5.50 257 310.20
260 .50 268 6.30 274 36.00 282 16.20 294 .30 297 1.70 304 284.40 307 11.00
326 8.00 330 1029.50 346 113.90 357 4911.10

St.53 2 146.90 11 21.00 12 1.40 14 203.60 22 12.80 29 275.40 35 4.10 54 303.30
59 15.90 60 20.90 6312854.60 65 1.40 69 17.70 71 11.10 73 13.00 77 .90
79 221.10 89 1260.80 90 15.40 103 1.00 128 314.30 130 7.60 136 2.40 139 6.20
141 2.00 149 12.60 166 3.00 180 721.50 184 2330.90 185 4.90 201 323.40 209 7.20
220 74.70 225 17.20 227 152.30 252 .60 257 29.70 267 1.80 274 716.30 282 3.60
297 1.70 305 2.80 307 5.50 326 208.00 329 1318.20 332 84.40 335 .90 346 25.90
362 1047.60

St.54 2 3816.40 11 19.60 12 4.90 14 137.20 18 .50 22 6.40 23 1.00 29 428.40
35 420.10 41 2.10 54 358.40 59 7.10 60 100.70 65 7.00 69 2768.00 71 185.00
73 1.50 79 67.00 90 46.20 101 9.30 105 33.40 122 15.30 130 30.40 136 5.60
139 3.10 149 3.60 176 6.00 180 336.70 195 22.10 200 14.40 201 300.30 209 .90
218 853.80 234 66.00 235 1566.70 249 41.80 258 1.10 260 .50 267 2.70 268 7.70
274 36.00 282 9.90 297 6.80 307 33.00 326 16.00 332 84.40 335 .90 346 14.00
352 1803.30 360 2614.80

St.55 2 212.90 11 16.80 12 10.50 14 64.40 18 .50 22 9.50 23 1.00 29 81.00
35 49.20 55 2.10 5956209.70 60 7.10 61 1.00 63 2378.40 65 8.40 69 67.80
71 2258.80 73 2.00 79 335.00 85 .40 103 3.00 104 .60 130 15.20 136 2.40
141 .40 148 15.40 149 9.00 166 1.50 180 2.00 183 245.80 184 115.90 201 8521.10
203 .60 209 .90 220 89.00 221 132.80 225 8.60 226 396.90 235 324.50 246 4.20
260 2.00 274 727.20 282 25.60 297 3.10 304 3.20 307 1.70 316 11.60 326 1305.10
332 144.50 335 .90 337 .50 346 33.20

St.56 2 79.60 13 3.30 23 2.00 29 15.30 35 4.10 5910155.40 60 20.90 69 208.20
73 .50 79 211.40 122 61.20 146 2.10 149 57.60 161 483.70 180 96.20 201 462.00
209 .90 225 17.20 227 15.20 234 6.60 235 308.50 244 1.50 248 64.00 259 23.60
262 1.80 268 .70 274 72.00 288 152.60 291 .60 326 8.00 332 42.20 346 11.90
351 9.10

St.57 2 5080.80 13 55.00 22 25.60 23 5.00 35 8.20 43 3.40 5911711.50 60 34.20
73 3.50 77 .90 131 3.60 139 3.10 149 18.90 195 3.90 201 369.60 225 4.30
229 1070.80 256 1.50 291 .60 333 .10 346 16.80 351 35.70

St.58 2 20.20 5 3.60 13 4.40 14 2.80 30 6.00 33 2.00 35 4.10 43 6.80
55 3.00 60 9.50 79 6.70 82 3.30 85 5008.00 97 1.40 109 .10 130 7.60
149 14.40 170 4060.90 199 1.80 206 1.80 229 266.30 268 14.00 276 41.50 297 1.70
335 .90 339 1.30 346 1.40 351 47.60

St.59 2 546.40 12 2.80 13 4.40 14 142.80 22 6.40 29 397.80 35 4.10 5919877.10
60 95.00 63 6098.30 69 4587.70 71 1718.20 73 7.00 79 194.30 83 27.90 90 30.80
105 33.40 136 1.60 139 12.40 141 .20 149 14.40 166 9.00 180 384.80 195 3.90
201 300.30 203 .60 209 1.80 225 38.70 234 13.20 256 1.00 267 .90 268 2.10
274 360.00 282 10.80 285 2.70 297 13.60 307 11.00 316 188.60 326 8.00 335 4.50
346 11.20 357 38.90 360 3503.90 362 174.60

St.60 2 427.70 7 10.70 11 5.60 12 2.80 14 201.40 23 7.00 25 1881.20 29 428.40

35 69.70 54 534.20 5913915.80 60 441.80 63 4651.10 69 112.10 70 13.20 71 1231.10
73 39.50 77 3.60 79 154.10 90 30.80 94 104.20 101 37.20 105 66.80 113 1.60
130 7.60 136 7.20 139 386.10 141 .80 149 51.30 159 180.70 180 432.90 184 211.90
195 32.00 198 390.40 201 508.20 203 7.20 209 6.30 218 426.90 225 43.00 227 60.80
229 226.80 246 4.20 255 1.60 256 .50 260 2.50 267 .90 268 5.60 274 689.80
282 2.70 297 3.40 307 44.00 31710405.50 326 2128.00 332 126.60 335 1.80 346 903.20
St.61 2 164.50 13 189.60 23 2.00 59 3278.70 60 9.70 69 662.20 73 .50 79 6.70
122 15.30 149 1.80 194 651.10 201 1042.30 225 21.50 238 4.00 256 .50 282 .90
346 76.40
St.62 2 67.60 14 2.80 31 .60 85 2881.80 180 1.10 201 6.00 227 15.20 229 3.40
St.63 2 3386.70 11 2.80 14 16.80 22 6.40 23 1.00 29 61.20 35 82.00 5931244.10
60 41.80 63 2691.50 65 1.40 69 2157.50 71 5823.10 73 3.50 79 67.00 130 7.60
136 8.80 137 4.00 139 40.30 180 144.30 201 207.90 209 1.80 223 7.00 229 113.40
235 884.50 238 7.20 256 1.50 268 2.10 274 108.00 282 46.80 297 20.40 316 188.60
320 .10 326 264.00 332 84.40 346 53.90 360 446.50
St.64 2 429.70 12 .70 14 74.20 15 493.20 17 12.50 22 6.40 23 3.00 29 128.30
33 .50 59 7835.10 60 10.70 63 77.20 65 2.80 69 1018.20 71 855.00 73 7.50
76 1.20 78 8.70 79 107.20 85 .60 90 25.20 130 7.60 136 6.40 139 18.50
149 16.20 159 7.30 180 193.20 183 153.50 184 202.30 201 102.30 203 .60 220 101.30
225 25.80 227 10.80 255 .80 257 118.30 268 3.50 274 43.60 282 63.80 304 296.60
31710730.30 326 1259.00 328 .40 332 180.20 346 27.30 360 1733.90 362 .30
St.65 13 23.10 23 1.00 31 .60 60 1.90 69 11.40 78 378.30 85 420.50 122 15.30
149 1.80 200 1.80 201 23.10 225 4.30 229 340.20 238 7.20 346 2.80
St.66 2 75.80 13 1.10 14 49.00 22 12.80 25 92.70 29 54.50 33 .50 35 4.10
43 3.40 5911325.40 60 52.40 63 22.20 65 9.80 69 821.20 71 498.30 73 2.50
77 .90 79 201.00 90 2.90 105 37.80 130 7.60 137 317.50 139 16.90 140 30.60
141 .20 148 15.10 149 14.40 166 3.00 180 40.90 185 2.20 195 1.40 201 167.00
209 .90 220 73.00 223 2.80 225 4.30 234 .70 256 .50 260 .50 267 .90
274 387.50 282 6.40 285 .40 297 21.70 307 .30 326 780.60 332 64.90 335 1.80
346 53.70 355 .70 362 .60
St.67 23 1.00 27 12.50 118 6.00 122 15.30 125 11.90 175 997.20 228 127.50 245 29.10
251 .10 255 5.20 267 1.80 273 .60 294 .30 306 .60 308 .60 310 154.40
335 .10 346 1.40
St.68 2 12.90 22 6.40 68 208.80 78 164.70 104 16.80 251 .10 345 32.90
St.69 2 136.40 14 4.20 29 25.50 41 .70 63 1178.60 69 285.70 76 4.20 82 3.30
87 22.60 101 18.60 118 12.00 122 30.60 137 1.10 139 15.50 141 .20 149 1.80
183 4074.90 194 651.10 195 14.30 201 138.60 223 7.00 229 453.60 234 397.60 247 4.40
249 1087.20 256 .50 268 2.10 274 36.00 283 .30 297 5.10 307 11.00 310 10.20
326 216.00 346 5.60 360 777.30 362 698.40
St.70 2 1252.20 9 144.40 14 23.80 22 6.40 23 11.00 29 188.70 34 2.00 35 4.10
54 .50 5928317.30 60 389.40 61 3.10 69 41.30 71 8.20 73 2.00 76 .60
79 33.50 90 15.40 101 18.60 103 1.00 122 45.90 128 694.90 131 3.60 136 .80
137 62.60 139 3.10 148 24.10 149 16.20 159 10.00 166 4.50 168 1.70 179 3.60
180 288.60 184 847.60 195 26.00 201 1402.40 203 .60 221 1943.90 225 34.40 227 30.40
229 113.40 234 19.80 235 2227.00 238 7.20 246 5.60 247 3.30 256 1.00 260 .50
265 6.30 274 144.00 279 2.00 282 2.70 291 1.80 292 .50 307 88.00 310 35.70
326 1888.00 329 2854.90 330 703.00 337 .50 345 1.60 346 739.20 353 2608.00 360 2128.90
St.71 11 1.40 14 14.00 23 2.00 27 50.00 29 56.10 43 17.00 54 1.60 60 80.00
69 243.20 73 3.50 76 1.80 77 1.80 78 14.00 79 120.60 82 3.30 103 1.00
105 33.40 122 91.80 125 .70 132 10.20 137 .80 149 7.20 159 238.10 167 1.50
180 144.30 195 5.20 200 1.80 201 23.10 209 1.80 224 6.00 228 42.50 234 495.10
257 130.30 262 809.00 265 12.60 268 4.20 274 209.80 282 13.30 285 10.80 297 8.50
307 5.50 326 520.00 332 42.20 335 2.70 346 26.60 362 1920.60
St.72 2 209.20 12 2.80 14 30.80 22 6.40 23 12.30 29 14.90 35 8.20 47 2878.90
59 5307.10 60 48.70 63 709.80 65 1.40 69 678.60 71 4151.30 73 4.50 79 207.70
114 1.60 122 3.10 136 11.50 137 73.30 139 28.70 140 10.20 149 30.60 159 15.90
161 1.00 180 656.70 195 7.00 196 8.70 198 1364.90 201 161.60 220 36.30 225 103.50
229 9.40 235 437.70 238 2.90 246 8.40 250 247.80 255 1.50 256 .50 271 55.50

274 .90 282 11.60 297 2.50 326 261.90 346 377.40 353 1796.50

St.73 2 .60 12 .70 14 1.40 60 1.90 78 35.30 85 420.50 114 1.60 136 1.60
149 .90 170 62.70 268 .70 326 16.00 351 11.90

St.74 11 1.40 14 4.20 23 5.00 25 5973.80 29 44.20 51 1.60 60 232.10 69 2121.10
71 55.80 73 .50 79 113.90 90 133.60 103 1.00 122 30.80 137 41.80 139 15.60
149 31.50 180 30.20 184 165.70 194 1742.00 197 1.60 201 2115.70 218 826.90 220 303.80
225 12.90 255 .70 260 .50 267 .90 274 24.60 282 3.20 326 347.80 346 154.10
362 93.20

St.75 2 199.50 12 .70 14 7.00 23 9.20 25 4337.70 27 1166.00 29 20.40 35 4.10
51 1.60 60 48.10 61 51.50 69 662.40 73 1.00 79 100.50 83 55.80 101 155.00
104 16.80 114 3.20 122 91.80 133 5.10 136 1.60 137 3.00 139 6.20 149 9.00
159 10.00 180 147.30 198 390.40 201 1062.60 220 56.80 221 1246.20 225 17.20 255 3.20
266 1.80 267 8.10 274 144.00 282 .90 311 1563.90 317 876.60 326 80.00 335 .90
340 5.10 346 32.70 351 .70 353 1745.60 357 3471.60 362 349.20

St.76 2 .40 12 .70 14 23.80 23 4.00 29 26.10 60 36.20 63 86.50 65 1.40
69 1834.30 71 674.90 73 .50 76 .60 79 147.40 90 18.20 118 12.00 122 9.40
136 .80 137 144.50 139 25.70 140 15.30 149 11.70 159 .10 180 5.00 195 3.60
201 4095.30 220 80.60 225 21.50 244 3.00 255 .10 256 1.00 267 1.80 282 .20
297 2.20 307 7.70 326 15.40 346 114.40 353 384.10 358 145.00 362 .10

St.77 2 224.80 11 2.80 12 2.10 14 35.00 23 6.00 25 31.10 29 260.10 33 .50
35 4.10 46 .90 5927494.80 60 112.30 63 1683.60 65 2.80 69 1244.80 71 5392.90
73 3.00 77 2.70 79 308.20 82 3.30 97 1.40 114 3.20 123 1510.40 136 3.20
137 38.00 139 46.50 141 1.60 147 30.80 148 15.40 149 27.90 159 264.40 179 1.30
180 192.40 184 1695.20 201 207.90 209 .90 218 426.90 220 83.70 223 7.00 225 17.20
229 226.80 255 .80 257 3996.90 262 11.60 267 1.80 268 4.90 271 27.80 274 771.80
282 7.20 291 .60 297 1.70 304 711.00 305 5.60 320 .10 326 5752.00 332 42.20
335 1.80 346 309.40 353 2033.20 362 1396.80

