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CONTENTS

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A survey of the nitrate and phosphate levels of inshore marine waters from Malta (Central Mediterranean)

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ABSTRACT

The nitrate and phosphate levels were monitored over a one-year period in three inshore localities in Malta. There were recorded no seasonal variations in nutrient levels at Marsaxlokk bay. At Mistra bay a slight decrease in nitrate-nitrogen was recorded during the autumn and winter periods. At both these locations, however the nitrate-nitrogen was generally below 1/µg-at/l and phosphate-phosphorus always less than 0.2 /µg-at/l. The values are typical of most areas in the Mediterranean. The concentrations of nutrients at Rinella creek were consistently manifold higher and peaked during the winter months. This, very probably, reflects the combined effects of organic pollution and rainfall on this very enclosed creek. Occasionally, short-lived high levels of nitrates were recorded at Marsaxlokk and Mistra bays. These seem to originate from agitation of bottom sediments.

Introduction

The scarcity of nitrates and phosphates in the Mediterranean was first described by Thomsen (1931) and subsequently confirmed by numerous workers. There is no published information on the distribution of nutrients in the inshore marine waters of Malta and thus this study presents the first observations on the occurrence of these nutrients that play such a vital role in primary production. The nutrient analyses described in this study were performed in connection with oyster growth trials. The results of these trials as well as a description of the hydrological conditions of the areas under study have been described elsewhere (Agius *et al.*, 1978). A preliminary survey of the phytoplankton populations of the areas under study has been carried out by Jaccarini *et al.* (1978).

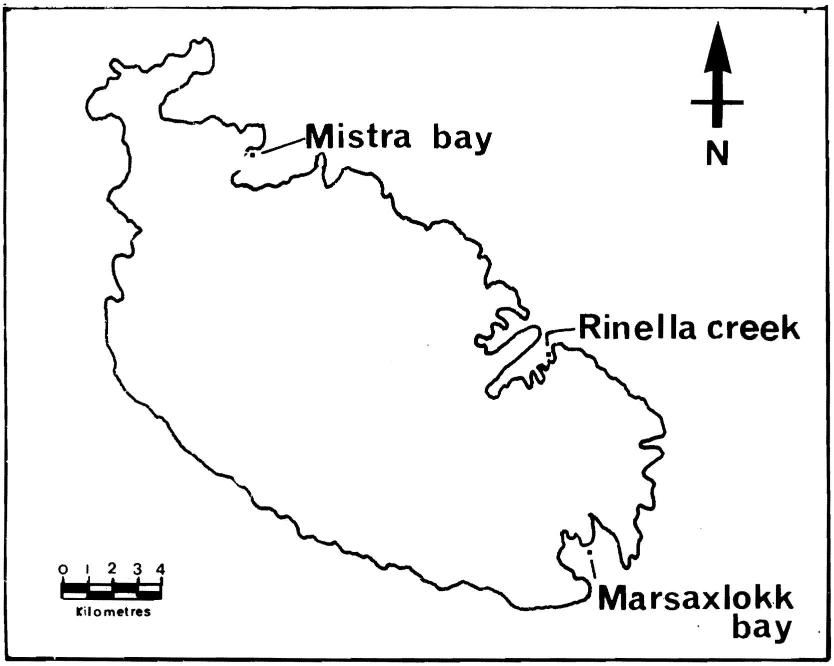


Fig. 1. Map of Malta showing sites from where samples for nutrient analysis were taken.

Materials and Methods

Sampling

Water samples were taken from Marsaxlokk bay, Mistra bay and Rinella creek (Fig. 1). Sampling was carried out at roughly two-weekly intervals. From February 1975 to March 1976 samples were taken from a depth of 3m from each location. From September 1975 to March 1976 samples were also taken from a depth of 8m from each location. Water samples were collected by means of a 3-litre capacity Van Dorn bottle and were transported to the laboratory in polyethylene bottles at 0 - 5°C in a thermos flask. Care was taken not to trap any air bubbles with the water samples. All samples were analysed for their nitrate and phosphate content. While in about 50% of the cases analyses were performed within three hours, at other times delays were unavoidable and samples were deep-frozen in a domestic-type freezer at its lowest temperature setting.

Determination of nitrate

This was carried out following the procedure described in Strickland and Parsons (1965) whereby the nitrate in sea water is reduced to nitrite when a sample is run through a column containing amalgamated cadmium filings. The nitrite thus produced is determined by diazotising with sulphanilamide and coupling with N-(l-naphthyl)-ethylenediamine to form a highly coloured azo dye, the extinction of which is measured at 543 nm. No correction was made for any nitrite initially present in the sample so that the results of the estimations actually represent the sum total of the nitrate and nitrite content. However, the latter is known to be normally much lower than the former.

Determination of phosphate

This was carried out employing the method for reactive phosphorus (low levels) described in Strickland and Parsons (1972). The water sample is allowed to react with a composite reagent containing molybdic acid, ascorbic acid and trivalent antimony. The resulting blue-coloured complex is extracted with isobutanol and its extinction measured at 690nm.

Results

The seasonal variations in nutrient levels in the three localities under investigation are shown in Fig. A. & B. The nitrate levels are expressed as µ/g-at/N/l and the phosphates as µ/g-a/t P/1.

As the plots show there were no consistent differences in nitrate or phosphate levels between the two depths at any of the sites tested. The nitrate-nitrogen levels were in most instances much higher than those of phosphate-phosphorus. The only consistent differences that could be detected between the nutrient levels at Marsaxlokk and Mistra was a slightly lower level of nitrate-nitrogen at Mistra during autumn and winter. The nutrient levels at Rinella were consistently much higher than those at the other two sites.

There were no marked seasonal variations in nutrient levels at Marsaxlokk bay. At Mistra bay a slight decrease in nitrate-nitrogen was recorded during autumn and winter. At both these locations, however, the nutrient levels recorded were very low throughout the year (NO_3-N generally below l/µg-at/1 and PO_4-P always less than 0.2 µ/g-at/1) except for some occasionally very high nitrate values which appeared to be of short duration. The levels of nutrients in Rinella waters showed significant increases during the winter months. In fact while the nitrate levels were persistently higher from November to February, the phosphate levels were significantly higher in January-February. Throughout the remaining part of the year the nutrient levels at this site were more or less constant (NO_3-N mainly between 1 and 3 µ/g-at/1 and PO_4-P mainly between 0.1 and 0.4µ/g-at/1).

Discussion

The levels of nitrates and phosphates recorded in this study support the now well-established contention that nitrates and especially phosphates are severely depleted in Mediterranean waters (for review of the pertinent literature see Agius and Jaccarini, 1982). Regions under the influence of fresh water or sewage outfalls are exceptions.

The consistently low values of nitrates and phosphates at Marsaxlokk and Mistra bays mean that these nutrients are consumed as fast as they are made available. On the other hand, the data for Rinella creek indicate that some factor other than nitrates or phosphates is normally limiting. The consistently higher nutrient levels at Rinella very probably reflect a high degree of organic pollution. Sewage effluent contains generous amounts of plant nutrients. Moreover, the possibility of fresh water outflows from the lower water table of Malta contributing to the nutrient levels must not be overlooked. Although several such outflows have been located below sea-level in various coastal areas, their contribution to nutrient availability for our coastal waters remains to be investigated.

The levels of nutrients recorded in this study were, to a large extent, reflected in the standing crop levels; these latter have been published elsewhere (Agius *et al.*, 1978;

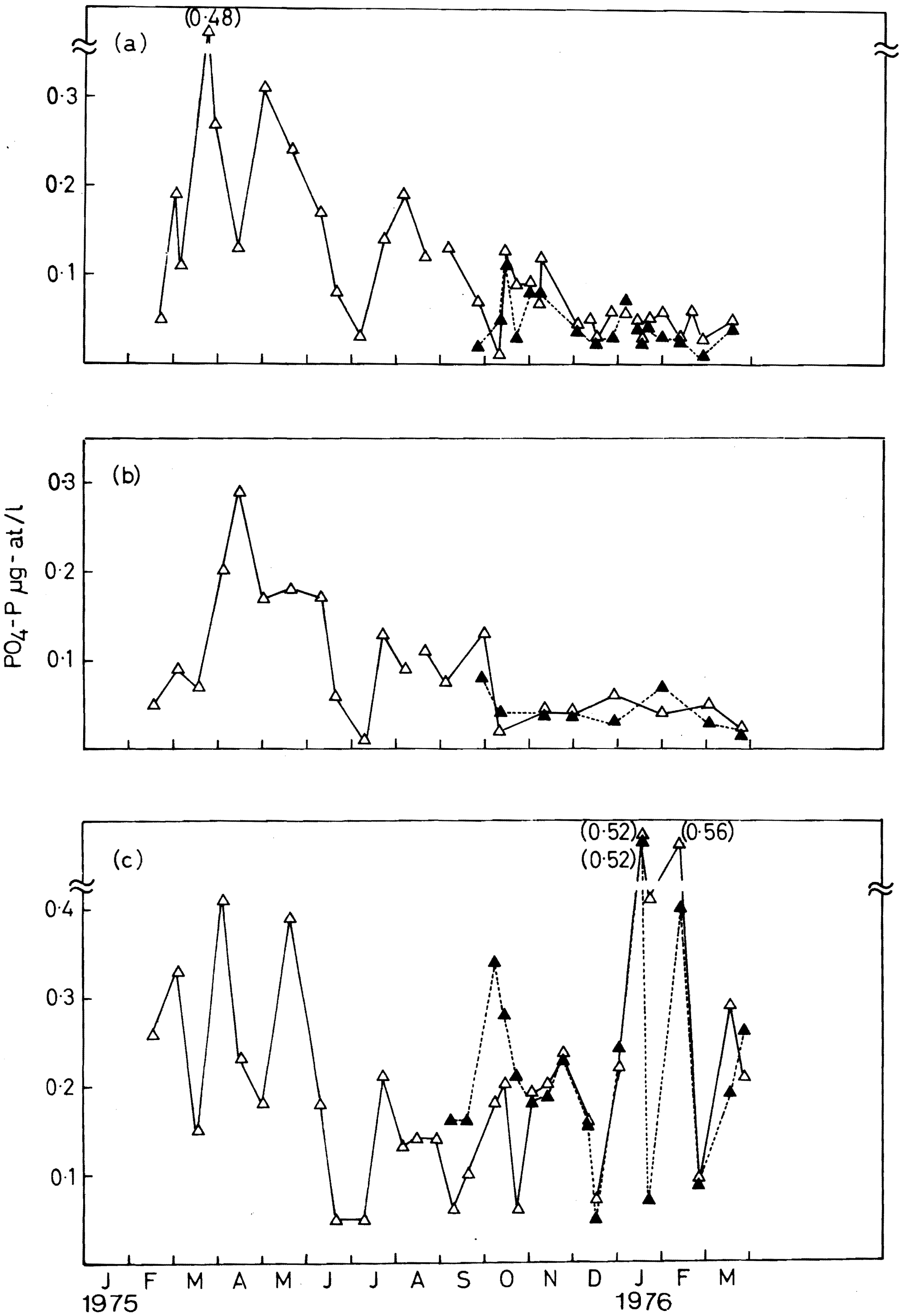
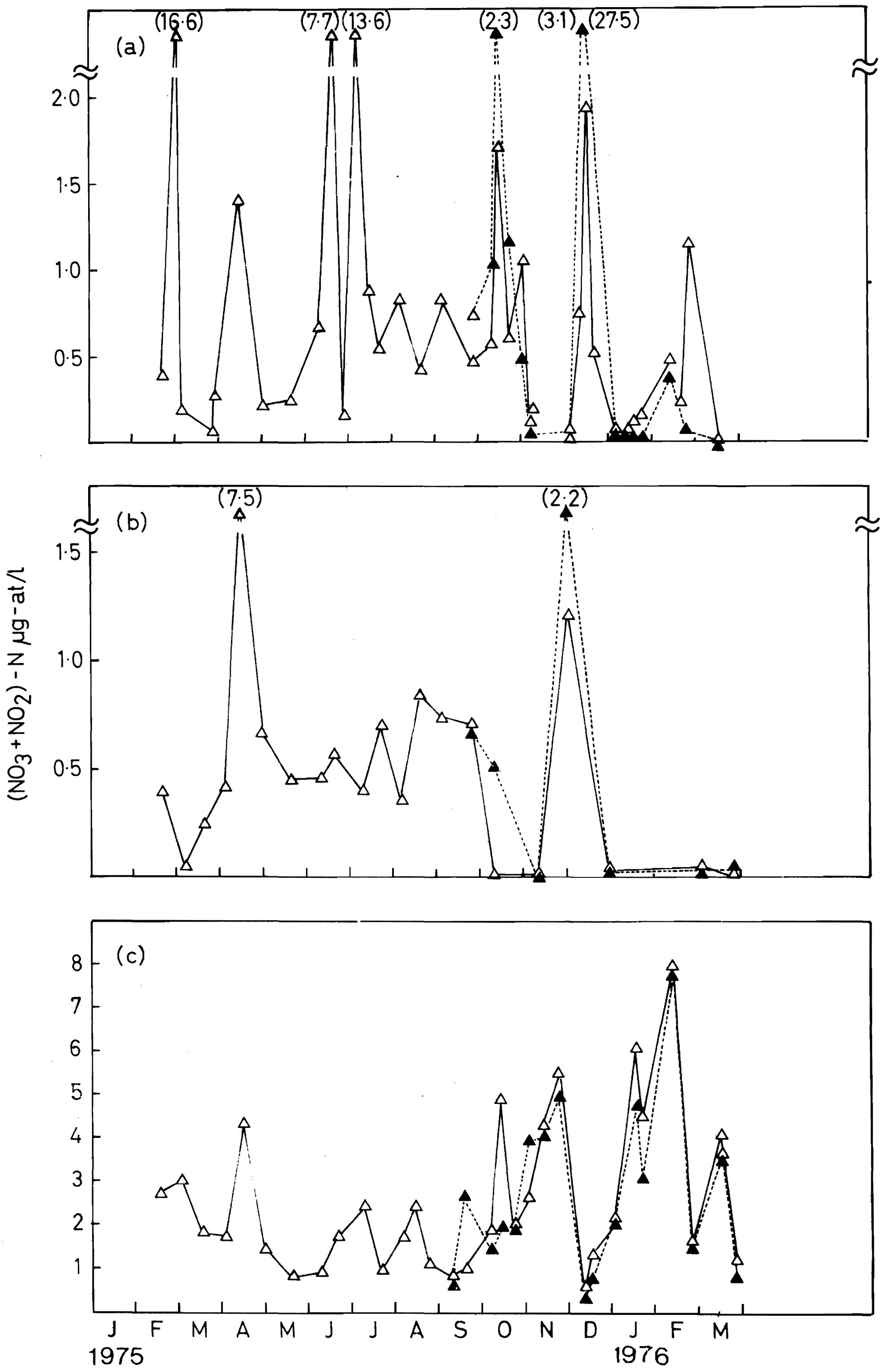


Fig. 2. Seasonal variations in nutrient levels in (a) Marsaxlokk bay; (b) Mistra bay and (c) Rinella creek.

△ – A represents the nutrient levels at 3m. depth

▲ – A represents the nutrient levels at 8m. depth.

(A)



(a)
(16·6)
(7·7)
(13·6)
(2·3)
(3·1)
(27·5)
2·0
1·5
1·0
0·5
(b)
(7·5)
(2·2)
1·5
1·0
0·5
(NO3 + NO2) - N µg-at/l
(c)
8
7
6
5
4
3
2
1
J F M A M J J A S O N D J F M
1975
1976

(B)

Jaccarini *et al.*, 1978), Particularly striking is the remarkable correspondence between standing crop increase and nutrient concentration decrease recorded during a phytoplankton bloom that occurred at Rinella in February 1976.

Throughout this study some attempt was made to monitor the sensitivity of nutrient levels to rainfall. It was observed that while rainfall does not significantly affect the waters of Marsaxlokk and Mistra bays, heavy rains considerably raised the nutrient levels at Rinella. Thus the high nutrient levels in January-February 1976 followed closely upon heavy rains and it seems that the higher winter nutrient values at this location are associated with the rainy season. This is probably a reflection of the more enclosed nature of Rinella creek enabling the retention of a much larger volume of rain water. Significantly, the salinity of the waters in this creek has been observed to drop, even if marginally following upon rainfalls. The salinities at the other two sites remain unaltered.