St.78 23 4.00 55 .10 60 .60 65 1.40 69 125.20 78 21.00 79 6.70 139 .70
149 .90 192 2.10 201 2.90 238 7.20 326 33.30 346 6.10 351 .70

St.79 11 1.40 14 8.40 22 25.60 23 7.00 25 8416.20 29 132.60 30 1.80 46 .90
56 1.40 5914849.20 60 58.90 6312111.40 65 5.60 69 779.00 71 2063.90 73 2.50
77 1.80 79 402.00 82 3.30 83 27.90 97 1.40 101 46.50 122 61.20 128 3125.20
129 5.10 136 1.60 137 11.50 139 37.20 140 5.10 141 .20 149 19.80 159 631.50
166 1.50 173 77.90 180 962.00 18416104.40 198 390.40 201 138.60 209 13.60 210 2198.10
220 243.50 225 4.30 226 90.60 234 6.60 251 .20 257 2519.50 260 .50 264 .60
268 23.10 274 1515.50 282 40.50 297 11.90 304 1279.80 309 .60 317 2755.00 326 2048.00
332 42.20 335 .90 346 93.80 351 .70 353 1930.20 362 3841.20

St.80 2 233.00 3 24.90 11 8.40 12 2.80 13 2.20 14 54.60 23 1.00 27 12.50
29 115.30 51 2.40 5929582.60 60 27.20 6310040.40 65 1.40 69 2369.00 71 5761.20
73 18.50 76 .60 79 140.70 83 101.10 87 22.60 130 7.60 136 14.40 139 9.60
149 23.40 159 9.00 180 17.80 194 565.40 201 322.00 209 4.50 225 4.30 229 3.00
238 1.60 257 166.30 268 1.40 282 11.60 297 12.00 326 224.40 346 33.30

St.81 14 1.40 18 .50 20 .50 22 6.40 23 4.00 25 4977.90 29 56.10 43 23.80
46 .90 56 2.10 60 442.20 69 64.90 71 79.20 73 120.00 77 30.60 79 6.70
82 13.20 85 420.50 93 9.50 98 35.30 113 16.00 118 6.00 122 107.10 125 4.90
130 15.20 139 34.10 149 11.70 159 50.00 165 282.20 166 63.30 168 3.40 180 336.70
18411579.00 196 13.10 209 72.10 220 597.30 224 42.90 228 170.00 234 1054.30 239 4.70
262 112.90 267 14.40 268 2.10 274 72.00 282 161.10 285 213.30 294 .60 297 42.50
305 11.20 309 .20 310 30.60 320 2.30 326 80.00 331 .40 335 66.60 337 1.00
354 1.40 361 7496.30

St.82 2 1174.90 10 2.50 17 15.10 29 102.00 54 76.10 56 .70 61 .30 63 17.20
69 23.60 71 865.10 73 .50 79 20.10 82 3.30 90 15.40 122 118.10 137 229.70
139 46.50 140 35.70 180 192.40 184 1271.40 195 20.80 200 7.20 201 23.10 220 59.10
225 4.30 226 33.80 234 13.20 238 4.00 239 1.40 267 .90 268 1.40 282 1.80
307 179.10 310 5.10 326 4144.00 335 6.30 346 91.70 353 2064.80

St.83 2 115.90 9 291.70 21 13.20 22 6.40 23 2.00 29 86.70 35 155.80 45 3.40
54 180.30 60 119.70 65 8.40 69 11.80 71 270.30 73 8.50 101 46.50 104 33.60
105 66.80 111 1.60 113 3.20 120 22.20 122 15.30 130 7.60 132 10.20 136 7.20

```
137   3.60 166   4.50 176   12.00 177 1469.50 180  992.60 184  635.70 195   76.70 198  390.40
209   3.60 220  41.60 221 2302.30 223  98.00 224  24.00 225   8.60 227  52.00 228  85.00
234  983.50 235 1317.20 245  19.40 246   1.40 257  125.50 267    .90 282  13.50 285  553.40
291    .60 292   1.00 297  13.60 305   5.60 307  242.00 310   5.10 317  937.60 326  120.00
330 4209.70 332  211.00 335  24.30 346  57.40 355    .70
 St.84  2  583.30  10  10.00  14  16.80  23  10.00  29   2.40  34  19.00  35   4.10  43   3.40
 5947605.40  60  12.80  69  49.20  70  69.90  73  10.50  76  182.70  87  64.10 101  831.70
 122  35.70 136   2.40 137   2.80 139   6.00 149  25.20 159   3.20 165  558.80 166   6.00
 178   7.50 183 7169.60 195  24.90 201  208.70 221 2903.00 223   7.30 225   4.30 229  395.70
 234  123.70 245  38.80 246   8.40 247   1.10 256   2.50 267    .90 268   2.80 279   2.00
 290  47.90 307  48.60 310   6.70 311 1517.60 326 1815.70 337   1.00 342  323.90 346  20.10
 360 5549.20 362 1222.00
 St.85  2  519.50   3  24.20  11   4.20  14  36.40  23  14.00  29  163.20  34   6.00  35   8.20
 5923946.80  60  186.70  61   1.50  69  185.30  71  113.10  73  22.50  76  24.60  79   6.70
 87   8.10  90  46.20 104  50.40 122  15.30 136    .80 139   9.30 159  30.00 178   1.20
 180  48.10 18313802.90 195   2.60 201  392.70 209    .90 221 4315.90 223   7.00 224   3.00
 225   8.40 227  60.80 229  226.80 234  198.00 238    .80 256   1.50 259  23.60 268   4.20
 277   1.50 307  33.00 310   5.10 311  559.40 31735845.60 326  800.00 346  454.60 360 2048.10
 362 2619.00
  St.86  2  113.30  14   2.80  60  19.00  68   6.60  69   5.90  71  121.20  98  25.80 107   1.30
 122  45.90 125   2.10 195   1.30 224   3.00 228  127.50 234  13.20 238    .80 245  19.40
 251    .10 282    .90 285   2.70 294   1.20 307   5.50 310  508.30 31710095.90 346   7.70
  St.87  2  441.20  29  459.00  60  22.00  69  811.00  71  704.50  73    .50 104  16.80 122  36.00
 137  153.10 139  27.90 140  15.30 167   4.50 180  144.30 195  13.00 200   1.80 225   4.30
 234   6.60 238  46.40 255   2.00 282   2.70 297   3.40 307  403.90 310  107.10 317 2125.20
 326  600.00 335    .90 346  332.90 353 4923.80
 St.88  14   4.20  23   2.00  29  20.40  54  611.30  60  87.40  61  16.80  69  938.10  71    .20
 73    .50  78  67.80  79  87.10 122  15.30 133   5.10 137  75.10 139  37.20 149    .90
 159  110.00 178    .30 200   1.80 201 1085.70 225  21.50 255   1.20 282    .90 312   3.00
 326  96.00 346  30.10 351   8.40 353 2046.30 362 1396.80
 St.89   2  21.00  14   8.40  23  22.20  25 1616.10  29  10.20  31    .60  35   4.10  43   3.40
 51    .80  60  64.60  61  24.70  69  727.30  71   4.20  73   1.00  76   1.80  79  13.40
 83  83.70  85  420.50 103   1.00 122  76.50 136    .80 139   3.10 149   6.30 159  60.00
 170  10.20 184  423.80 200   3.60 201 4897.20 209    .90 225   4.30 229  113.40 250  159.10
 268   3.50 297   1.70 309    .40 326  24.00 346   2.80 351   4.90
  St.90   2  46.60  23   1.00  61   3.30  69  106.20  71  24.40  78  154.50  79   6.70  85  420.50
 116   1.60 122  15.30 123  755.20 139   3.10 159  194.00 200   1.80 201 1617.00 229  226.80
 257  68.80 326  16.00
  St.91 14   1.40  22  68.90  23  11.00  27  58.00  29  188.70  30   1.80  33   1.00  41    .70
  55   1.50  56   7.00  59 8504.60  60  80.10  61   4.70  69  248.20  71  294.20  73   5.50
  79  348.40  82  19.80  83  27.90 104  16.80 122  107.10 139   6.20 141    .20 149  81.00
 159  314.60 180  144.30 184 2119.00 195   1.30 201  92.40 209  17.10 220  93.00 223   7.00
 225  12.90 234  19.80 255   2.00 256   2.50 260   1.00 268  30.10 274  392.60 289  51.10
 297   1.70 310  10.20 317 1660.20 326 1560.00 335   1.80 346  76.40 351   2.80 362  698.40
  St.92 22   6.40  29   5.10  55   1.50  60   3.80  79  13.40  97    .70 139   3.10 192   3.60
 209    .90 229  113.40 238   3.20 268   1.40 326  32.00 346   1.40
  St.93  55 3922.20 160  14.70 192  10.80 229  113.40 238  39.80 309    .20 326  16.00
  St.94  13   1.10  23   3.00  57  253.10  59 3693.30  60  32.30  63 2648.60  65   1.40  69  332.00
  71  38.00  73   1.00  83  55.80  85  420.50 122  15.30 149    .90 159  91.40 178  40.70
 195   1.30 200   1.80 201  69.30 209    .90 225   8.60 229  226.80 238    .80 246   1.40
 274  132.80 282    .90 309    .40 311 2019.00 346   2.80 362 1047.60
  St.96 22  12.80  23   1.00  55   1.50  56    .70  60  60.80  61  108.70  69  23.60  73   1.50
 114   1.60 118   6.00 122  137.70 125   2.10 141    .60 149    .90 165  141.10 166  36.00
 168  10.30 184  211.90 195   2.60 198  390.40 209   1.80 225   4.30 228  212.50 238   5.60
 246  15.40 251   2.40 256    .50 267  27.90 268    .70 277   1.50 282   4.50 285   8.10
 294    .30 310 1711.50 320    .10 326   8.00 335   9.00 340   4.30 345  121.20 362  174.60
  St.97 14   1.40  18   2.50  22   6.40  23  10.00  29  15.30  35  16.40  41    .70  51    .80
  54  365.40  56  16.80  60  60.80  65  21.20  69  960.90  71  104.10  73  157.50  77  663.00
```

79 174.20 103 1.00 104 16.80 122 15.30 129 25.50 141 1.00 149 31.50 159 40.00
165 933.80 166 1.50 180 817.70 18417137.20 187 1.00 198 390.40 201 23.10 203 .60
220 205.70 224 28.50 225 30.10 235 598.90 246 5.60 256 10.50 257 465.90 260 1.00
268 9.10 274 288.00 279 2.00 282 4.50 285 5.40 286 101.60 297 10.20 305 5.60
310 445.90 320 .40 326 48.00 335 5.40 346 6.30

St.98 14 2.80 23 5.00 29 260.10 43 3.40 54 205.70 56 1.40 60 246.00 63 6984.40
65 11.20 69 171.10 71 530.40 73 4.50 74 18.40 77 37.80 79 328.30 97 2.10
101 18.60 113 6.40 122 45.90 130 30.40 137 43.50 141 .20 149 4.50 159 341.50
166 1.50 171 100.60 180 432.90 18412925.90 195 1.30 209 6.30 220 57.00 225 4.30
234 13.20 246 1.40 255 .80 257 78.20 268 .70 274 393.50 282 2.70 309 .20
311 900.60 317 5349.50 326 448.00 335 .90 346 483.80 353 3578.90 362 1047.60

St.99 2 121.50 14 2.80 23 1.00 29 25.50 60 3.80 69 924.80 73 1.00 76 .60
122 30.60 125 .70 137 2.40 149 .90 159 20.00 195 2.60 200 5.40 220 35.20
229 113.40 234 52.80 245 19.40 249 154.60 274 36.00 282 .90 285 8.10 297 6.80
307 22.00 310 163.20 326 1920.00 346 1.40 362 1571.40

St.100 2 375.00 14 2.80 22 6.40 29 165.80 35 155.80 43 3.40 54 149.60 60 35.20
63 2045.20 65 8.40 69 2164.80 71 383.90 73 3.00 79 6.70 104 67.00 122 .50
129 10.20 131 7.20 136 .80 137 48.60 139 8.20 149 3.60 166 1.50 180 31.10
184 1802.50 195 22.80 200 1.80 201 69.40 210 2513.80 215 .90 217 241.40 220 199.60
225 3.20 234 70.20 235 658.90 249 83.50 251 .10 255 .10 257 147.50 282 1.20
307 401.70 310 1.30 311 1236.90 31719959.00 323 22.30 326 5054.00 332 183.50 346 21.70
353 975.90 362 5.20

St.101 2 432.40 14 1.40 20 .50 21 13.20 23 2.00 29 31.50 35 770.80 43 3.40
54 30.70 60 283.10 61 2.30 63 44.60 65 12.60 69 64.90 73 27.50 90 15.40
105 33.40 113 3.20 118 4.00 122 15.30 133 10.20 136 8.00 137 63.00 139 19.60
149 7.20 159 301.00 166 1.50 176 1.50 177 248.60 180 481.00 195 69.00 200 3.60
201 23.10 203 1.80 209 .90 215 1.00 223 7.00 225 17.20 228 42.50 234 39.80
235 2322.90 238 16.80 246 1.40 255 .40 256 1.00 261 533.10 282 3.60 297 11.90
305 2.80 307 396.00 309 .20 314 1.40 320 .40 326 376.00 332 42.20 346 193.00
358 4.30 362 349.20

St.102 3 956.10 14 1.40 43 3.40 63 4060.20 69 110.90 73 1.50 136 14.40 137 2.20
139 10.20 149 1.80 229 126.10 256 1.00 326 11.30 349 .60 351 .70 362 7.40

St.103 2 3.60 11 2.80 14 21.00 20 .50 29 61.20 35 20.50 43 6.80 65 7.00
69 1570.70 71 188.90 73 4.50 79 46.90 101 27.90 122 30.60 130 7.60 139 93.00
149 4.50 164 387.80 176 4.50 180 192.40 184 211.90 195 2.60 209 9.90 225 12.90
234 19.80 256 .50 262 960.50 268 .70 307 181.50 310 15.30 317 1461.10 326 136.00
335 .90 346 83.30