The occasional and short-lived high nitrate values observed at Marsaxlokk and Mistra are difficult to interpret. It was noted that on some of the instances when such high levels of nitrate were recorded, the water was rather turbid. Although the exact origin and nature of the suspended matter are still unknown it seems most likely that they originated from bottom sediments. What forces bring them into suspension and their lifetime in this state also remain to be thoroughly investigated. The possibilty of sediments acting as potential stores of nutrients in the sea has been identified by various workers (see for example Hood, 1974). It thus became apparent that the sediments in the areas under study may be potential stores of nutrients which are released when agitated into suspension. This hypothesis was tested by collecting samples of sediment from Marsaxlokk bay in October 1975 and mixing 200 ml portions of this sediment with 600 ml portions of synthetic sea water prepared using Analytical Grade reagents. These were stirred vigorously, allowed to settle and after thirty minutes had their nitrate and phosphate levels monitored. Mixing and nutrient analysis was repeated at 30 min intervals for two hours. The results are tabulated in Table 1.

Table 1. Changes in the levels of nitrate and phosphate in artificial sea water after mixing with sediment.

Time (hrs)	$(NO_3 + NO_2) - N$.conc. µ/g-at/l	PO_4-P.conc. µ/g-at/l
0*	0.31	0.12
½	5.37	2.73
1	5.60	3.50
2	5.60	5.23

*synthetic sea water only

Nitrates and phosphates were released in large amounts on mixing with sediment. Thus, mixing processes involving sediments could well explain the occasional high nitrate values recorded. Why the increase in nitrate levels is not accompanied in nature by an increase in phosphates could be explained on the basis of the marked differences in the solubility of these two classes of compounds. Nitrates are very soluble and thus liable to go into solution and remain so for a long time. Phosphates are much less soluble and on agitation of the sediments may exist only temporarily in a finely suspended state before they resettle on the bottom. Thus while in raw sea water samples phosphates are not likely to be detected they could have been detected in the mixing experiment because of the periodic agitation, the relatively small volumes of the water, and the relatively short time given for it to settle.

Needless to say other phenomena such as some form of upwelling or man-made perturbations may be responsible. Various physical, chemical and biological parameters of the areas described here have subsequently been monitored in an attempt to clarify this problem. This will be published separately.

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On the Biology of some rice-field weeds in Sardinia: Cotula and Heteranthera

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ABSTRACT

The biology and ecology of *Cotula coronopifolia* L. *(Compositae), Heteranthera rotundifolia* (Kunth) Griseb. and *Heteranthera reniformis* Ruiz & Pavon *(Pontederiaceae),* three new weeds naturalized in rice-fields of central-southern Sardinia, are described. Attention is focussed on the degree of propagation of these "taxa", as a consequence of their suitability for the environmental conditions of Sardinian rice-fields, where it seems that marked convergences exist with regard to the original habitat of these species.

Introduction

Rice growing is not a tradition in the island of Sardinia, and has only been introduced recently to exploit the salty soils reclaimed from vast coastal marshlands (Aru & Baldaccini, 1961).

Rice is cultivated in the Oristano region (central-western Sardinia) and in the Sarrabus (Muravera, in the SE), covering an area of some 1,600 ha. In contrast to the rice-growing areas of northern Italy where numerous studies on the flora and vegetation have been conducted, including those by Pignatti, 1957; Pirola, 1964; Pruneddu, 1969; Piccoli, 1979; Piccoli & Gerdol, 1981, Sardinian rice-fields have been little studied, apart from a few observations on floristics and distribution of adventitious rice-field weeds in the Oristano region and at Muravera (Marchioni, 1967; De Martis & Marchioni, 1975; Marchioni & De Martis, 1982).

Since a floristic, and especially biological, knowledge of rice-field weeds is essential if exploitation of soils suited to rice-growing is to be improved, we have focussed our attention on three species in particular, acquired only recently and presently rapidly spreading in Sardinian rice-fields: *Cotula coronopifolia L., Heteranthera rotundifolia* (Kunth) Griseb. and H. *reniformis* Ruiz & Pavon.

Materials and Methods for Germination Tests

Cotula coronopifolia, Heteranthera rotundifolia and *Heteranthera reniformis* seeds were collected from dry capitula and capsules in September 1985 and stored dry in parchment bags at laboratory temperatures (18-23°C). These were used in monthly germination assays of seeds which were performed all year round. Only the data for April, May and June are reported here, firstly because these months coincide with the preparation and growing periods in Sardinian rice-fields and secondly because the results are more significant. In the three species examined, first germinations were observed between February and March: *H. rotundifolia* 28% in February; *H. reniformis* and *C. coronopifolia* respectively 33% and 20% in March, after 15 days culture.

The seeds were examined under a microscope and were found to be intact and homogeneous in size and colour. Each monthly assay consisted of four replicates of 50 seeds each for each species. Seeds were placed to germinate in glass petri dishes (Ø 6 cm) on Whatman No. 2 paper wetted with 5 ml of deionized water. Temperature was kept constant at 20°C and a light regimen of 12 h light, 12 h dark was maintained with Philips TL tubes 40W/33RS providing 1800 lux cm^{-2} s^{-1} (Bertagnin climate chambers type 500). Optimum experimental conditions were determined after preliminary tests under different temperature and light conditions. The seeds were checked daily and considered as germinated when the radicles reached 2 mm in length.

Results of Germination Tests

The results, shown in Table I, reveal the good germination ability of *Heteranthera rotundifolia* and *Heteranthera reniformis* seeds in May and June. Germination percentages as high as 95% and 72% respectively were reached after just 5 days and 100% was obtained after another 10 days, for *H. rotundifolia* and *H. reniformis.*

By contrast, despite exhibiting good germination ability, *Cotula coronopifolia* seeds attain or exceed 80% germination only after 15 days culture in May and June.

The germination behaviour observed in 1986 reflects that noted in tests conducted in 1983 and 1984.

Discussion and Conclusions

The three species and their biology in Sardinia will be examined separately in relation to germination tests and field observations.

Cotula coronopifolia L.

This species, a native of S. Africa (Tutin, 1976), is almost considered cosmopolitan due to its extremely wide distribution. It readily adapts to a wide variety of climates and environments. In its country of origin it thrives in humid marshlands and flowers from May to February (Adamson & Salter, 1950) or September to May in brackish and freshwater of Australia (Aston, 1977).

In the authors' opinion, the most likely hypothesis to explain its spread, is that advanced by Corillon & Lollierou (1956) but its extension and subsequent establishment is undeniably to be attributed to its broad ecological range. In Sardinia this species grows equally well in fresh or sea-water marshes on wet or dry sandy-loamy soils and on filler soils (De Martis & Marchioni, 1975). It flowers from April-May to September-October and throughout this period produces an extremely larger number of seeds (35-50 per capitulum) which can germinate over different periods of time (see Tab. I, about 80-90% in 15 days) provided that humidity is minimum. Its biological cycle is closely related to the absence or continuous presence of water, hence it can be either an annual (T scap) or a stoloniferous perennial (I scd). In view of its biology, it is easy to understand why this species has spread and established so rapidly. In one rice-field in Sardinia it has colonised the ground to such an extent that any further cultivation of those salty soils termed "recovered" (Marchioni, 1967) is now compromised. This harmful adventitious plant was later sighted in other places in Sardinia (De Martis & Marchioni, 1975). It was recently found in a marsh near rice-fields in the Oristano region (Marchioni Ortu & De Martis, 1984).

Heteranthera rotundifolia (Kunth) Griseb.

Originating from the subtropics of America, this species has spread to the Caribbean islands, South America (except Perù and Chile), Mexico, Brazil and the United States. This species has been introduced into rice-fields in N. Italy (Horn, 1985; Soldano in litteris) and in Sardinia (sub *H. limosa* (Swartz) Willd., Marchioni & De Martis, 1982).

In its native habitat it is a semi-aquatic annual plant with a procumbent stem growing in ephemeral pools and small ponds and flowering in summer (Horn, 1985). Like *H. limosa* (Barret & Seaman, 1980), this species, after chasmogamic and/or cleistogamic flowering, also dies, regardless of environmental conditions.

In Sardinia it first appeared around 1980 in the rice-fields of the Oristano region and later in those of Muravera (Marchioni & De Martis, 1982). Here it quickly spread by seeding even to the ridges.

It thrives in aquatic environments where the seeds germinate in sandy-loamy soils producing annual seedlings and/or rarely stoloniferous stems, rooting at the nodes. It flowers and bears fruit between July and September-October. The high number of seeds produced per capsula (250-300) and their germination percentage (Tab. 1) explain the rapidity with which this species propagates.

Heteranthera reniformis Ruiz & Pavon

This species, an autochthon of central-southern America, is now found in the West Indies, Mexico, Florida, Texas, and in North Connecticut, New York State, Kentucky, Indiana, Illinois, Missouri and Nebraska (Hausman, 1947; Small, 1903; Britton & Brown, 1913). It is a stoloniferous perennial and produces numerous new roots at its nodes, which enable it to survive, propagating even when it is cut up into several pieces (Russo & Pruneddu, 1970).

In its original habitat it grows in low water or muddy places, flowers between July and September and bears fruit continuously until October. Propagation is secured mainly by the high number of seeds produced, but also by the propagules of the creeping stem which survive in muddy soils.

The spread of this species is also attributed to contamination of rice seeds.

In Sardinia *Heteranthera reniformis,* in our opinion acquired very recently, was first sighted in 1984 in a rice-field in the Oristano region. Here it has established between plants of *Heteranthera rotundifolia* on the edges of the rice-fields. The seedlings quickly develop creeping stoloniferous stems which attach to the muddy substratum by means of the numerous roots emerging from the nodes.

Flowering begins towards the end of July, as in its natural habitat, and continues until October, reaching a maximum in August. Fruit is borne during the same period with the formation of loculicid capsules which release the seeds into the surrounding water. Some seeds can germinate immediately and in the rice harvesting season (October) numerous seedlings can be observed, their survival depending on climatic conditions. The ability of this species to spread is therefore related to the presence of humid zones, to the good germination percentage of its seeds (Tab. I) and to the production of stolons penetrating into the muddy layer which ensure vegetative reproduction. *Heteranthera reniformis* grows by invading those spaces left by *Cyperus difformis, Cyperus fuscus, Scirpus maritimus* and *Heteranthera ss.pp.* which seem to keep it under control, by checking, for the time being, its spread.

C. coronopifolia, H. rotundifolia and *H. reniformis,* with their crassula-like habit and prolific stem and leaf growth, deprive the rice plant *(Oryza sativa L.)* of space, light and nutrients, especially nitrogen, though the extent of this deprivation is not easy to assess.

Table I. Germination percentage of *Cotula coronopifolia, Heteranthera rotundifolia* and *Heteranthera reniformis* seeds in April, May and June, after 5, 10 and 15 days culture in deionized water: temperature 20°C, alternating light (12 h per day emitted by Philips TL 40W/33RS).

Month	Days	*Cotula*	*H. rotundifolia*	*H. reniformis*
	5	–	–	5 ± 1.1
April	10	4 ± 0.2	76 ± 2.1	74 ± 0.5
	15	30 ± 0.9	97 ± 1.6	88 ± 2.4
	5	1 ± 1.2	95 ± 0.8	14 ± 0.5
May	10	7 ± 1.0	97 ± 0.6	76 ± 0.5
	15	82 ± 0.5	100 ± 0.0	88 ± 0.4
	5	2 ± 1.4	68 ± 1.2	72 ± 1.6
June	10	12 ± 0.8	86 ± 0.4	84 ± 0.5
	15	89 ± 0.6	100 ± 0.0	100 ± 0.0

These species are therefore rapidly spreading adventitious weeds suited to humid environments such as rice-fields where ecological conditions are similar to those of their native habitat. All three originate from hot, temperate, subtropical climates with hot dry summers and wet winters where average annual rainfall is about 600mm and average summer temperature around 22°C and where temperatures remain around 10°C for at least four months of the year (America: California, N. Mexico, Arizona, Florida; S. Africa: Cape Town) (Strahler, 1975). "Mediterranean climates", where a dry summer is followed by a cold rainy season can be included in this category (Emberger, 1955). Based on his phytoclimatic study, Arrigoni (1968) also ranks the whole of Sardinia as having a "Mediterranean climate". In the Sardinian rice-fields of Muravera and the Oristano region where *Cotula* and *Heteranthera* thrive, annual rainfall is 661 mm and 566 mm respectively, while summer temperatures average 23°C, just one degree higher than the native habitat of these species. Hence the climatic conditions to which these species are exposed during their biological cycle in Sardinian rice-fields reflect pretty accurately those of their countries of origin.

Moreover, the fact that in their original habitat these species grow on sludge in marshlands and swamps, explains why they grow in our rice-growing areas where, at least during part of the growing cycle (May-June) the new weeds find ideal environmental conditions to reproduce by seed. In Sardinia, seeds of these three weeds germinate in the rice-fields in May and June, when the fields are flooded and dried thus enabling the seedlings to attach to the muddy soil and grow. The plants flower and bear fruit mainly in August and September and during this time the two *Heteranthera* species produce numerous seeds which lie on the ground until next year's growth. *Cotula* flowers and bears fruit practically all year round (May to February) releasing seeds which can always germinate and produce seedlings which thirve even out of water. This adaptability, in conjunction with its dispersal by transhumant cattle grazing on the rice stubble, contributes without doubt to its establishment in non-marshy soils (De Martis & Marchioni, 1975). On the other hand, *Heteranthera* can propagate in the Sardinian rice-fields not only by seeds but also by means of migratory Anatidae which feed on them (Mabbot, 1920 in Fassett, 1940).

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Preliminary Chemical and Hydrological Observations in the Ionian Sea

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ABSTRACT

The paper contains the results of the investigation on nutrients and hydrological parameters at 11 stations at standard depths covering all the water column in the Ionian Sea in March 1983.

The following characteristics can be observed from the vertical distribution of dissolved oxygen during the Spring: from 0 to 75 m the waters are always saturated; a maximum gradient depletion occurs between 75-150 m, where easily oxidizable material is decomposed and respiration processes prevail; the concentration gradient is very small from 150 m to the bottom.

The distrubution of nutrients can be considered as a normal pattern for Mediterranean waters. In the euphotic zone, nutrients are practically depleted by the phytoplankton uptake. The oxidation of organic material induces a progressive enrichment of reactive phosphate, nitrate and silica from 100 m to the bottom. A nitrate maximum is observed at the compensation depth for photosynthesis.

The N:P and Si:P atomic ratios are characterized by a wide variability with depth at the euphotic zone. On the contrary, from 75 m to abour 80 m, the ratios increase and afterwards they tend to constant value of 21 for N:P and 35 for Si:P.

Some conclusions are also drawn about the levantine and deep waters filling the Ionian basin.

Introduction

Literature on the distribution of nutrients and physical features in the Ionian Sea is limited to a few series of observations made by Mc Gill (1965) and Ovchinnikov (1966).

In this paper the hydrological parameters, the nutrient content and the nutrient ratios over a wide area of the Ionian Sea will be examined.

Methods

The samples were collected by metallic Nansen bottles provided with reversing thermometers from a cruise of the Greek Navy at 11 stations (Fig. 1) at standard depths covering all the water column in the Ionian Sea in March 1983. Determination of salinity and dissolved oxygen were carried out immediately on board.