St.104 38 61.10 69 33.40 78 181.20 125 .10 195 1.20 228 169.40 234 4.30 251 .30
294 .20 310 1312.70 311 2034.90

St.105 14 1.40 23 4.00 26 18.30 29 525.30 31 1.80 41 .70 54 59.10 56 1.40
5913751.30 60 76.00 65 18.20 69 1234.10 71 2275.40 73 2.50 77 5.40 79 201.00
83 27.90 97 .70 113 3.20 139 12.40 149 14.40 159 350.00 177 769.10 180 432.90
184 2330.90 198 390.40 201 23.10 209 27.90 218 426.90 224 6.00 225 8.60 226 67.00
229 113.40 235 415.70 255 1.20 257 1294.30 268 1.40 274 335.10 282 17.10 285 5.40
294 .60 297 10.20 305 8.40 309 .40 310 25.50 311 3067.10 317 5493.30 326 260.40
332 42.20 346 24.50 362 174.60

St.106 10 5.00 34 4.10 51 1.60 60 3.80 61 3.10 69 23.60 122 122.40 125 1.40
228 297.50 245 9.70 251 3.00 254 .30 267 .90 294 1.20 310 1762.00 317 305.20
327 .90 345 861.70 351 6.30

St.107 3 34.70 13 2.20 23 1.00 29 10.20 31 .60 59 10.50 61 3.50 69 11.80
73 1.00 76 .60 77 6.30 85 841.00 130 7.60 141 .20 159 50.00 200 5.40
229 1842.50 310 38.30 326 16.00 333 .40 351 4.20

St.108 29 91.80 51 1.60 60 9.50 69 614.70 79 6.70 122 61.20 137 8.70 140 5.10
159 10.00 166 3.00 195 10.40 200 12.60 222 2.50 234 219.20 245 77.60 251 .20
282 1.80 307 38.50 310 252.80 311 4570.40 326 600.00 327 .90 346 7.00 362 174.60

St.109 2 17.20 9 156.50 29 193.80 60 24.70 69 507.50 85 420.50 137 147.70 139 12.40
140 25.50 149 1.80 166 1.50 167 4.50 195 13.00 220 12.70 222 2.50 225 4.30
234 72.60 238 1.60 245 29.10 255 2.40 282 .90 287 120.90 307 115.50 310 51.00

311 7014.20 326 184.00 346 112.60 353 3850.20 362 1571.40
St.110 2 .40 9 108.20 14 1.40 29 42.70 60 8.80 61 22.80 63 1846.20 65 4.20
69 2422.80 73 1.50 76 3.00 77 2.70 90 9.30 104 103.20 137 38.60 167 3.00
184 435.10 195 1.30 196 5.60 201 7.10 220 101.30 223 7.30 234 334.60 249 74.90
274 61.30 282 .40 297 1.00 307 150.50 310 21.80 326 135.40 335 .90 346 8.50
362 .80
St.111 2 145.20 3 23.60 9 108.30 10 2.50 11 1.40 14 25.20 21 2.20 23 7.00
29 76.50 42 59.80 43 6.80 5922018.40 60 17.10 61 28.10 63 4515.30 69 362.50
73 13.50 76 49.20 77 1.80 83 27.90 85 420.50 90 46.20 101 46.50 104 16.80
122 308.30 136 .80 137 27.10 139 34.10 140 5.10 149 7.20 159 20.00 166 6.00
178 5.70 196 26.10 201 53.30 225 12.90 227 15.20 234 446.70 235 2.40 255 .80
268 2.10 274 36.00 297 1.70 307 33.00 310 40.80 31713377.40 326 584.00 346 42.70
353 1016.30 362 1920.60
St.112 2 3.70 14 8.40 25 2334.40 29 41.90 59 6503.10 60 11.20 61 8.50 63 3719.60
65 1.40 69 1957.80 71 1.80 73 .50 76 1.20 79 6.70 90 4.10 122 1.30
139 14.10 149 1.80 196 9.90 201 4.50 234 40.20 274 524.60 307 55.10 310 19.10
311 4046.00 31718243.10 326 1938.20 346 .80 362 828.50
St.113 2 98.80 11 1.40 14 7.00 23 1.00 29 357.00 35 8.20 43 3.40 60 7.60
63 2410.80 65 1.40 69 2061.00 71 374.80 73 1.50 90 46.20 104 16.80 133 10.20
137 36.50 140 10.20 149 1.80 201 23.10 220 115.90 229 113.40 255 1.20 270 11.00
274 36.00 277 1.50 282 .90 285 2.70 307 242.00 310 15.30 326 4896.00 346 11.20
353 2248.70 362 635.40
St.114 2 379.70 29 15.00 60 8.20 69 185.60 71 83.50 90 66.60 137 .70 139 8.00
140 10.20 164 431.40 184 593.20 229 77.40 234 18.60 307 46.90 310 2.30 311 485.50
323 22.30 326 1137.40 346 .30 353 2787.50 362 2547.20
St.115 60 1.90 69 5.90 78 365.60 118 6.00 122 15.30 125 1.40 228 127.50 238 .80
251 1.10 273 .20 282 .90 306 .40 310 445.20 345 28.00
St.116 14 2.80 23 3.00 2518309.60 29 10.20 60 53.20 61 463.10 69 492.00 71 .90
73 1.00 74 7.90 76 .60 77 .90 78 186.60 79 46.90 122 15.30 137 .30
139 6.20 149 .90 159 10.00 184 211.90 229 453.60 245 9.70 255 .40 257 32.80
267 .90 326 16.00 333 .60 362 523.80
St.117 31 .60 60 3.80 69 17.70 77 3.60 97 4.20 199 1.80 229 143.30 268 .70
326 16.00 362 174.60
St.118 51 .80 61 50.00 69 378.00 71 92.10 78 246.10 137 125.10 140 10.20 333 .10
346 21.70 353 385.70 362 523.80
St.119 29 10.20 60 3.80 61 4.80 68 6.60 69 109.80 73 .50 78 1089.50 97 .70
120 18.70 122 45.80 166 1.50 180 48.10 200 3.60 209 .90 234 13.20 251 .30
285 5.40 300 2.70 310 43.20 311 2914.90 323 22.30 326 48.00 327 .90 345 116.20
St.121 69 91.20 71 2.60 125 .10 139 5.50 229 1.90 310 138.20
St.122 9 162.20 14 1.40 29 102.00 54 258.70 59 6698.20 60 50.10 63 597.90 65 4.20
69 70.80 71 12.00 73 1.00 76 3.00 132 5.10 137 131.40 139 102.30 140 15.30
159 55.00 166 12.00 180 96.20 202 2.40 209 2.70 234 33.00 238 11.20 255 10.40
282 .90 307 165.10 310 35.70 311 3634.90 319 .30 326 560.00 328 .40 346 231.30
353 4608.40
St.123 34 2.00 38 1022.30 54 1.20 60 3.80 61 14.40 122 15.30 125 1.40 178 685.60
228 127.50 238 .80 245 9.70 310 450.20 319 .60 345 1053.40 362 349.20
St.124 14 4.20 29 25.50 60 24.70 61 2.90 65 18.20 69 1094.10 71 296.60 73 16.00
77 .90 90 30.80 104 67.20 122 107.10 129 5.10 137 169.50 139 34.10 140 40.80
159 10.00 167 10.50 180 48.10 202 1.20 203 .60 209 2.70 220 20.50 225 8.60
234 19.80 235 41.20 238 8.00 251 .30 255 10.40 257 52.50 285 2.70 307 264.00
310 20.40 324 .10 326 224.00 346 55.30 353 8520.10 362 523.80
St.125 69 1242.40 167 3.00 310 5.10 353 1989.20
St.126 3 689.40 69 9.60 229 260.00 250 15.40 362 349.20
St.127 55 1.50 60 1.90 61 29.30 122 15.30 125 3.50 139 6.20 146 3.00 228 510.00
237 .40 251 1.10 254 .60 282 .90 297 1.70 306 .70 310 96.90
St.128 29 5.10 60 1.90 69 278.10 73 .50 75 .50 125 .70 139 6.20 201 23.10
202 1.20 228 85.00 310 357.90 321 2.80 345 55.40
St.129 2 3.50 14 4.20 22 12.80 25 2604.30 29 96.90 30 .60 51 .80 56 .70

```
59   9.10 60  13.30 61   7.30 65   2.80 73   7.00 74  13.00 76  60.00 77  13.50
78 351.60 79  13.40 83  83.70 113   1.60 114   1.60 122  45.90 123 755.20 139  21.70
149   .90 159 600.80 180  48.10 201 600.60 209   5.40 214   1.20 225   4.30 229 567.00
234 237.00 237   .20 255   .40 257   5.60 265  31.50 274  78.70 307  66.00 310  81.60
311 1228.30 31710805.60 346  12.60 362 174.60
St.130 14  14.00 23   1.00 29  56.10 60  36.10 65   5.60 69 271.40 71 207.20 73  15.00
76   .60 77   .90 78 488.50 90  30.80 104  33.60 122  15.30 137  46.20 139  18.60
140  25.50 159  20.00 166   3.00 167   6.00 180 192.40 209   1.80 225   8.60 229 113.40
234   6.60 238   8.80 255   1.60 307  99.00 317 4900.70 319   .30 326  16.00 346  29.40
353 2913.50 362 349.20
St.131 21   4.40 54 175.10 60  34.20 61   4.50 63  36.30 65   8.40 69 215.50 122  45.90
131   3.60 137   4.30 159  51.70 225  17.20 234  13.20 245   9.70 285  10.80 307  22.00
310 342.30 311 3636.60 330 1269.30 362 349.20
St.132 29   5.10 54 287.40 65   2.80 69 119.20 71 179.10 73   1.00 129   5.10 137  13.20
139  12.40 159  47.80 202  12.00 209   1.80 224   4.50 234  44.40 255   4.80 307  11.00
320   .60 323 163.20 353 390.50
St.133  9  46.40 14   2.80 56   4.90 65   5.60 69  19.10 73   1.00 77   2.70 79  13.40
97   6.30 130  30.40 133   5.10 139   9.30 149   .90 153   1.50 159  60.50 17719133.00
194 1953.30 209   6.30 224   1.50 235 169.10 255   .40 268   9.10 274  46.30 282   .90
331   .20
  0
```

Sado Estuary. Subtidal macrofauna ash-free dry weight biomass data, mg.0.1m^{-2}

```
(I5,8(I4,F8.2))
  100
 St.1  2  1.16  8  1.16 14   .13 18   .05 21   .68 22   .87 24   .05 26   8.17
42   4.04 45   9.83 50   .61 53  15.49 54  48.24 55  11.78 56   1.31 61   .32
77   3.49 80   2.35 98   1.62 111  1.27 113  8.26 118   .53 122   .64 125   .16
126   .12 131  2.51 149   .11 151   .03 154  5.81 162  4.39 180 12.82 189  2.26
194  1.85 195   .72 199  7.50 209   .09 213   .20 221 131.81 222  1.03 224  3.43
229 11.69 234 53.10 235  9.10 236   .07 237   .01 245   .79 251   .01 253   .40
255   .33 256   .06 264   .17 267  1.72 268   .15 272  8.54 273   .03 274  6.59
277   .06 280   .05 282   .12 291   .09 294   .62 296   .34 299   .64 305   .48
312  3.35 321   .45 329 1213.41 335   .10 339   .66 347   .03 357 2902.04 363  10.86
 St.2 13   .10 18   .15 24   .35 34   .13 36  43.56 45   5.73 49   1.02 54   .09
58   6.74 69   .52 77   .51 86   .01 96  60.28 105  6.59 113 12.39 118  2.66
120  3.61 125   .09 130  1.06 142   .22 144  7.74 149   .22 156   .06 189   .19
195   .86 200   .18 210  1.10 223  1.92 224   .89 228   .36 234 32.60 235   .30
237   .17 245   .79 251   .02 255   .18 268   .69 273  1.18 280  3.76 285   .04
294   .16 295   .01 298   .01 299   .32 306   .06 312 12.02 320   .03 322   .02
323  1.63 331   .06 334   .10 335   .20
 St.3 34   .13 68   .53 113   .15 125  3.71 204   .11 224   .35 228 69.94 237   .04
251   .14 267  2.50 268   .08 273   .25 294   .27 299   .32 306   .16 323  1.63
345  61.13
 St.4 14   .13 22   .87 23   .54 56   .15 65   .28 69   .04 73   .23 82   .65
118  5.32 120 76.07 122  5.95 126   .41 149   .11 195   .01 200  1.96 224  1.95
226 15.88 228   .04 234 50.90 236   .99 237   .04 245  6.32 251   .05 256   .61
265  1.24 267 46.46 268   .23 273   .08 280   .01 282   .12 285  4.49 294   .10
297   .01 299  1.58 306   .05 323   .19 325   .74 326   .40 329  4.61 331   .21
335   .20 355   .22 356   .43
 St.5 13   .40 21   1.70 22   2.61 23   .27 24   .10 25  32.33 28   4.18 29   1.44
34   .13 36  57.81 45  13.13 54  83.30 56   .69 60   .84 61  14.24 70   5.23
73   2.17 77   .51 88   .13 102   .52 105  7.55 106 54.51 113 19.69 120 48.41
126  2.30 130  6.36 131  1.51 135   .32 142   .64 146   .22 156   .02 166   .30
176   .45 180 28.42 183   .56 189  1.88 193  1.68 195  3.37 199  1.61 200   .36
209   .18 210 246.55 211 14.53 220 95.55 221 116.26 224  1.60 228 32.52 234 662.30
235 410.80 243   .12 249 49.18 256   .06 264   .07 265   .86 267 37.08 285  2.54
291   .03 294   .01 295   .01 296 107.69 305  2.33 312 44.51 316 178.61 327   .47
329  4.08 335   .82 336   .10 357 1124.30 358 254.64 359  90.66
 St.6  2   .81 10   2.96 14   .26 22   .87 23   .82 30   .12 31   .30 33   .20
34  94.23 41   .11 43   .34 55   .19 56   1.39 69   .63 76   .07 82   1.64
88 274.58 97   1.74 101 40.51 109   .06 122  1.11 149  2.44 168   .17 170   .66
178   .01 180  3.02 195  1.99 221 328.57 222   .31 229 104.65 233  1.84 234 417.00
245   .79 260   .10 267   .86 268  2.08 294   .02 304   .37 325   .59 327   .16
340  2.75 341  5.72 345 121.05 347   .47 357   .10 360 340.28
 St.7 34   .13 68   .53 98   .93 118 13.29 120   .12 228 19.43 237   .06 251   .02
256   .17 267   .43 273   .22 294   .01 306   .08 327   .32 329  2.52 354   .14
 St.8 24   .10 68  33.32 118 11.16 120   .31 125   .06 138   .03 210   .08 224   .53
228  1.38 234  4.50 237   .01 251   .10 255   .01 273  1.01 284   .01 298   .01
306   .11 323  1.78 335   .10 356   .43
 St.9 23   .14 28   .57 29   .77 36   .03 44   1.01 45   .34 68   .53 70   .10
95  17.72 98  16.86 99   .84 118  2.66 120  7.25 125  3.79 131  4.01 195   .35
222   .31 224   .71 234 33.90 237   .07 245  3.94 251   .50 255   .03 256   .17
260   .05 265   .62 267   .09 273  1.61 277   .07 280   .14 283   .03 294  1.74
305   .06 306   .12 312  1.10 320   .25 323  3.56 325   .04 327   .81 329  3.46
335   .43 357   .05
 St.10 48  36.07 61   1.25 99   1.52 107   .31 118  1.06 120  5.43 125   .27 189   .19
```