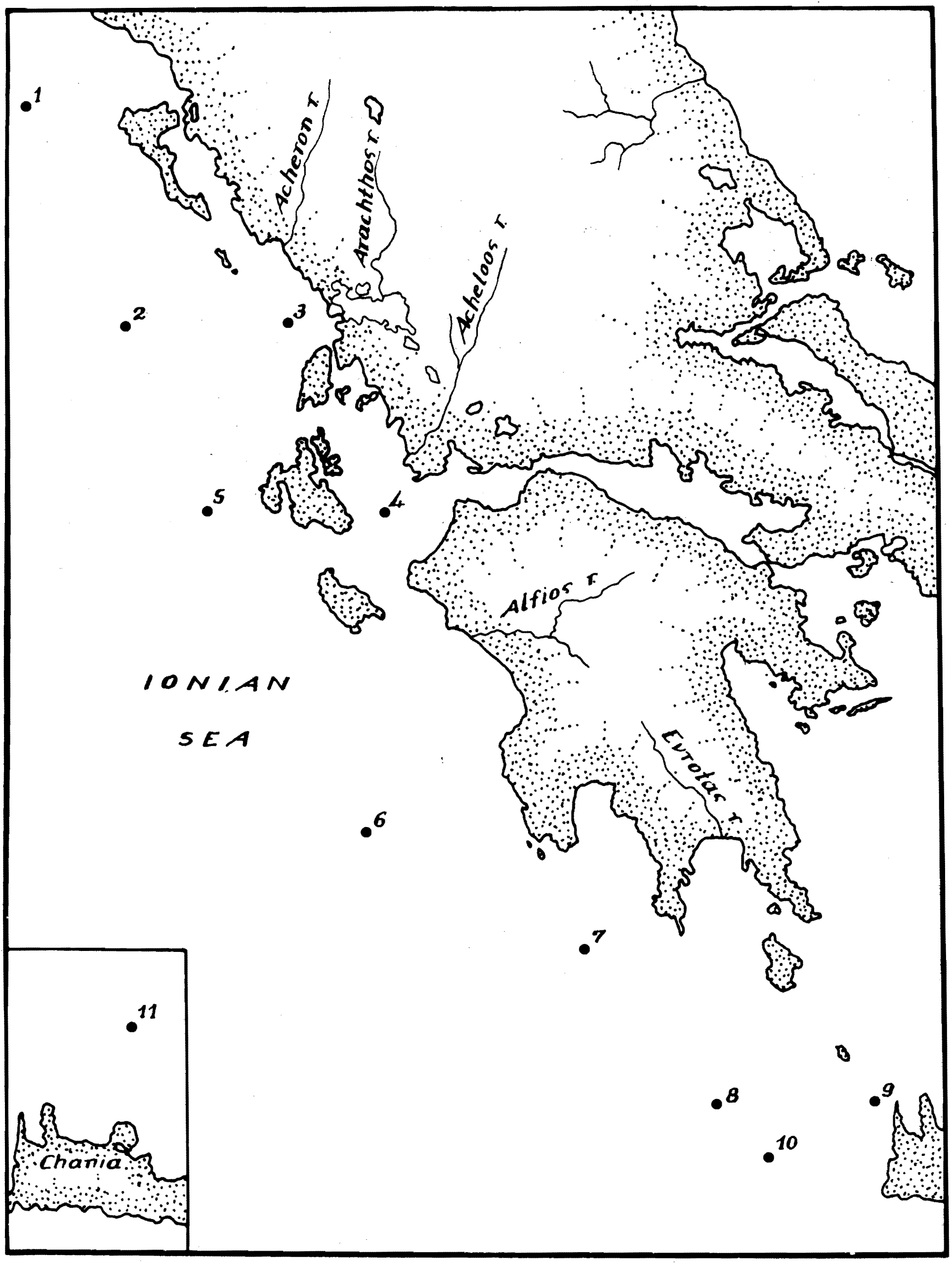


Fig. 1. Map of the investigated area.

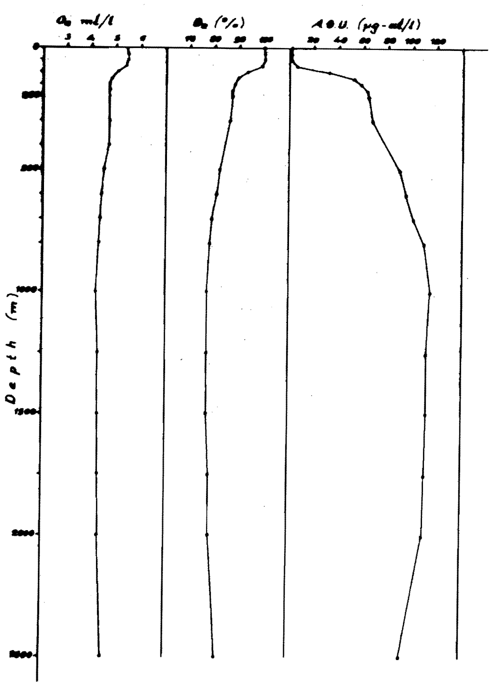
Samples for nutrients were taken and frozen for later analysis with a Technicon Autoanalyser. Measurements of salinity, dissolved oxygen and inorganic nutrsients were made by methods described by Friligos (1982).

Results and Discussion

Vertical distribution of temperature, salinity and density

The mean vertical distributions of temperature, salinity and density are presented in Fig. 2 Variations are essentially restricted to the upper layer, but a significant modification was found to happen in the deeper ones too. At present we consider the surface layer extending from the surface down to the density interface, where the mean salinity is 38.4‰ . A maximum of salinity (– 38.8‰) occurs from 150 m to 400 m (Fig. 2), tagging the levantine waters spreading all over the Eastern Mediterranean at intermediate depths. To prove this statement we must have in mind that, as the levantine water spreads from the eastern basin, its properties progressively modify from T = 15.70° and S = 39.10‰ at the origin (Lacombe-Tchiernia, 1960), to T = 14.20°C and S = 38.75‰ as it leaves the strait of Sicily (Morel, 1970).

Deeper waters have the characteristics of the Eastern Mediterranean (Fig. 2). The deep water of the Eastern Mediterranean fills the Ionian and Levantine basins to depths of 700 m. It is remarkably uniform at 13.6°C and 38.7‰ . Some variation exists between 700-1600 m, a layer that may be considered as transitional between the levantine intermediate waters and deep waters (Pollack, 1951). The water below 700 m represents 66‰ of the total Eastern Mediterranean volume (excluding the Aegean and Adriatic). Also, the analysis carried out by Pollack (1951) indicated that the deep waters in the two basins had the same temperature of 13.7°C and a salinity sporadically



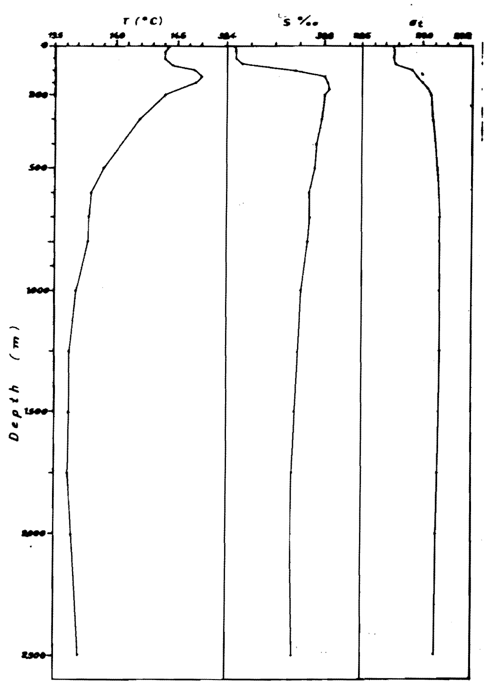


Fig. 2. Vertical distribution of temperature, salinity and density. Points represent mean values.
Fig. 3. Vertical distribution of dissolved oxygen, saturation values and oxygen utilization. Points represent mean values.

varying in the range 38.67 + .04‰ at similar depths. It should be noted that deep waters of the Eastern Mediterranean originate from the mixing of the Southern Adriatic winter water type T = 12.95 °C; S = 38.60 (Zore-Armada, 1963) and the Rhodes winter water type T = 15.70°C; S = 39.10‰ (Lacombe-Tohernia, 1960).

Vertical distribution of oxygen

Fig. 3 shows the vertical distribution of dissolved oxygen. The curves have been obtained by graphical interpolation among experimental mean values at the various stations during the March 1983 survey.

Three main layers can be identified in the oxygen curve. The first one, between 0 and 75 m, characterized by saturation conditions in the whole water column, after which the gas concentration starts to diminish; an intermediate layer in the range of 150-500 m. where the concentration gradient is very small; a layer extending from 500 m to the bottom. During Spring the slow rate of oxygen from the surface waters together with the excess of oxygen produced photosynthetically are responsible for a saturation at any depth above 75 m. Since the greater part of organic material has been oxidized in the upper layer (75-150 m), oxygen depletion diminishes with depth and consequently waters from 150 to 500 m are characterized by a smaller negative gradient of oxygen concentration.

Nutrient content

The integrated mean values of nutrients, the surface chlorophyll a and the depth at each station are presented in Table 1. Stations *1* to *6,* located in the northern part of the Ionian Sea, presented higher surface chlorophyll a values, in contrast to stations *7* to *11*.

The range, the mean, the ratio and the correlation coefficient of nutrients for all stations and depths are summarised in Table 2. The variations in nutrient concentration generally agree with the nutrient salts of the Ionian Sea presented by McGill (1965). Levels of nutrients in the Ionian Sea represent a two-fold increase of those in the Aegean (Friligos, 1981). Also, Thomsen (1931) presented data for the southern regions of all basins and showed increasing concentrations westward. However, he noted that "although the quantity of nitrate and phosphate increases considerably as we go from the eastern part of the Mediterranean to the western yet the quantity of phosphate and nitrate even in the westernmost is less than at the same depths in the oceanic regions". This bears out the observation of Redfield (1958) of a sixfold difference between the phosphate level of the eastern Mediterranean and that for the Atlantic.