221 147.54 224 .18 228 64.93 232 .13 234 .10 237 .04 251 .01 267 .09
273 .12 294 .01 329 14.24 350 .15 354 2.84 356 .14
St.11 23 .14 32 .06 33 .10 43 .34 60 .65 65 .14 68 .53 73 .11
113 .31 118 .53 122 5.32 134 .08 138 .01 168 .17 172 8.78 195 .52
200 2.86 228 18.93 234 12.00 237 .03 251 .11 256 .50 267 .43 268 .08
273 4.57 280 .34 282 .01 294 .01 305 .01 306 .22 312 1.12 313 13.12
323 1.78 325 .20 326 .44 329 .95 335 .10 356 .14
St.12 2 2.59 6 153.71 23 .82 27 1.86 29 .75 34 .40 35 .55 39 .25
45 .67 54 .03 60 2.57 73 8.78 79 1.06 92 9.17 98 .79 101 .09
118 .53 120 3.04 122 .93 125 .37 138 .03 144 .66 149 .33 155 .16
158 1.52 163 .32 166 2.53 183 .27 195 .52 207 .50 209 .45 210 .08
224 20.29 225 1.53 226 7.94 228 .28 234 .10 237 .04 246 .11 251 .07
256 44.13 262 .84 267 43.10 268 .08 273 .06 274 .07 277 .10 280 .08
282 .11 285 1.06 294 .41 297 5.63 310 32.69 316 .31 320 .08 325 .15
326 2.92 329 51.29 335 .61 340 1.05 346 .35 357 1.97
St.13 2 333.49 4 132.82 14 .26 21 .34 23 .54 29 5.73 35 8.77 39 .12
45 .67 54 58.91 55 .39 56 .23 59 352.12 60 15.08 65 .56 69 .69
70 6.63 71 20.71 73 5.30 79 3.19 82 .33 88 277.13 90 10.03 92 29.26
95 357.76 96 32.66 98 .16 101 2.20 109 .01 111 .16 119 76.12 132 .71
134 .32 136 1.35 141 .24 149 8.54 157 109.16 158 520.23 165 .14 166 .89
171 5.82 180 12.51 183 187.14 184 56.24 190 .31 191 .59 195 22.53 199 .36
200 1.07 203 .06 209 .36 221 310.40 224 .71 225 3.56 226 31.75 229 4.31
234 5.10 235 2062.30 238 .23 241 19.23 245 1.58 246 2.61 247 .63 248 9.82
252 .04 255 .41 256 .17 259 .02 260 .15 265 25.70 267 1.03 268 .62
282 .06 285 .07 292 .01 297 .62 307 1.89 312 .54 316 18.44 326 6.27
329 62.09 330 84.27 332 6.89 337 .10 344 446.51 346 58.46 347 31.47 349 .06
357 182.44 358 66.61 360 759.86
St.14 2 63.38 14 1.79 21 .17 22 .87 23 .27 29 2.32 35 48.24 42 12.11
45 .67 54 68.91 60 37.06 65 1.11 69 43.63 71 26.02 73 4.28 85 .44
90 .76 101 3.30 103 .27 105 4.22 108 .02 113 .15 120 .88 130 1.06
131 .50 133 .71 134 1.35 148 1.74 149 .67 158 6.83 159 1.13 161 .17
174 21.80 176 .60 180 80.24 194 221.73 195 7.22 200 .71 201 38.58 203 .79
223 1.81 224 1.42 225 .51 226 42.65 234 24.40 235 3629.60 245 4.73 246 .11
249 7.73 251 .01 256 3.31 257 11.34 260 .20 265 .44 267 .43 274 3.82
279 .26 282 .85 291 1.16 297 2.08 307 .23 314 .58 316 19.82 326 1.89
329 143.79 330 63.47 335 .71 346 40.51 351 1.52 357 5026.03 358 66.61 360 433.65
St.15 2 6.49 14 .13 22 3.48 23 .54 25 502.25 29 .38 34 .40 43 .67
45 .67 60 1.19 61 .61 68 .53 73 3.31 103 .27 105 .69 118 .53
121 31.15 122 7.18 124 11.24 125 .02 144 .01 149 .89 163 .63 166 1.49
195 2.14 200 3.57 206 .09 224 2.84 228 93.91 234 18.30 237 .10 244 .15
245 5.51 247 .18 256 18.14 260 .05 267 55.61 273 .01 280 .03 294 .84
297 6.70 310 15.78 323 1.78 326 .27 327 .39 329 4.54 343 12.10 350 .30
354 .14
St.16 2 90.17 12 .26 14 1.15 18 .05 22 20.62 23 .54 25 2452.57 29 16.98
33 .05 34 14.04 35 4.39 42 24.20 51 .20 54 11.60 55 1.31 60 23.64
65 .42 69 2.06 71 12.01 73 2.68 79 4.25 87 4.78 95 267.94 96 2.04
98 .62 101 56.21 103 .84 104 .78 109 .01 121 107.87 122 21.49 130 1.06
141 .11 144 5.85 149 2.44 159 7.72 166 1.79 173 1.45 178 .31 179 3.26
180 17.56 183 4.33 191 1.80 195 64.01 196 1.69 198 .85 200 3.39 201 64.99
203 .36 208 .54 215 .02 219 11.58 221 140.23 223 .15 224 2.89 225 2.03
228 9.65 229 2.44 234 260.90 238 .64 246 1.82 247 2.23 248 28.52 258 .17
260 .40 262 .18 265 6.61 267 .17 274 12.05 277 .18 279 1.53 282 .91
291 .77 292 .19 297 21.92 305 1.65 310 3.56 312 .34 320 .02 326 79.75
327 .16 332 1.83 340 .87 341 5.00 346 17.76 355 1.58 357 923.49 358 66.61
360 122.52
St.17 21 .85 22 2.61 23 .95 28 5.75 29 2.98 40 11.21 42 16.15 45 .34
54 .25 56 .46 60 4.32 63 149.21 69 .32 77 1.03 98 1.59 113 .76
118 1.06 122 17.11 125 .01 130 2.12 141 .03 149 .33 180 161.48 183 1.79

```
189   .38 191  5.29 195  5.92 200  3.04 209   .27 210  3.23 216  1.05 220  1.05
221  1.90 223   .58 224  3.37 225  2.03 228 36.50 234 1843.50 243   .98 245  1.58
251   .05 265  1.03 267  1.98 268   .08 272  5.99 279   .52 282  6.50 285 11.37
294   .05 297  2.57 305 10.76 310  7.78 312  7.19 320   .02 326  8.80 327   .05
329 88.14 331   .08 346   .25 357 95.58
 St.18 2 1232.32 11  .51 12  .06 14  .89 23  3.79 29 13.41 34  .13 35  .55
 43   .34 54   .14 55   .11 60  1.88 61   .08 69  1.44 70   .88 73  1.71
 76   .41 85   .16 87 19.85 101 91.85 109   .01 122   .75 127  7.19 143   .15
 149  3.66 171  7.68 179  2.34 183 58.13 195 11.18 201 26.45 212   .07 220  6.30
 221 40.15 225  1.53 226 1096.02 229 43.19 234 185.10 235 2394.30 246  2.27 247   .45
 248  9.06 256   .22 265  2.06 274   .20 279  4.65 282   .70 285   .34 291   .04
 292   .25 294   .01 297   .32 307   .19 310  2.15 325   .08 326  5.98 327   .37
 330 87.31 335   .31 345   .05 346   .91 351  2.03 360 152.60
  St.19 2  32.26 14   .13 18   .10 21   .68 22  16.93 23  9.29 27  17.33 29  27.04
 33   .05 42  82.95 45   .34 51   .10 54  12.72 56   .15 60  2.44 63 919.91
 65  1.39 69   .79 71  34.59 73   .97 76   .07 77   .51 83   .50 87  3.05
 101  2.78 104   .17 108   .02 113   .31 121 39.34 125   .01 130  4.24 144   .20
 149  1.11 159 61.12 166   .30 169   .17 173  1.42 180 45.55 183 49.86 184 37.61
 191  6.48 194  2.22 195 11.36 198  1.25 200   .54 209   .18 216  4.09 220  6.62
 221  1.56 222   .20 223  1.35 225  9.19 226 1298.57 228 20.36 234 268.00 235 149.00
 238   .58 245  2.36 250  9.64 262 30.64 265  8.95 267   .34 274 37.09 277   .07
 279   .61 281  2.21 282  5.28 285  4.49 292   .02 294   .01 297 10.91 305  6.35
 307   .37 310 15.77 312   .98 325   .75 326  8.99 329 127.49 331   .06 332   .49
 335  1.84 346  1.38 357 392.68 359  15.58
  St.20 2  33.48 10  2.05 12   .06 14  2.93 22  4.35 23   .95 29  5.19 35   .55
 54  2.05 55   .35 60  99.70 69  4.21 73  2.05 76  1.64 79  1.06 94  14.90
 101 30.50 103   .68 109   .01 122 95.47 137  1.45 143   .05 149  4.32 159  2.42
 166   .89 168   .51 171 11.13 176   .15 179  1.00 190   .43 195  7.14 201 58.21
 205   .05 206   .09 209   .54 216  1.22 221  1.64 223   .40 224   .18 225  2.03
 226  7.94 227 13.72 229  5.48 234 710.00 245   .79 246  1.82 247   .54 248 109.51
 256   .50 258   .09 265  4.50 268   .08 279   .17 282  3.14 292   .43 297  3.64
 310   .99 325   .05 326 28.32 327   .05 329  1.80 332 24.49 341  7.32 346 10.63
 347 21.77 355   .14 357   .21 362 475.79
  St.21 2  28.77 14   .26 20   .25 21  1.88 23  3.13 27  1.86 29  3.33 34  17.51
 35  3.29 45   .34 51   .39 60   .84 68   .53 71  2.80 73  9.92 76   .07
 77   .10 83   .68 93   .53 98  1.95 101  8.55 120  2.05 121 91.60 122  7.76
 125  3.10 130  2.12 131   .50 144 21.07 149  1.11 163  1.27 165 15.18 166  4.17
 183  2.79 186   .15 195 20.12 200   .18 203   .06 209   .89 214   .26 224  6.39
 225   .51 226 17.28 228 13.65 234 91.90 238  1.16 245  1.58 246   .11 252   .13
 255   .17 256 17.76 265   .56 267  2.06 270  1.25 273   .03 274 14.59 277   .19
 282   .14 285   .33 292   .18 294   .62 297  2.99 305   .07 310 17.08 320   .23
 323   .10 326 35.14 329   .09 335   .82 338   .05 340 82.96 346  1.02 350   .60
 357 153.12
  St.22  2  31.16 11   .13 14  1.40 17   .08 20   .05 21  1.36 22   .87 23   .54
 25   .64 28   .14 29  5.42 34   .40 35  4.93 42  49.92 45  1.35 51   .20
 54  17.86 56  1.00 60  14.39 62   .10 69  5.86 73  7.24 76   .14 113   .46
 120  3.38 122  3.41 130  3.18 135   .08 136   .16 149  1.55 166  1.34 176  1.34
 179   .16 180 67.56 183  1.06 186   .15 194 67.79 195 18.58 200  1.79 201  3.65
 203   .12 209   .18 223  1.12 224   .35 225   .51 229   .07 234  7.70 235 174.60
 246   .34 247   .09 255   .32 256  8.66 260   .35 265  3.47 267  1.38 282   .44
 291   .16 297  3.51 312   .99 326  1.05 329 333.98 332 30.70 335   .31 346 73.26
 351   .30 357 9851.34 362   .03
  St.23 2  39.14 17  1.58 23  1.36 27 108.90 29  20.63 30   .18 35  9.32 41   .22
 60  5.21 65   .14 69  23.37 73   .11 79  12.74 82  4.36 83  19.87 85  8.29
 97   .07 100 65.47 109   .02 122 13.09 139 24.05 148   .79 149  3.88 159  3.53
 179 49.57 180 104.94 183 36.42 190  7.55 195 45.80 201 377.32 209   .18 218 51.46
 221 101.64 223   .39 225  2.03 227  1.35 229  5.22 234 101.60 235 33.50 248 68.80
 255   .05 257  1.12 259  2.68 265  3.92 268   .23 274 14.56 282  1.68 291   .12
```

297 1.36 301 .10 304 28.61 312 .02 318 .33 326 56.36 332 3.92 346 .44
351 .81 357 6.53 362 96.79

St.24 2 90.61 23 .41 55 1.73 60 .40 73 .06 76 .14 85 44.06 122 .05
149 .33 179 .21 201 2.84 226 92.77 229 75.78 234 2.10 268 .08 274 .13
282 .03 297 .06 310 .05 318 .06 332 2.76 340 .65 346 .13 351 4.46

St.25 2 43.91 11 4.85 12 .32 13 .80 14 2.42 18 .05 21 1.02 22 5.73
27 1.97 29 4.70 35 21.93 42 4.04 45 .34 54 8.75 55 .18 60 46.53
65 .28 69 .99 73 3.13 79 1.06 84 .17 87 .21 88 .09 90 1.29
101 .40 105 18.21 110 42.48 113 .15 127 .15 130 1.06 136 1.11 139 .27
141 .03 149 .33 159 2.86 163 .32 166 .15 180 202.65 189 1.70 194 35.44
195 1.43 197 .16 201 1.22 203 .36 224 .53 225 1.02 226 7.94 227 5.21
235 2670.40 247 .09 256 .44 260 .05 262 .04 264 20.48 265 .71 268 .08
274 .23 282 3.48 285 1.44 291 .24 297 26.38 305 .04 307 2.01 312 .11
316 186.80 326 3.19 332 .61 335 .41 346 76.32 360 165.75 362 25.38

St.26 55 2602.56 57 19.10 60 .09 63 467.28 69 1.07 79 1.06 109 .09 146 .93
149 .55 192 10.35 221 3282.53 230 2.54 235 68.60 242 .09 268 .08 297 .04
346 .84

St.27 2 19.94 11 2.93 12 2.93 14 4.59 22 1.74 23 .27 29 11.37 35 23.02
54 24.59 56 .23 59 218.73 60 2.60 63 1193.70 65 3.25 69 1.66 71 90.61
73 2.45 79 18.05 101 4.22 103 .14 122 2.09 127 4.90 136 2.21 139 1.47
148 1.74 149 .44 159 27.71 180 22.97 195 1.84 201 258.89 203 .18 209 .36
223 1.59 225 .51 234 13.20 235 5679.90 256 .06 257 2.49 259 2.68 260 .15
262 10.78 265 .71 268 .08 282 6.28 291 .06 297 13.34 305 .66 326 3.12
332 5.88 335 .10 346 3.02 351 .41

St.28 2 24.87 11 3.06 17 3.72 18 .05 20 .05 21 2.22 23 .14 25 58.20
27 1.86 28 .52 29 35.48 35 7.67 41 .33 42 8.07 45 3.04 54 44.51
60 62.83 63 493.52 65 .83 66 .46 69 31.95 73 4.84 77 .10 79 2.12
88 21.80 101 5.52 104 .64 105 56.78 113 3.06 120 .38 122 .81 125 .11
130 4.24 131 4.01 136 .32 141 .32 144 5.61 148 3.48 149 .22 176 1.34
180 177.32 189 7.35 195 24.05 200 1.07 201 1.97 203 .18 209 1.25 223 5.01
224 1.60 225 3.86 226 15.88 228 .21 232 2.27 234 719.90 235 224.50 246 .11
252 .04 253 .40 255 .31 260 .44 264 .84 274 139.35 282 .68 285 .40
291 .31 293 105.03 294 .15 297 .27 307 4.63 309 .02 312 1.93 314 .20
316 136.80 320 .05 327 .01 329 .85 332 .26 335 1.74 346 16.90 355 .07
357 .71 359 249.07 361 1355.27

St.29 2 14.48 11 1.40 14 2.30 22 5.22 23 1.09 29 31.63 35 .55 39 .12
42 4.04 51 .10 54 15.14 60 42.14 63 1.53 65 .14 69 11.38 71 2.68
73 1.71 79 28.67 81 22.10 85 99.07 90 4.90 95 6.39 103 .14 105 26.51
115 35.45 120 1.52 122 8.37 130 2.12 131 1.00 136 .32 149 .33 166 1.64
180 160.84 184 24.92 195 36.05 198 44.27 200 .18 201 18.76 203 .12 209 .98
223 .79 224 .89 225 5.41 226 7.94 228 6.29 232 1.20 234 59.40 246 .34
248 7.26 252 .36 255 .14 256 .06 260 .10 262 7.08 265 .71 267 .26
268 .85 274 17.52 282 1.13 285 29.11 298 .01 305 .33 307 6.24 326 2.49
327 .26 329 119.57 332 11.77 335 1.33 346 15.05 352 30.16 355 .29 360 322.94
362 73.70

St.30 2 125.40 11 .26 14 1.40 23 .68 29 15.90 33 .10 35 .55 60 22.64
63 8.31 65 .14 68 .53 69 3.70 71 76.72 73 1.03 79 3.19 95 6.80
101 8.05 103 .14 118 1.06 122 10.55 136 .08 149 5.10 159 2.38 166 .45
168 .67 180 21.38 195 79.06 201 7.32 203 .12 209 .09 225 3.56 226 33.51
229 2.75 234 333.50 236 .10 238 .23 246 .68 247 .63 248 74.06 253 .40
256 .06 260 .15 265 .06 267 .09 268 .08 274 1.66 279 1.50 282 .48
285 .21 297 1.06 307 6.38 310 7.97 317 64.72 326 25.36 327 .02 346 16.79
355 .22 360 329.36 362 210.18

St.31 68 33.32 107 .10 118 2.13 120 1.93 228 13.47 273 1.09

St.32 29 .78 107 .21 118 1.24 125 .01 181 .10 189 .19 220 3.62 221 250.05
228 36.10 229 678.06 240 .28 291 .05 310 5.21 335 .10 345 25.18

St.33 2 4.81 29 4.94 35 .55 42 4.04 54 26.51 60 2.17 67 .21 111 .16
120 17.81 122 6.24 131 .50 144 2.64 176 .15 180 33.72 189 .19 195 .46

220 15.53 221 462.26 223 1.59 224 .18 228 18.87 234 33.00 245 .79 272 3.64
282 .17 285 .48 291 .06 294 .03 297 .16 307 .62 310 .66 312 1.02
316 12.07 323 .10 329 694.88 335 .41 346 .16 357 12497.17
St.34 2 74.21 12 .06 22 .87 29 17.32 33 .10 38 23.05 60 1.80 68 .53
95 30.47 111 .16 122 7.88 125 .01 149 .11 195 4.35 200 .36 227 9.92
229 .62 234 38.80 268 .08 274 4.60 279 .26 282 .16 294 .05 310 221.37
326 5.09 327 .01 330 58.03 335 .41 340 98.99 346 4.45 362 404.48
St.35 2 120.06 7 .14 10 2.05 12 .32 14 1.66 23 .14 29 25.70 55 .18
60 25.88 66 .07 68 1.58 69 5.82 73 .17 76 .21 79 3.19 90 2.45
122 8.37 136 .08 141 .08 149 .11 159 .89 168 .17 180 7.66 184 24.92
190 3.20 195 30.12 201 5.36 225 1.02 228 6.29 229 16.78 234 138.60 238 .23
244 .45 248 43.55 256 .11 274 12.82 279 .45 297 .16 310 27.25 326 34.28
332 5.88 335 .41 340 22.83 346 21.23 362 466.76
St.36 2 48.67 11 .13 12 .13 14 4.97 22 5.22 23 .95 29 6.71 35 4.93
45 .34 55 .01 56 .08 59 1821.14 60 3.25 63 2556.62 71 27.20 73 10.26
76 .48 77 .10 79 6.37 82 .33 85 1.34 90 2.40 101 104.26 122 7.41
123 5.29 136 .48 139 .32 149 3.22 166 1.64 168 .34 180 30.25 184 11.34
195 .66 201 124.51 203 .12 223 4.39 225 1.02 226 364.68 229 20.41 234 23.60
235 3488.80 238 .23 244 4.74 245 6.30 246 .34 247 .18 255 .07 256 4.36
259 2.40 260 .20 262 15.40 264 .04 265 4.47 267 .26 268 .39 275 106.77
282 .57 297 .83 307 .28 326 24.46 330 109.46 332 4.73 346 4.04
St.37 2 5.75 11 .38 20 .05 21 .51 29 33.11 34 .07 37 2.62 41 1.11
45 2.02 54 9.18 60 39.46 71 7.19 73 4.79 79 1.06 95 6.47 98 .58
104 17.15 105 11.36 113 .15 120 1.52 122 2.09 130 2.12 131 6.02 135 .71
141 .32 144 15.83 166 .45 180 122.52 191 4.36 195 35.14 200 .18 203 .06
209 1.44 223 6.35 224 4.83 225 2.03 226 22.12 228 37.74 234 79.20 238 .46
245 1.58 249 9.30 255 .14 257 2.78 260 .05 264 .17 267 .60 274 149.16
282 .53 285 9.01 291 .06 294 .14 297 .33 298 .04 305 .33 307 .62
309 .02 312 1.02 316 47.59 320 .02 329 16.85 331 .02 335 3.78 340 14.77
346 4.74 357 40.47 359 103.98
St.38 2 11.87 12 .06 14 .51 17 1.58 22 1.74 29 26.46 34 18.45 35 1.64
45 .67 51 .10 60 18.68 69 .75 71 1.44 73 1.37 76 .07 79 3.19
84 .17 91 35.65 101 4.35 110 .43 113 .15 121 73.01 122 3.23 144 3.63
149 .89 166 2.83 180 20.15 183 267.03 189 .38 195 .31 201 .26 225 3.05
229 33.45 234 325.60 238 .23 255 .18 256 1.99 260 .05 267 2.24 268 .15
274 12.43 282 .01 285 .12 307 .14 310 .21 312 .16 320 .02 326 6.12
329 18.39 331 .12 335 .51 337 .10 346 23.01 357 4.41 362 842.09
St.39 2 1044.71 11 1.02 12 .32 14 .64 22 6.96 23 .68 25 832.15 29 16.80
30 .42 33 .15 35 8.77 54 .72 59 627.95 60 29.28 63 141.99 64 46.74
69 13.29 71 20.38 73 .28 77 .62 79 15.93 82 .71 94 14.90 101 6.33
109 .01 111 .48 122 2.09 123 201.31 127 2.45 130 1.06 136 .56 139 12.68
149 3.55 159 .89 168 .34 170 467.41 176 .15 180 30.63 183 27.91 195 37.60
201 66.99 209 .27 220 30.87 221 308.67 225 3.69 226 19.47 229 16.78 234 13.20
235 3836.80 246 .23 256 .11 260 .25 265 2.14 268 .23 274 3.20 277 .07
282 .17 283 .06 291 .12 292 .10 326 14.33 346 56.63 351 54.08
St.40 2 486.07 11 14.67 12 9.07 13 .20 14 2.93 18 .05 22 5.22 23 2.18
25 1107.30 29 11.43 33 .05 35 14.25 54 6.17 59 1051.33 60 21.88 63 153.03
69 111.89 71 10.35 73 .17 77 1.23 79 27.61 83 8.62 101 62.27 103 .14
130 4.24 136 .16 139 .71 149 6.43 165 20.17 180 89.73 183 308.31 190 1.28
195 .40 198 64.49 201 1074.80 203 .06 215 .20 221 4.60 225 2.50 226 20.28
228 .55 235 1129.50 246 .68 248 24.12 257 30.87 259 8.28 260 .46 264 .08
265 2.19 268 .62 274 4.07 282 .17 304 102.55 307 .25 326 312.74 330 122.05
331 .02 332 7.56 340 .19 346 74.75 351 .10 360 208.38 362 270.92
St.41 2 729.12 11 .64 12 1.02 13 .20 14 1.40 18 .05 23 .41 29 20.76
35 20.83 59 146.44 60 6.57 63 440.81 69 381.08 71 35.94 73 .06 79 6.37
83 3.16 103 .14 122 6.28 123 103.31 130 1.06 136 .32 139 3.30 149 3.88
159 2.67 180 15.32 182 83.04 183 16.72 195 .61 201 150.06 209 .09 225 5.26
226 55.04 234 26.40 235 3019.40 246 .23 257 100.88 263 1.04 265 1.43 268 .08