Vertical distribution of nutrients

The vertical nutrient distributions shown in Fig. 4 can be considered as very normal for Mediterranean waters. In the euphotic zone, nutrients are practically depleted by the phytoplankton uptake. The oxidation of organic matter induces a rapid increase in the nutrient concentration below 100 m, and the enrichment in reactive phosphate, nitrate and silica rises progressively in deeper waters. The nitrate maximum is frequently observed at the compensation depth for photosynthesis. Vaccaro (1965) establised the common boundary of the maximum at 75-125 m, in good agreement with the results presented in Fig. 4. It should be noted that nutrient concentrations increased below 200 m in the Aegean Sea (Friligos, 1981). This is due to more stratification in the Aegean (Miller, 1963). Bumpus (1948) found that the rate of vertical transfer for phosphorus was unusually low in the Aegean Sea and, from this, he concluded that the enrichment of the surface from the deep water was not taking place.

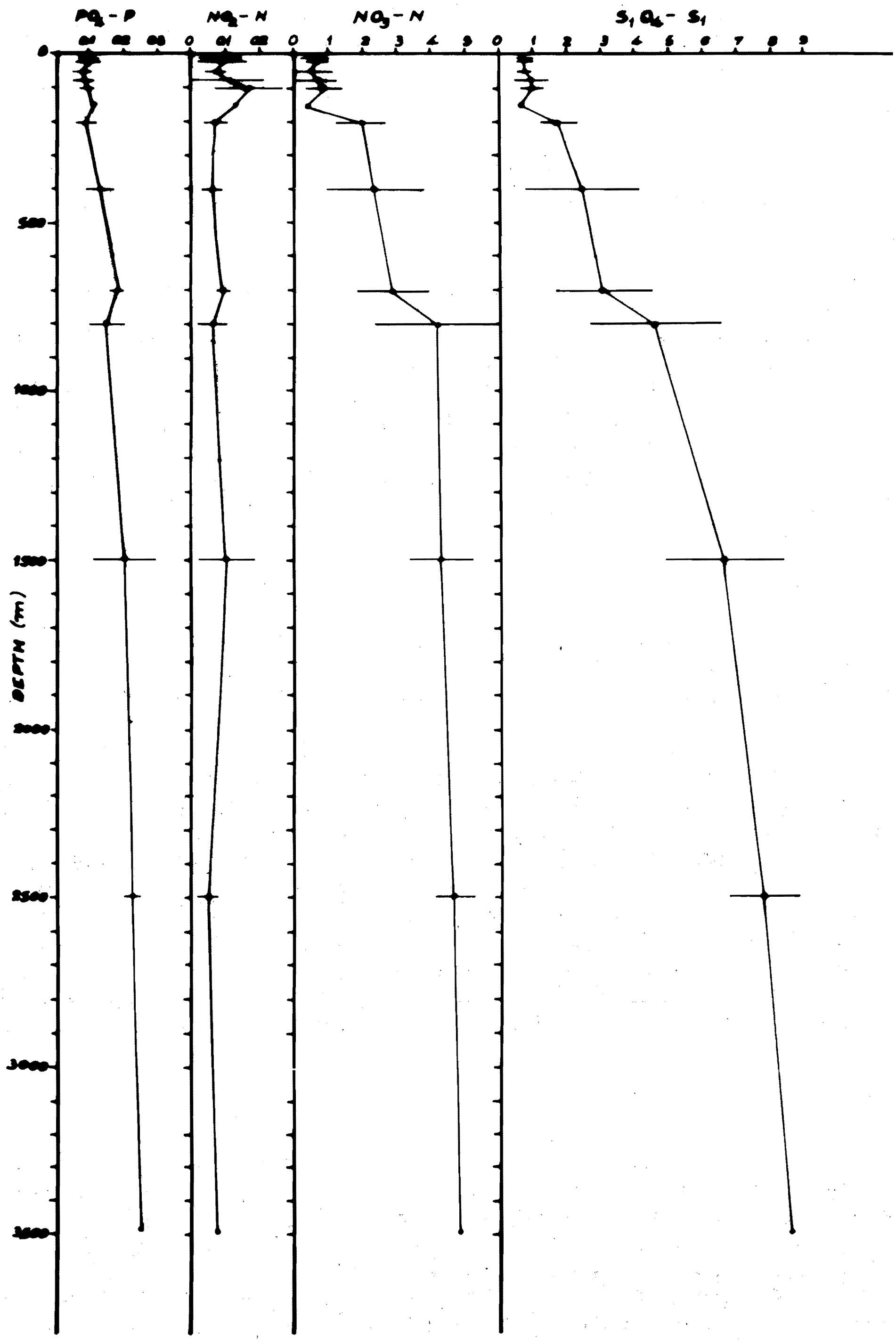


Fig. 4. Vertical distribution of nutrients, Segments indicate mean deviation of measurements (ug-at/1).

However, in the Ionian Sea and the Western Mediterranean, Bumpus obtained a good correlation between turbulence and the change in nutrient concentration. Nevertheless, Redfield *et al.* (1963) pointed out that the exchange over the sill at Gibraltar withdraws nutrients at intermediate depths and, thus, reduces the accumulation in deeper layers. This limits the effectiveness of vertical turbulence as a mechanism of enrichment in the Western Mediterranean.

Nutrient ratios

Many authors, including Cooper (1938), are of opinion, that it is useful to look upon the N:Si:P ratios in various parts of the ocean, and that only certain values of the ratios are favourable for bioproductivity. The best ratio for healthy diatoms is about 15:15:1. From the fifth column in Table 2, we see that the N:Si:P ratios are higher than normal and agree with those found by McGill (1965). We notice that the nutrient ratios found recently in the Adriatic Sea (Buljian *et al.,* 1975) are different from the old ones (McGill, 1965). An evaluation of the ratio of change was also made (Table 2). The ΔN:ΔP ratios were close to the N:P ratio, while the ΔSi:ΔP ratios approached a rather high value of 27.7.

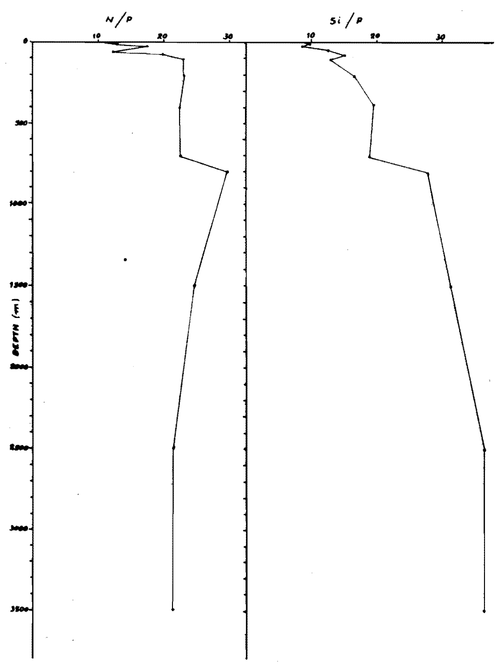


Fig. 5. Vertical distribution of the N:P and Si:P ratios by atoms at different depths. Points represent mean values.

The N:P and Si:P ratios by atoms are characterized by a wide variability with depth. Two different zones can be distinguised (Fig. 5): from 76 to about 800 m the ratios increase rapidly, afterwards, they tend to constant values of 22 for N:P and 34 for Si:P. Strong gradients found in the upper regions are probably due to the progressive regeneration of nitrate and silica following the more rapid regeneration of phosphate. Whereas the N:P ratios found in the deeper regions are in agreement with the results obtained by other authors, there is some discrepancy between the presented Si:P results and those generally accepted for oceanic waters.