282 .09 326 38.64 330 94.55 332 11.77 346 60.78 351 2.74
St.42 2 107.20 11 .51 12 .64 22 3.48 23 .54 29 10.87 35 .55 51 .10
54 1.96 60 75.41 69 186.62 73 .28 79 9.56 95 1.11 139 .37 149 1.00
180 15.32 195 .77 201 184.89 218 48.41 225 2.54 234 6.60 238 .12 246 .34
248 7.26 255 .23 256 .83 274 9.61 282 .09 292 .05 310 .66 326 1.87
329 185.67 335 .20 346 71.93
St.43 2 9.03 10 4.78 12 .26 14 6.50 21 .34 22 4.35 23 1.50 29 5.93
34 .40 37 .17 54 3.76 56 .15 60 46.77 61 1.34 63 13.31 65 .56
69 1.32 71 2.90 73 3.42 79 1.06 95 3.22 101 1.05 113 .15 122 6.28
130 1.06 137 .16 139 .37 141 .03 149 2.11 159 3.56 166 1.19 172 2.11
176 .60 180 15.32 183 .69 184 24.92 191 3.39 195 5.07 197 .79 200 .71
201 2.68 203 .06 209 .62 216 1.36 221 146.04 222 .31 224 4.08 225 3.56
228 25.16 229 16.78 234 477.80 245 1.58 247 .45 248 7.26 252 .04 255 .05
267 .17 268 .08 269 .06 274 3.20 279 1.13 282 1.31 285 .48 297 2.80
307 .62 310 24.84 323 1.78 327 .17 328 .08 329 1.18 335 .31 346 9.45
350 .15 355 3.79 357 14.31 362 24.57
St.44 2 26.27 10 .46 14 .51 22 2.61 29 10.03 31 .12 41 .22 46 .41
54 2.64 60 1.77 65 .69 69 4.77 73 .97 76 2.12 79 14.87 83 .78
85 16.19 101 98.36 122 2.93 128 .06 130 1.06 136 .08 141 .03 149 3.33
153 .25 159 17.17 166 2.68 179 .22 180 .02 183 4.35 192 3.09 195 .51
201 131.65 203 .06 209 1.43 215 .08 221 56.97 225 2.54 229 123.36 234 78.20
237 .01 246 1.25 247 .18 248 17.41 256 .99 267 .09 268 2.32 269 .06
274 22.23 282 .82 304 236.89 310 .43 317 240.04 318 .59 326 201.15 332 .40
346 2.94 347 .08 349 .08 352 10.89 362 33.35
St.45 2 1.98 18 .05 21 .68 28 11.51 29 1.98 35 1.64 40 11.22 42 8.07
52 158.54 54 .20 56 3.26 60 7.04 65 1.67 69 19.32 71 1.89 73 1.77
113 12.54 122 23.02 125 .08 130 4.24 131 9.03 141 .08 144 2.64 152 .17
166 .45 176 2.90 180 84.23 189 5.47 195 2.77 199 .36 200 23.72 209 1.43
220 27.37 221 271.05 224 6.21 225 2.54 226 6.19 234 1090.40 244 .15 251 .03
253 2.38 260 .05 268 .15 272 7.27 274 83.30 278 .11 282 .26 285 6.25
286 13.85 294 .14 304 16.13 307 3.74 308 .02 310 3.99 312 4.76 320 .05
326 3.12 329 1.09 335 1.84 357 10.82
St.46 2 5.26 14 .38 22 3.48 23 .54 34 18.72 41 .11 44 .34 56 .15
60 8.65 69 3.22 73 .06 76 .07 78 2.10 100 4.12 101 169.19 109 .01
122 10.47 125 .16 128 68.21 130 1.06 149 1.00 150 .32 159 .89 165 15.99
166 .15 184 24.92 195 2.00 200 .18 221 220.30 225 .51 234 290.40 245 1.58
256 .33 268 .77 279 .68 285 .24 310 1.99 325 .33 340 10.77 347 .11
356 .14 360 261.27
St.47 2 13.44 16 .12 19 1.02 22 1.74 26 37.05 29 11.86 30 11.05 33 .30
34 .27 35 7.67 41 .22 43 1.69 50 .51 54 .06 56 .53 60 1.73
63 149.21 65 .14 67 .10 69 4.15 72 .06 78 1.74 80 .94 82 1.71
83 3.16 85 99.07 87 .46 97 7.18 101 44.29 122 2.09 125 1.35 149 1.88
153 .40 159 4.45 179 1.88 180 61.26 183 .27 188 1.50 191 .48 195 13.37
201 21.44 209 1.25 215 .43 221 1807.41 224 1.42 225 1.53 227 1.35 228 6.29
231 25.72 234 145.20 235 49.50 237 .16 239 .08 248 21.77 251 .02 258 .12
261 60.45 268 7.28 291 .47 294 .07 301 .24 302 2.73 304 370.89 307 1.25
310 15.28 311 106.98 326 6.86 332 5.88 339 .16 340 19.70 346 1.14 348 .12
357 4.14
St.48 22 .87 28 .14 29 .99 60 .65 111 .16 117 10.70 120 6.07 122 2.09
125 .48 166 .15 176 .15 181 3.39 195 1.38 200 .18 214 .14 224 .18
228 6.29 234 85.80 249 25.80 251 .03 256 .06 268 .54 273 .07 282 .09
285 .48 305 .33 310 1.99 312 2.38 320 .06 325 .16 326 .62 335 .31
346 .08 356 .29 357 .06
St.49 27 1.86 29 .49 60 .43 61 .09 65 .28 73 .06 118 .53 122 6.28
125 .40 138 .01 195 .61 204 .07 228 18.87 234 142.80 237 .57 251 .85
255 1.41 267 .09 268 .08 273 .43 280 .32 294 .95 306 .01 308 .02
309 .02 310 3.32 323 1.63 326 1.87 356 .29
St.50 10 10.39 12 .06 14 3.83 22 1.74 29 6.50 41 10.62 54 .23 59 401.39

60 2.81 69 131.82 71 1.72 73 .23 76 .48 79 1.11 83 2.36 97 .28
118 .53 122 .70 136 .08 137 1.10 141 .03 149 .22 165 3.20 168 .17
184 16.12 185 .23 195 52.32 225 1.53 228 .36 234 72.60 256 .17 268 .85
274 11.82 279 .39 282 1.30 304 .67 307 4.22 310 9.19 315 .90 317 203.09
326 36.18 346 2.22 362 .20
St.51 2 69.15 3 32.02 12 .57 14 7.78 21 .17 22 20.92 29 .49 35 1.64
54 .82 59 1435.77 60 2.17 65 .14 69 8.31 71 101.55 73 1.82 76 .21
77 .10 79 1.06 97 .07 101 10.10 118 .53 132 .71 136 .56 139 2.56
145 .39 149 2.22 159 .89 166 .30 195 .31 201 2.68 209 .18 229 33.57
235 1403.60 246 .11 248 50.80 256 .22 265 .71 267 .09 270 1.25 297 .33
303 .16 330 107.24 346 .98 360 266.60 362 73.70
St.52 2 13.35 14 .38 17 1.34 23 .41 29 8.90 35 1.64 43 .34 55 2.98
59 861.54 60 28.59 63 901.10 65 .42 69 19.11 71 88.95 77 .10 79 8.50
82 .33 94 74.50 112 .16 118 .53 122 2.09 123 103.31 128 70.65 131 .50
136 .08 139 6.50 140 .45 149 4.10 180 22.97 195 1.43 200 .18 201 45.55
203 .12 209 .36 225 3.56 235 1454.90 238 .12 250 11.88 256 .61 257 14.05
260 .05 268 .69 274 3.20 282 1.57 294 .03 297 .16 304 32.25 307 1.25
326 .62 330 64.96 346 13.29 357 388.47
St.53 2 7.74 11 1.91 12 .13 14 18.55 22 1.74 29 26.69 35 .55 54 18.59
59 .72 60 2.38 63 944.81 65 .14 69 2.49 71 .70 73 1.48 77 .10
79 35.04 89 99.73 90 2.45 103 .14 128 21.75 130 1.06 136 .24 139 .73
141 .27 149 1.55 166 .30 180 114.86 184 274.11 185 .31 201 37.51 209 .71
220 4.77 225 2.03 227 13.55 252 .09 257 1.35 267 .17 274 63.75 282 .35
297 .16 305 .33 307 .62 326 16.20 329 83.18 332 11.77 335 .10 346 3.02
362 147.40
St.54 2 201.12 11 1.79 12 .45 14 12.50 18 .05 22 .87 23 .14 29 41.51
35 56.17 41 .33 54 21.97 59 .32 60 11.49 65 .69 69 389.73 71 11.67
73 .17 79 10.62 90 7.36 101 1.05 105 3.79 122 2.09 130 4.24 136 .56
139 .37 149 .44 176 .60 180 53.60 195 2.61 200 1.43 201 34.83 209 .09
218 96.82 234 66.00 235 1566.70 249 4.72 258 .05 260 .05 267 .26 268 .85
274 3.20 282 .96 297 .66 307 3.74 326 1.25 332 11.77 335 .10 346 1.63
352 124.79 360 206.83
St.55 2 11.22 11 1.53 12 .96 14 5.87 18 .05 22 1.29 23 .14 29 7.85
35 6.58 55 .25 59 2546.30 60 .81 61 .05 63 174.81 65 .83 69 9.55
71 142.53 73 .23 79 53.10 85 .05 103 .41 104 .07 130 2.12 136 .24
141 .05 148 1.74 149 1.11 166 .15 180 .32 183 15.51 184 13.63 201 988.45
203 .06 209 .09 220 5.69 221 9.65 225 1.02 226 47.03 235 324.50 246 .34
260 .20 274 64.72 282 2.48 297 .30 304 .36 307 .19 316 .60 326 101.67
332 20.14 335 .10 337 .05 346 3.87
St.56 2 4.19 13 .30 23 .27 29 1.48 35 .55 59 460.04 60 2.38 69 29.31
73 .06 79 33.51 122 8.37 146 .15 149 7.10 161 35.55 180 15.32 201 53.59
209 .09 225 2.03 227 1.35 234 6.60 235 308.50 244 .15 248 7.26 259 2.68
262 .08 268 .08 274 6.41 288 22.31 291 .06 326 .62 332 5.88 346 1.39
351 1.32
St.57 2 267.76 13 5.01 22 3.48 23 .68 35 1.10 43 .34 59 530.53 60 3.90
73 .40 77 .10 131 .50 139 .37 149 2.33 195 .46 201 42.87 225 .51
229 158.48 256 .17 291 .06 333 .01 346 1.96 351 5.17
St.58 2 1.06 5 .50 13 .40 14 .26 30 .60 33 .20 35 .55 43 .67
55 .36 60 1.08 79 1.06 82 .33 85 589.94 97 .14 109 .01 130 1.06
149 1.77 170 467.41 199 .18 206 .17 229 39.41 268 1.54 276 4.71 297 .16
335 .10 339 .19 346 .16 351 6.90
St.59 2 28.80 12 .26 13 .40 14 13.01 22 .87 29 38.55 35 .55 59 900.43
60 10.84 63 448.23 69 645.95 71 108.42 73 .80 79 30.80 83 3.16 90 4.90
105 3.79 136 .16 139 1.47 141 .03 149 1.77 166 .89 180 61.26 195 .46
201 34.83 203 .06 209 .18 225 4.58 234 13.20 256 .11 267 .09 268 .23
274 32.04 282 1.05 285 .24 297 1.32 307 1.25 316 9.83 326 .62 335 .51
346 1.31 357 3.08 360 277.16 362 24.57
St.60 2 22.54 7 .47 11 .51 12 .26 14 18.35 23 .95 25 262.05 29 41.51

```
35   9.32  54   32.75  59  630.39  60   50.41  63  341.86  69   15.78  70    1.50  71   77.68
73   4.50  77    .41  79   24.42  90    4.90  94   14.90 101    4.22 105    7.58 113     .15
130   1.06 136    .71 139   45.64 141     .11 149    6.32 159   16.08 180   68.92 184   24.92
195   3.78 198   44.27 201  58.95 203     .71 209     .62 218   48.41 225    5.09 227    5.41
229  33.57 246    .34 255     .18 256     .06 260     .25 267     .09 268     .62 274   61.39
282    .26 297    .33 307    4.99 317  656.59 326  165.77 332   17.65 335     .20 346  105.40
 St.61  2   8.67  13   17.27  23     .27  59  148.53  60    1.11  69   93.24  73     .06  79    1.06
122   2.09 149    .22 194   73.83 201 120.91 225    2.54 238     .58 256     .06 282     .09
346   8.92
 St.62  2   3.56  14    .26  31     .06  85  339.48 180     .18 201     .70 227    1.35 229     .50
 St.63  2 178.48  11    .26  14    1.53  22     .87  23     .14  29    5.93  35   10.96  59 1415.36
60   4.77  63  197.83  65     .14  69  303.78  71  367.44  73     .40  79   10.62 130    1.06
136    .87 137    .22 139    4.76 180   22.97 201   24.12 209     .18 223     .79 229   16.78
235 884.50 238   1.04 256     .17 268     .23 274    9.61 282    4.53 297    1.98 316    9.83
320    .01 326  20.57 332   11.77 346    6.29 360   35.32
 St.64  2  22.65  12    .06  14    6.76  15   38.22  17    1.11  22     .87  23     .41  29   12.43
33    .05  59  354.93  60    1.22  63    5.67  65     .28  69  143.36  71   53.95  73     .86
76    .14  78    .98  79   16.99  85     .07  90    4.01 130    1.06 136     .63 139    2.19
149   2.00 159    .65 180   30.76 183    9.69 184   23.79 201   11.87 203     .06 220    6.47
225   3.05 227    .96 255     .09 257    5.36 268     .39 274    3.88 282    6.18 304   33.63
317 677.08 326  98.08 328     .04 332   25.12 346    3.19 360  137.15 362     .04
 St.65 13   2.10  23    .14  31     .06  60     .22  69    1.61  78   42.71  85   49.53 122    2.09
149    .22 200    .18 201    2.68 225     .51 229   50.35 238    1.04 346     .33
 St.66  2   3.99  13    .10  14    4.46  22    1.74  25   12.91  29    5.28  33     .05  35     .55
43    .34  59  513.04  60    5.98  63    1.63  65     .97  69  115.62  71   31.44  73     .28
77    .10  79   31.86  90     .46 105    4.29 130    1.06 137   17.84 139    2.00 140    2.71
141    .03 148   1.70 149    1.77 166     .30 180    6.51 185     .14 195     .17 201   19.37
209    .09 220   4.66 223     .32 225     .51 234     .70 256     .06 260     .05 267     .09
274  34.49 282    .62 285     .04 297    2.10 307     .03 326   60.81 332    9.05 335     .20
346   6.27 355    .07 362     .08
 St.67 23    .14  27   1.86 118     .53 122    2.09 125    1.35 175  114.78 228   18.87 245    2.36
251    .01 255    .59 267     .17 273     .07 294     .03 306     .07 308     .07 310   20.12
335    .01 346    .16
 St.68  2    .68  22    .87  68   16.66  78   18.59 104    1.91 251     .01 345    3.98
 St.69  2   7.19  14    .38  29    2.47  41     .11  63   86.63  69   40.23  76     .48  82     .33
87   1.43 101   2.11 118    1.06 122    4.19 137     .06 139    1.83 141     .03 149     .22
183 257.13 194  73.83 195    1.69 201   16.08 223     .79 229   67.13 234  397.60 247     .36
249 122.74 256    .06 268     .23 274    3.20 283     .03 297     .49 307    1.25 310    1.33
326  16.83 346    .65 360   61.48 362   98.26
 St.70  2  65.99   9  12.85  14    2.17  22     .87  23    1.50  29   18.29  34     .27  35     .55
54    .03  59 1282.77  60   44.43  61     .14  69    5.82  71     .52  73     .23  76     .07
79   5.31  90   2.45 101    2.11 103     .14 122    6.28 128   48.09 131     .50 136     .08
137   3.52 139    .37 148    2.72 149    2.00 159     .89 166     .45 168     .17 179     .23
180  45.95 184  99.68 195    3.07 201  162.68 203     .06 221  141.32 225    4.07 227    2.71
229  16.78 234  19.80 235 2227.00 238    1.04 246     .45 247     .27 256     .11 260     .05
265    .71 274  12.82 279     .23 282     .26 291     .17 292     .05 307    9.98 310    4.65
326 147.08 329 180.14 330   44.36 337     .05 345     .19 346   86.26 353  316.09 360  168.40
 St.71 11    .13  14   1.28  23     .27  27    7.45  29    5.44  43    1.69  54     .10  60    9.13
69  34.24  73    .40  76     .21  77     .21  78    1.58  79   19.12  82     .33 103     .14
105   3.79 122  12.56 125     .08 132    1.42 137     .04 149     .89 159   21.19 167     .15
180  22.97 195    .61 200     .18 201    2.68 209     .18 224     .71 228    6.29 234  495.10
257   5.90 262  35.52 265    1.43 268     .46 274   18.67 282    1.29 285     .96 297     .82
307    .62 326  40.51 332    5.88 335     .31 346    3.10 362  270.23
 St.72  2  11.02  12    .26  14    2.81  22     .87  23    1.67  29    1.44  35    1.10  47  181.66
59 240.41  60   5.56  63   52.17  65     .14  69   95.55  71  261.95  73     .51  79   32.92
114    .15 122    .42 136    1.14 137    4.12 139    3.39 140     .90 149    3.77 159    1.42
161    .07 180 104.55 195     .83 196     .98 198  154.78 201   18.75 220    2.32 225   12.24
229   1.39 235 437.70 238     .42 246     .68 250   15.64 255     .17 256     .06 271    6.27
```

274 .08 282 1.12 297 .24 326 20.40 346 44.04 353 217.74
St.73 2 .03 12 .06 14 .13 60 .22 78 3.99 85 49.53 114 .15 136 .16
149 .11 170 7.22 268 .08 326 1.25 351 1.72
St.74 11 .13 14 .38 23 .68 25 832.15 29 4.28 51 .20 60 26.48 69 298.65
71 3.52 73 .06 79 18.05 90 21.27 103 .14 122 4.21 137 2.35 139 1.84
149 3.88 180 4.81 184 19.49 194 197.54 197 .16 201 245.42 218 93.77 220 19.41
225 1.53 255 .08 260 .05 267 .09 274 2.19 282 .31 326 27.09 346 17.98
362 13.11
St.75 2 10.51 12 .06 14 .64 23 1.25 25 604.24 27 173.73 29 1.98 35 .55
51 .20 60 5.49 61 2.33 69 93.27 73 .11 79 15.93 83 6.33 101 17.58
104 1.91 114 .31 122 12.56 133 .71 136 .16 137 .17 139 .73 149 1.11
159 .89 180 23.45 198 44.27 201 123.26 220 3.63 221 90.60 225 2.03 255 .36
266 .17 267 .77 274 12.82 282 .09 311 82.42 317 55.31 326 6.23 335 .10
340 .62 346 3.82 351 .10 353 211.57 357 274.60 362 49.13
St.76 2 .02 12 .06 14 2.17 23 .54 29 2.53 60 4.13 63 6.36 65 .14
69 258.27 71 42.59 73 .06 76 .07 79 23.36 90 2.90 118 1.06 122 1.29
136 .08 137 8.12 139 3.04 140 1.36 149 1.44 159 .01 180 .80 195 .43
201 475.05 220 5.15 225 2.54 244 .30 255 .01 256 .11 267 .17 282 .02
297 .21 307 .87 326 1.20 346 13.35 353 46.55 358 11.47 362 .01
St.77 2 11.85 11 .26 12 .19 14 3.19 23 .82 25 4.33 29 25.20 33 .05
35 .55 46 .10 59 1245.51 60 12.81 63 123.74 65 .28 69 175.27 71 340.29
73 .34 77 .31 79 48.85 82 .33 97 .14 114 .31 123 206.62 136 .32
137 2.14 139 5.50 141 .21 147 3.48 148 1.74 149 3.44 159 23.53 179 .08
180 30.63 184 199.36 201 24.12 209 .09 218 48.41 220 5.35 223 .79 225 2.03
229 33.57 255 .09 257 181.06 262 .51 267 .17 268 .54 271 3.14 274 68.69
282 .70 291 .06 297 .16 304 80.63 305 .66 320 .01 326 448.08 332 5.88
335 .20 346 36.11 353 246.42 362 196.53
St.78 23 .54 55 .01 60 .07 65 .14 69 17.63 78 2.37 79 1.06 139 .08
149 .11 192 .20 201 .34 238 1.04 326 2.59 346 .71 351 .10
St.79 11 .13 14 .77 22 3.48 23 .95 25 1172.38 29 12.85 30 .18 46 .10
56 .15 59 672.67 60 6.72 63 890.19 65 .56 69 109.68 71 130.23 73 .28
77 .21 79 63.72 82 .33 83 3.16 97 .14 101 5.27 122 8.37 128 216.26
129 .71 136 .16 137 .65 139 4.40 140 .45 141 .03 149 2.44 159 56.20
166 .15 173 8.97 180 153.15 184 1893.88 198 44.27 201 16.08 209 1.35 210 138.70
220 15.56 225 .51 226 10.74 234 6.60 251 .02 257 114.13 260 .05 264 .08
268 2.55 274 134.88 282 3.92 297 1.15 304 145.13 309 .07 317 173.84 326 159.54
332 5.88 335 .10 346 10.95 351 .10 353 233.94 362 540.46
St.80 2 12.28 3 1.31 11 .77 12 .26 13 .20 14 4.97 23 .14 27 1.86
29 11.17 51 .30 59 1340.09 60 3.10 63 737.97 65 .14 69 333.56 71 363.53
73 2.11 76 .07 79 22.30 83 11.46 87 1.43 130 1.06 136 1.43 139 1.13
149 2.88 159 .80 180 2.83 194 64.12 201 37.35 209 .45 225 .51 229 .44
238 .23 257 7.53 268 .15 282 1.12 297 1.16 326 17.48 346 3.89
St.81 14 .13 18 .05 20 .05 22 .87 23 .54 25 693.42 29 5.44 43 2.36
46 .10 56 .23 60 50.46 69 9.14 71 5.00 73 13.68 77 3.49 79 1.06
82 1.31 85 49.53 93 .53 98 2.23 113 1.53 118 .53 122 14.65 125 .56
130 2.12 139 4.03 149 1.44 159 4.45 165 31.97 166 6.28 168 .34 180 53.60
184 1361.69 196 1.48 209 7.15 220 38.17 224 5.08 228 25.16 234 1054.30 239 .53
262 4.96 267 1.38 268 .23 274 6.41 282 15.61 285 18.98 294 .07 297 4.12
305 1.32 309 .02 310 3.99 320 .26 326 6.23 331 .04 335 7.55 337 .10
354 .14 361 592.96
St.82 2 61.92 10 .23 17 1.34 29 9.88 54 4.66 56 .08 61 .01 63 1.26
69 3.32 71 54.59 73 .06 79 3.19 82 .33 90 2.45 122 16.16 137 12.91
139 5.50 140 3.16 180 30.63 184 149.52 195 2.46 200 .71 201 2.68 220 3.78
225 .51 226 4.01 234 13.20 238 .58 239 .16 267 .09 268 .15 282 .17
307 20.31 310 .66 326 322.82 335 .71 346 10.70 353 250.25
St.83 2 6.11 9 25.96 21 1.02 22 .87 23 .27 29 8.40 35 20.83 45 .34
54 11.05 60 13.66 65 .83 69 1.66 71 17.06 73 .97 101 5.27 104 3.81
105 7.58 111 .16 113 .31 120 3.04 122 2.09 130 1.06 132 1.42 136 .71

137 .20 166 .45 176 1.19 177 92.73 180 158.02 184 74.76 195 9.07 198 44.27
209 .36 220 2.66 221 167.38 223 11.11 224 2.84 225 1.02 227 4.63 228 12.58
234 983.50 235 1317.20 245 1.58 246 .11 257 5.69 267 .09 282 1.31 285 49.25
291 .06 292 .10 297 1.32 305 .66 307 27.44 310 .66 317 59.16 326 9.35
330 265.63 332 29.41 335 2.76 346 6.70 355 .07
St.84 2 30.74 10 .91 14 1.53 23 1.36 29 .23 34 2.54 35 .55 43 .34
59 2156.52 60 1.46 69 6.93 70 7.93 73 1.20 76 20.83 87 4.04 101 94.31
122 4.88 136 .24 137 .16 139 .71 149 3.10 159 .28 165 63.31 166 .60
178 .47 183 452.40 195 2.94 201 24.21 221 211.05 223 .83 225 .51 229 58.56
234 123.70 245 3.15 246 .68 247 .09 256 .28 267 .09 268 .31 279 .23
290 5.43 307 5.51 310 .87 311 79.98 326 141.44 337 .10 342 39.19 346 2.35
360 438.94 362 171.94
St.85 2 27.38 3 1.28 11 .38 14 3.32 23 1.90 29 15.81 34 .80 35 1.10
59 1084.79 60 21.30 61 .07 69 26.09 71 7.14 73 2.57 76 2.80 79 1.06
87 .51 90 7.36 104 5.72 122 2.09 136 .08 139 1.10 159 2.67 178 .08
180 7.66 183 870.96 195 .31 201 45.55 209 .09 221 313.77 223 .79 224 .35
225 .99 227 5.41 229 33.57 234 198.00 238 .12 256 .17 259 2.68 268 .46
277 .07 307 3.74 310 .66 311 29.48 317 2261.86 326 62.32 346 53.05 360 162.00
362 368.49
St.86 2 5.97 14 .26 60 2.17 68 .53 69 .83 71 7.65 98 1.63 107 .10
122 6.28 125 .24 195 .15 224 .35 228 18.87 234 13.20 238 .12 245 1.58
251 .01 282 .09 285 .24 294 .14 307 .62 310 66.23 317 637.05 346 .90
St.87 2 23.25 29 44.48 60 2.51 69 114.19 71 44.45 73 .06 104 1.91 122 4.92
137 8.60 139 3.30 140 1.36 167 .45 180 22.97 195 1.54 200 .18 225 .51
234 6.60 238 6.72 255 .23 282 .26 297 .33 307 45.80 310 13.96 317 134.10
326 46.74 335 .10 346 38.85 353 596.76
St.88 14 .38 23 .27 29 1.98 54 37.47 60 9.97 61 .76 69 132.08 71 .01
73 .06 78 7.65 79 13.81 122 2.09 133 .71 137 4.22 139 4.40 149 .11
159 9.79 178 .02 200 .18 201 125.94 225 2.54 255 .14 282 .09 312 .34
326 7.48 346 3.51 351 1.22 353 248.01 362 196.53
St.89 2 1.11 14 .77 23 3.02 25 225.12 29 .99 31 .06 35 .55 43 .34
51 .10 60 7.37 61 1.12 69 102.40 71 .27 73 .11 76 .21 79 2.12
83 9.49 85 49.53 103 .14 122 10.47 136 .08 139 .37 149 .78 159 5.34
170 1.17 184 49.84 200 .36 201 568.08 209 .09 225 .51 229 16.78 250 10.04
268 .39 297 .16 309 .05 326 1.87 346 .33 351 .71
St.90 2 2.46 23 .14 61 .15 69 14.95 71 1.54 78 17.44 79 1.06 85 49.53
116 .15 122 2.09 123 103.31 139 .37 159 17.27 200 .18 201 187.57 229 33.57
257 3.12 326 1.25
St.91 14 .13 22 9.37 23 1.50 27 8.64 29 18.29 30 .18 33 .10 41 .11
55 .18 56 .77 59 385.26 60 9.14 61 .21 69 34.95 71 18.56 73 .63
79 55.22 82 1.96 83 3.16 104 1.91 122 14.65 139 .73 141 .03 149 9.98
159 28.00 180 22.97 184 249.19 195 .15 201 10.72 209 1.70 220 5.94 223 .79
225 1.53 234 19.80 255 .23 256 .28 260 .10 268 3.32 274 34.94 289 7.47
297 .16 310 1.33 317 104.76 326 121.52 335 .20 346 8.92 351 .41 362 98.26
St.92 22 .87 29 .49 55 .18 60 .43 79 2.12 97 .07 139 .37 192 .35
209 .09 229 16.78 238 .46 268 .15 326 2.49 346 .16
St.93 55 467.53 160 1.81 192 1.05 229 16.78 238 5.77 309 .02 326 1.25
St.94 13 .10 23 .41 57 29.13 59 167.31 60 3.69 63 194.67 65 .14 69 46.75
71 2.40 73 .11 83 6.33 85 49.53 122 2.09 149 .11 159 8.13 178 2.57
195 .15 200 .18 201 8.04 209 .09 225 1.02 229 33.57 238 .12 246 .11
274 11.82 282 .09 309 .05 311 106.40 346 .33 362 147.40
St.96 22 1.74 23 .14 55 .18 56 .08 60 6.94 61 4.92 69 3.32 73 .17
114 .15 118 .53 122 18.84 125 .24 141 .08 149 .11 165 15.99 166 3.57
168 1.02 184 24.92 195 .31 198 44.27 209 .18 225 .51 228 31.45 238 .81
246 1.25 251 .27 256 .06 267 2.67 268 .08 277 .07 282 .44 285 .72
294 .03 310 223.01 320 .01 326 .62 335 1.02 340 .52 345 14.67 362 24.57
St.97 14 .13 18 .25 22 .87 23 1.36 29 1.48 35 2.19 41 .11 51 .10
54 22.40 56 1.85 60 6.94 65 2.10 69 135.29 71 6.57 73 17.95 77 75.58