Table 1

The integrated mean values of nutrients in uM and the maximum depth at each station

Station	NH_4-N	NO_2-N	NO_3-N	MN	PO_4-P	SiO_4-Si	Chlor. *a*	Depth (m)
1	0.10	0.04	3.66	3.80	0.16	4.21	0.15	800
2	0.23	0.06	3.08	3.37	0.11	2.95	0.22	800
3	0.25	0.06	1.48	1.79	0.06	1.34	0.15	300
4	0.46	0.09	0.57	1.13	0.06	0.92	0.28	75
5	0.41	0.06	3.97	4.45	0.11	5.51	0.15	2500
6	0.96	0.12	3.95	5.03	0.21	5.72	0.17	2500
7	0.23	0.04	4.23	4.52	0.21	6.69	0.11	3500
8	1.29	0.15	1.71	3.16	0.16	1.91	0.03	1500
9	0.86	0.12	1.17	2.15	0.11	1.32	0.15	400
10	1.00	0.11	3.08	4.19	0.17	3.80	0.09	2700
11	1.05	0.11	1.15	2.30	0.11	1.15	0.12	1000

Table 2

Nutrient Relationship

Component	*Number of observations*	*Minimum and maximum values*	*Mean concentration (wM)*	*Mean concentration ratio (by atoms)*	*Ratio of change*	*Correlation coefficient*
PO_4 – P	106	0.07-0.24	0.11 + 0.05			
NR_4 – N	106	0.08-2.83	0.67 + 0.59			
NO_2 – N	106	0.05-0.30	0.10 + 0.07			
PO_3 – N	106	0.20-6.91	1.56 + 1.53			
ΣN	106	0.50-7.37	2.33 + 1.58	ΣN:P = 21.2	ΔNi:ΔP = 21.6	0.71
Si	106	0.48-8.56	1.96 + 2.05	Si:P = 17.8	ΔSi:ΔP = 27.7	0.70

An excess of silica over that expected from biochemical regeneration is rather frequent in the deeper oceanic waters, where it is probably caused, according to Richards (1958), either by an upward diffusion from bottom deposits or by a redissolution of silica taking place after the complete regeneration of phosphate and nitrate. The high observed **Δ** Si:**Δ** P ratios (see Table 2) support this view. In the case of the Mediterranean Sea, this excess is more probably due to a greater contribution of continental waters.

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Airborne pollens analysis in Cagliari (south Sardinia): observations on *Ailanthus altissima* (Miller) Swingle, *Casuarina equisetifolia* J.R. & G. Foster and *Schinus molle* L.

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ABSTRACT

In this paper the phenological and airborne pollens dispersal data of *Casuarina equisetifolia* J.R. & G. Foster, *Ailanthus altissima* (Miller) Swingle and *Schinus molle* L., three exotic species widely used for street planting, are examined. The findings have enabled a detailed identification of the phenological stages and to determine the amount of airborne pollens of each species, resulting in a better understanding of their biorhythms and of their pathogenic role.
Key words: *Casuarina, Ailanthus, Schinus,* airborne pollen, Cagliari.

Introduction

Large amounts of pollen of some introduced exotic tree species, widely planted for ornament, have been observed during continuous aerobiological measurements (Ballero et al. 1984, 1985) in Cagliari (South Sardinia, Italy). The airborne pollens concentrations (Fig. 1a) of *Ailanthus altissima* (Miller) Swingle *(Simaroubaceae), Casuarina equisetifolia J.R. & G. Foster (Casuarinaceae), Schinus molle* L. *(Anacardiaceae)* are reported herein and phenological observations as well as some remarks on their palynological features are also provided in order to evaluate how their presence, extraneous to the area, is reflected in the atmosphere.

Ailanthus altissima, a tree which can grow to heights of 30 m, is very adaptable and readily naturalizes in ruderal soils with nitrophilous tendencies; *Casuarina equisetifolia* a tree species native to Australia, has been introduced and is widely planted for afforestation due to its rapid growth. *Schinus molle,* a native of Brazil and known as the "pepper tree" reaches, in our climate, heights of 15-20 m.

Methods

Airborne pollens have been sampled with a Burkard 7-day recording trap similar to that employed by Hirst (1952), placed at 25 m above street level in the town centre of Cagliari. Daily counts have been made using an Orthodox Leitx binocular microscope with a magnification of 400 x. For grain identification Erdtman (1969) and Kapp (1969) have been consulted and checks then made on samples taken directly from the plants in question. Morphometric measurements refer to the average over a sample of 100 grains with a magnification of 600x. As for phenological observations, the National Phenological Network recommendations have been followed, along the lines

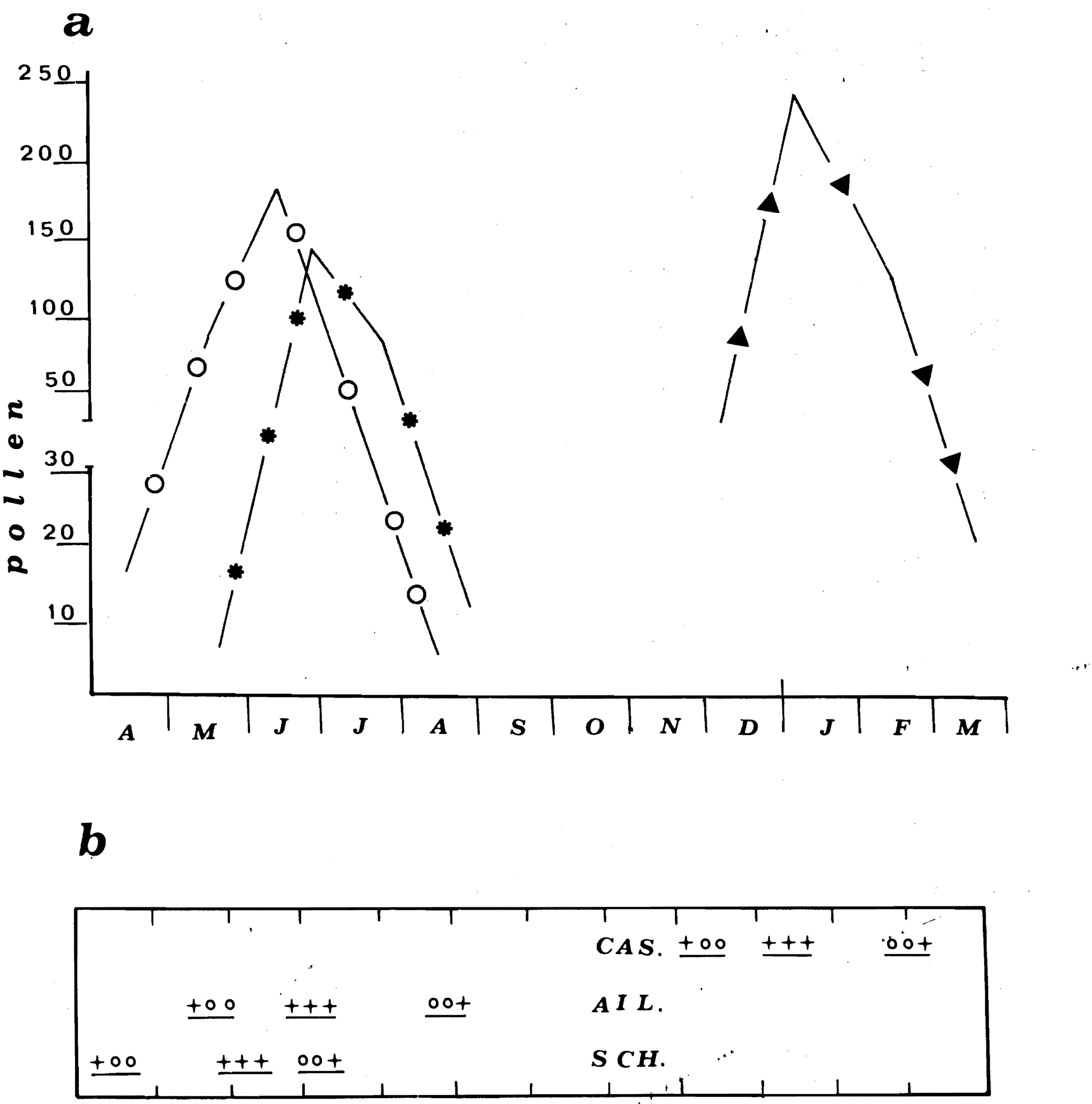

Fig. 1 – (a) Monthly presence from Casuarina (▲▲▲), Ailanthus (★ ★ ★ ★ ★) and Schinus (O O O) pollens; average value 1981-1985. (b) Phenological measurements on the flowering of Casuarina, Ailanthus and Schinus. (+OO beginning of lowerign with presence of buds, + + + acme, OO+ final stages with dried lowers).

suggested by Marcello (1957). For the systematic determination of the three plant species studied, Elliot & Jones (1982) and Everett (1982) have been consulted. All data refer to counts averaged over 5 years (1981-1985) of continuous monitoring.