79 27.61 103 .14 104 1.91 122 2.09 129 3.55 141 .13 149 3.88 159 3.56
165 105.80 166 .15 180 130.18 184 2015.33 187 .11 198 44.27 201 2.68 203 .06
220 13.14 224 3.37 225 3.56 235 598.90 246 .45 256 1.16 257 21.11 260 .10
268 1.00 274 25.63 279 .23 282 .44 285 .48 286 14.85 297 .99 305 .66
310 58.10 320 .05 326 3.74 335 .61 346 .74
St.98 14 .26 23 .68 29 25.20 43 .34 54 12.61 56 .15 60 28.07 63 513.35
65 1.11 69 24.09 71 33.47 73 .51 74 2.10 77 4.31 79 52.04 97 .21
101 2.11 113 .61 122 6.28 130 4.24 137 2.44 141 .03 149 .55 159 30.39
166 .15 171 11.58 180 68.92 184 1520.09 195 .15 209 .62 220 3.64 225 .51
234 13.20 246 .11 255 .09 257 3.54 268 .08 274 35.02 282 .26 309 .02
311 47.46 317 337.55 326 34.90 335 .10 346 56.46 353 433.76 362 147.40
St.99 2 6.40 14 .26 23 .14 29 2.47 60 .43 69 130.21 73 .11 76 .07
122 4.19 125 .08 137 .13 149 .11 159 1.78 195 .31 200 .54 220 2.25
229 16.78 234 52.80 245 1.58 249 17.45 274 3.20 282 .09 285 .72 297 .66
307 2.49 310 21.26 326 149.57 346 .16 362 221.10
St.100 2 19.76 14 .26 22 .87 29 16.07 35 20.83 43 .34 54 9.17 60 4.02
63 150.32 65 .83 69 304.80 71 24.22 73 .34 79 1.06 104 7.60 122 .07
129 1.42 131 1.00 136 .08 137 2.73 139 .97 149 .44 166 .15 180 4.95
184 211.97 195 2.69 200 .18 201 8.05 210 158.62 215 .05 217 15.23 220 12.75
225 .38 234 70.20 235 658.90 249 9.43 251 .01 255 .01 257 6.68 282 .12
307 45.55 310 .17 311 65.18 317 1259.41 323 1.78 326 393.71 332 25.58 346 2.53
353 118.28 362 .73
St.101 2 22.79 14 .13 20 .05 21 1.02 23 .27 29 3.05 35 103.06 43 .34
54 1.88 60 32.30 61 .10 63 3.28 65 1.25 69 9.14 73 3.13 90 2.45
105 3.79 113 .31 118 .35 122 2.09 133 1.42 136 .79 137 3.54 139 2.32
149 .89 159 26.79 166 .15 176 .15 177 15.69 180 76.58 195 8.16 200 .36
201 2.68 203 .18 209 .09 215 .06 223 .79 225 2.03 228 6.29 234 39.80
235 2322.90 238 2.43 246 .11 255 .05 256 .11 261 60.45 282 .35 297 1.15
305 .33 307 44.91 309 .02 314 .16 320 .05 326 29.29 332 5.88 346 22.52
358 .34 362 49.13
St.102 3 50.39 14 .13 43 .34 63 298.42 69 15.61 73 .17 136 1.43 137 .12
139 1.21 149 .22 229 18.66 256 .11 326 .88 349 .04 351 .10 362 1.04
St.103 2 .19 11 .26 14 1.91 20 .05 29 5.93 35 2.74 43 .67 65 .69
69 221.15 71 11.92 73 .51 79 7.43 101 3.16 122 4.19 130 1.06 139 10.99
149 .55 164 43.98 176 .45 180 30.63 184 24.92 195 .31 209 .98 225 1.53
234 19.80 256 .06 262 42.17 268 .08 307 20.58 310 1.99 317 92.20 326 10.59
335 .10 346 9.72
St.104 38 7.96 69 4.70 78 20.46 125 .01 195 .14 228 25.07 234 4.30 251 .03
294 .02 310 171.04 311 107.24
St.105 14 .13 23 .54 26 2.62 29 50.90 31 .18 41 .11 54 3.62 56 .15
59 622.93 60 8.67 65 1.81 69 173.76 71 143.58 73 .28 77 .62 79 31.86
83 3.16 97 .07 113 .31 139 1.47 149 1.77 159 31.15 177 48.53 180 68.92
184 274.11 198 44.27 201 2.68 209 2.77 218 48.41 224 .71 225 1.02 226 7.94
229 16.78 235 415.70 255 .14 257 58.63 268 .15 274 29.82 282 1.66 285 .48
294 .07 297 .99 305 .99 309 .05 310 3.32 311 161.64 317 346.63 326 20.29
332 5.88 346 2.86 362 24.57
St.106 10 .46 34 .55 51 .20 60 .43 61 .14 69 3.32 122 16.74 125 .16
228 44.03 245 .79 251 .34 254 .03 267 .09 294 .14 310 229.59 317 19.26
327 .09 345 104.27 351 .91
St.107 3 1.83 13 .20 23 .14 29 .99 31 .06 59 .48 61 .16 69 1.66
73 .11 76 .07 77 .72 85 99.07 130 1.06 141 .03 159 4.45 200 .54
229 272.69 310 4.99 326 1.25 333 .04 351 .61
St.108 29 8.90 51 .20 60 1.08 69 86.55 79 1.06 122 8.37 137 .49 140 .45
159 .89 166 .30 195 1.23 200 1.25 222 .31 234 219.20 245 6.30 251 .02
282 .17 307 4.37 310 32.94 311 240.86 326 46.74 327 .09 346 .82 362 24.57
St.109 2 .91 9 13.93 29 18.78 60 2.82 69 71.46 85 49.53 137 8.30 139 1.47
140 2.26 149 .22 166 .15 167 .45 195 1.54 220 .81 222 .31 225 .51
234 72.60 238 .23 245 2.36 255 .27 282 .09 287 17.68 307 13.10 310 6.65

311 369.65 326 14.33 346 13.14 353 466.64 362 221.10
St.110 2 .02 9 9.63 14 .13 29 4.14 60 1.00 61 1.03 63 135.70 65 .42
69 341.13 73 .17 76 .34 77 .31 90 1.48 104 11.70 137 2.17 167 .30
184 51.17 195 .15 196 .63 201 .82 220 6.47 223 .83 234 334.60 249 8.46
274 5.46 282 .04 297 .10 307 17.07 310 2.84 326 10.55 335 .10 346 .99
362 .11
St.111 2 7.65 3 1.24 9 9.64 10 .23 11 .13 14 2.30 21 .17 23 .95
29 7.41 42 4.04 43 .67 59 997.43 60 1.95 61 1.27 63 331.87 69 51.04
73 1.54 76 5.61 77 .21 83 3.16 85 49.53 90 7.36 101 5.27 104 1.91
122 42.18 136 .08 137 1.52 139 4.03 140 .45 149 .89 159 1.78 166 .60
178 .36 196 2.95 201 6.18 225 1.53 227 1.35 234 446.70 235 2.40 255 .09
268 .23 274 3.20 297 .16 307 3.74 310 5.32 317 844.11 326 45.49 346 4.98
353 123.18 362 270.23
St.112 2 .19 14 .77 25 325.18 29 4.06 59 294.59 60 1.28 61 .39 63 273.39
65 .14 69 275.66 71 .11 73 .06 76 .14 79 1.06 90 .65 122 .18
139 1.67 149 .22 196 1.12 201 .52 234 40.20 274 46.69 307 6.25 310 2.49
311 213.22 317 1151.14 326 150.99 346 .09 362 116.57
St.113 2 5.21 11 .13 14 .64 23 .14 29 34.59 35 1.10 43 .34 60 .87
63 177.19 65 .14 69 290.19 71 23.65 73 .17 90 7.36 104 1.91 133 1.42
137 2.05 140 .90 149 .22 201 2.68 220 7.41 229 16.78 255 .14 270 1.25
274 3.20 277 .07 282 .09 285 .24 307 27.44 310 1.99 326 381.40 346 1.31
353 272.54 362 98.26
St.114 2 20.01 29 1.45 60 .94 69 26.13 71 5.27 90 10.60 137 .04 139 .95
140 .90 164 48.92 184 69.76 229 11.46 234 18.60 307 5.32 310 .30 311 25.59
323 1.78 326 88.60 346 .04 353 337.85 362 358.39
St.115 60 .22 69 .83 78 41.28 118 .53 122 2.09 125 .16 228 18.87 238 .12
251 .12 273 .02 282 .09 306 .05 310 58.01 345 3.39
St.116 14 .26 23 .41 25 2550.53 29 .99 60 6.07 61 20.98 69 69.27 71 .06
73 .11 74 .90 76 .07 77 .10 78 21.07 79 7.43 122 2.09 137 .02
139 .73 149 .11 159 .89 184 24.92 229 67.13 245 .79 255 .05 257 1.49
267 .09 326 1.25 333 .06 362 73.70
St.117 31 .06 60 .43 69 2.49 77 .41 97 .42 199 .18 229 21.21 268 .08
326 1.25 362 24.57
St.118 51 .10 61 2.26 69 53.22 71 5.81 78 27.78 137 7.03 140 .90 333 .01
346 2.53 353 46.75 362 73.70
St.119 29 .99 60 .43 61 .22 68 .53 69 15.46 73 .06 78 123.00 97 .07
120 2.56 122 6.27 166 .15 180 7.66 200 .36 209 .09 234 13.20 251 .03
285 .48 300 .26 310 5.63 311 153.62 323 1.78 326 3.74 327 .09 345 14.06
St.121 69 12.84 71 .16 125 .01 139 .65 229 .28 310 18.01
St.122 9 14.44 14 .13 29 9.88 54 15.86 59 303.43 60 5.72 63 43.95 65 .42
69 9.97 71 .76 73 .11 76 .34 132 .71 137 7.38 139 12.09 140 1.36
159 4.89 166 1.19 180 15.32 202 .24 209 .27 234 33.00 238 1.62 255 1.18
282 .09 307 18.72 310 4.65 311 191.56 319 .02 326 45.62 328 .04 346 26.99
353 558.54
St.123 34 .27 38 133.21 54 .07 60 .43 61 .65 122 2.09 125 .16 178 43.26
228 18.87 238 .12 245 .79 310 58.66 319 .05 345 127.46 362 49.13
St.124 14 .38 29 2.47 60 2.82 61 .13 65 1.81 69 154.05 71 18.72 73 1.82
77 .10 90 4.90 104 7.62 122 14.65 129 .71 137 9.53 139 4.03 140 3.61
159 .89 167 1.04 180 7.66 202 .12 203 .06 209 .27 220 1.31 225 1.02
234 19.80 235 41.20 238 1.16 251 .03 255 1.18 257 2.38 285 .24 307 29.94
310 2.66 324 .01 326 17.45 346 6.45 353 1032.64 362 73.70
St.125 69 174.93 167 .30 310 .66 353 241.09
St.126 3 36.33 69 1.35 229 38.48 250 .97 362 49.13
St.127 55 .18 60 .22 61 1.33 122 2.09 125 .40 139 .73 146 .21 228 75.48
237 .06 251 .12 254 .07 282 .09 297 .16 306 .08 310 12.63
St.128 29 .49 60 .22 69 39.16 73 .06 75 .06 125 .08 139 .73 201 2.68
202 .12 228 12.58 310 46.63 321 .22 345 6.70
St.129 2 .18 14 .38 22 1.74 25 362.78 29 9.39 30 .06 51 .10 56 .08

```
59   .41  60   1.52  61   .33  65   .28  73   .80  74   1.48  76   6.84  77   1.54
78  39.70  79   2.12  83   9.49 113   .15 114   .15 122   6.28 123  103.31 139   2.56
149   .11 159  53.47 180   7.66 201  69.67 209   .54 214   .14 225   .51 229  83.92
234 237.00 237   .03 255   .05 257   .25 265   3.57 274   7.00 307   7.48 310  10.63
311  64.73 317 681.83 346   1.47 362  24.57
St.130 14   1.28  23   .14  29   5.44  60   4.12  65   .56  69  38.21  71  13.07  73   1.71
76   .07  77   .10  78  55.15  90   4.90 104   3.81 122   2.09 137   2.60 139   2.20
140   2.26 159   1.78 166   .30 167   .60 180  30.63 209   .18 225   1.02 229  16.78
234   6.60 238   1.28 255   .18 307  11.23 317 309.23 319   .02 326   1.25 346   3.43
353 353.12 362  49.13
St.131 21   .34  54  10.73  60   3.90  61   .20  63   2.67  65   .83  69  30.34 122   6.28
131   .50 137   .24 159   4.60 225   2.03 234  13.20 245   .79 285   .96 307   2.49
310  44.60 311 191.65 330  80.09 362  49.13
St.132 29   .49  54  17.62  65   .28  69  16.78  71  11.30  73   .11 129   .71 137   .74
139   1.47 159   4.25 202   1.19 209   .18 224   .53 234  44.40 255   .54 307   1.25
320   .07 323  13.02 353  47.33
St.133 9   4.13  14   .26  56   .54  65   .56  69   2.69  73   .11  77   .31  79   2.12
97   .62 130   4.24 133   .71 139   1.10 149   .11 153   .15 159   5.38 177 1207.29
194 221.50 209   .62 224   .18 235 169.10 255   .05 268   1.00 274   4.12 282   .09
331   .02
 0
```