The Vegetation around Cagliari

Vines, cereals and citrus are cultivated in the countryside around Cagliari. The spontaneous vegetation, typical of submediterranean coast, is strongly affected by the almost perennial strong W NW and S SE winds of over 10 m/sec that often last for days and by a shortage of rainfall (average annual rainfall 400 mm, water deficit 460 mm). In the sands along the coast *Ammophila littoralis* and *Agropyron junceum* associations and *Juniperus oxycedrus* undergrowth flourish: on the cliffs by the sea *Juniperus phoenicea* undergrowth has established. In the humid coastal zone *Typha, Scirpus, Limonium, Inula* and *Chenopodiaceae* sp.pl. associations are found. In the inland plain and highland *Oleo-lentiscentum* is present with *Pistacia lentiscus* as well as *Quercetum ilicis* formations composed typically of *Quercus ilex* or *Quercus suber (Quercetum ilicis suberetosum), Arbutus unedo, Erica arborea,* etc. Numerous introduced species, such as those studied herein, have intruded into these associations, denaturalizing their original composition.

Results and Discussion

The following families were identified in the 1981-1985 sampling campaign: *Pinaceae, Cupressaceae, Casuarinaceae, Salicaceae, Juglandaceae, Betulaceae, Corylaceae, Fagaceae, Ulmaceae, Urticaceae, Polygonaceae, Cheno-Amarantaceae, Caryophllaceae, Papaveraceae, Cruciferae, Rosaceae, Leguminosae, Euphorbiaceae, Simaroubaceae, Anacardiaceae, Tiliaceae, Myrtaceae, Umbelliferae, Ericaceae, Oleaceae, Rubiaceae, Convolvulaceae, Boraginaceae, Labiatae, Plantaginaceae, Caprifoliaceae, Compositae, Liliaceae, Iridaceae, Juncaceae, Graminaceae, Palmae, Cyperaceae.* The highest pollen concentrations were detected in the first six months of the year (Fig. 2) over a period of 150-170 days, in correspondence with flowering which occurs some tens of days earlier in South Sardinia than in other mainland cities such as Genoa, Bari, Naples which share many common features with Cagliari (Negrini & D'Amato 1985).

The annual count (averaged over 5 years) was 27,147 grains per m^3 of air, 3.78% of which produced by trees and/or shrubs and 58.16% by grasses. In addition, 469 (1.73%) pollens of *Typhaceae, Tamaricaceae, Araliaceae, Buxaceae, Lauraceae, Moraceae* and *Solanaceae* were counted and grouped into miscellany as they are not well represented.

The collected pollen grains of *Ailanthus altissima* are prolate spheroidal of 30 x 24 µ with three triangular furrows at the bottom of which lay the colpi. Wartlike striate exine, NPC = 345. Those of *Casuarina equisetifolia* are subprolate with diameter of 30 µ and have pores with onci and rugate exsine, NPC = 346. The pollen grains of *Schinus molle,* Rhus type, are 3-colpate with finely reticulate exine, 25 x 21 µ in size, NPC = 345.

Figure 1 b shows the main anthesis stages of the three species: 000 total absence of flowers, +00 beginning of flowering with flower buds, + + + acme of flowering with buds, open and dried flowers, 00+ end of flowering with presence of only wilting flowers. The monthly pollen count is superimposed on these data. As can be observed, the pollen concentrations faithfully reflect the evolution of the anthesis phenomenon, since in all three species examined the process of pollen ripening is very close to that of its release which occurs, among other things, with considerable intensity.

Ailanthus and *Casuarina* can be considered paleorhythmic in that their phenology appears to be controlled by biorhythms steadily acquired through time and little influenced by extemporaneous climatic conditions. This is supported by the fact that in

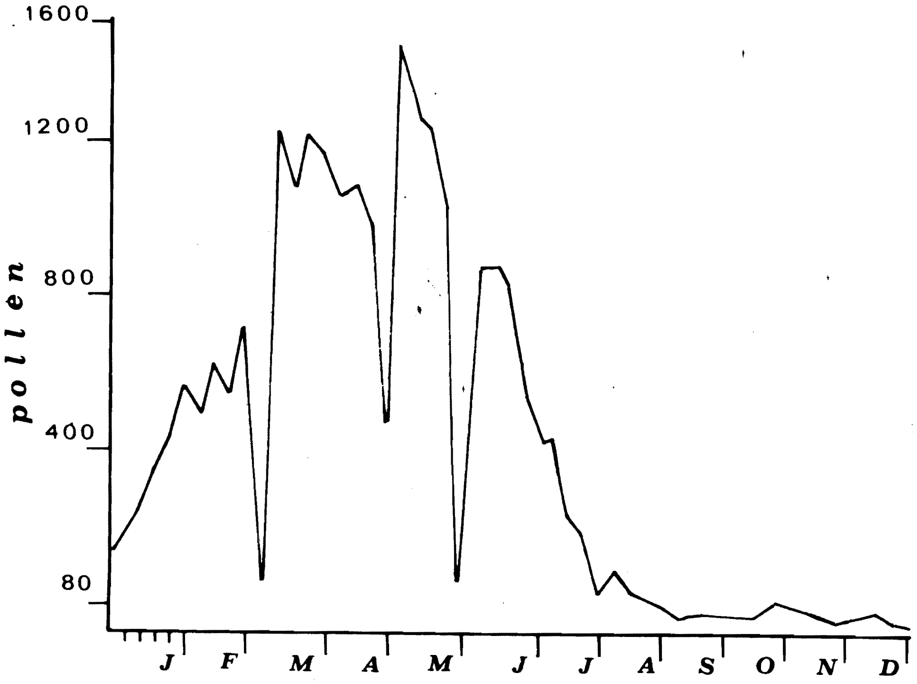

Fig. 2 – Total pollens present in 1 m^3 of air in Cagliari. (Average values 1981-1985).

the 5 years of observations, the pollination period and amount of grain released remained constant, despite varying climatic parameters. This is not true of *Schinus* which exhibits a greater sensitivity to temperature (Fig. 3). From a detailed analysis of the circadian rhythms of *Casuarina* (Fig. 4) made possible by its limited pollination period, it emerges that the greater amount of pollen grains is released between 09.00 and 15.00 h, i.e. in coincidence with higher temperatures and a reduction in wind or rain. Conversely, at night this tendency is reversed and almost no pollen was detected in the atmosphere, apart from the grains released during the day and reentrained due to turbolence in the Prandtl stratum, the lowest zone of the atmosphere extending from the laminar sub-layer (of a few cm) for 50-100 m, where the friction between particles constituting the aeroplankton creates turbulent flows, resulting in their vortical dispersion. The marked morphological diversity of these grains, due to the different pressure of the substatum where they settled and to friction with other bodies, confirms that they were released beforehand.

Similar airborne pollen studies of, among others, *Schinus* and *Casuarina*, conducted in Algiers (Korteby et al. 1974) and Tunis (Chadli et al. 1973) where meteoclimatic conditions are similar to those of Cagliari, confirm, qualitatively, the data collected in Cagliari, despite plausible variations in the pollen calendar. However a more specific quantitative comparison is out of the question due to the different sampling procedure, Durham trap (Durham 1946), followed in the African towns.

Useful indications can be drawn from the data reported here as well as valuable phenological elements, also of an applicative nature, such as the problem of hypersensitivity to pollen. Undoubtedly, a more detailed analysis of the production and emission phenomena of pollen grains may provide further insight into the biology of little-known species, not much studied as they do not belong to the autochthonic flora, despite being widely planted.

The identification of pollens of trees such as *Schinus* and *Casuarina*, not recognised as having allergenic properties in Italy, although several non Italian authors (Pott 1922;

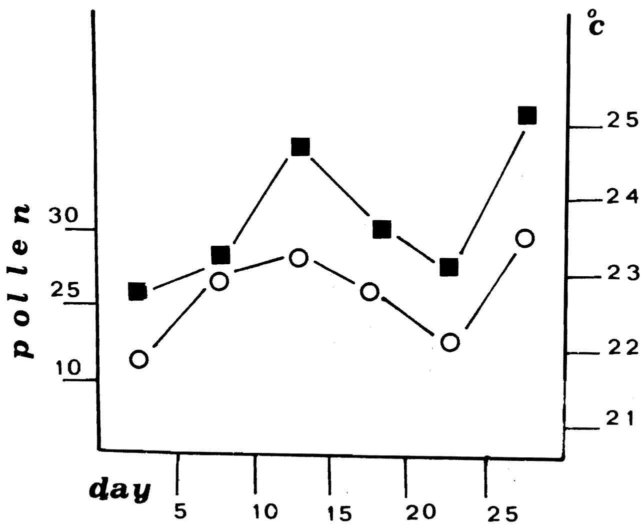

Fig. 3 – Comparison between Schinus pollen (O O O) and daily temperature (■ ■ ■ ■) in Cagliari. Average value: june 1981-1985.

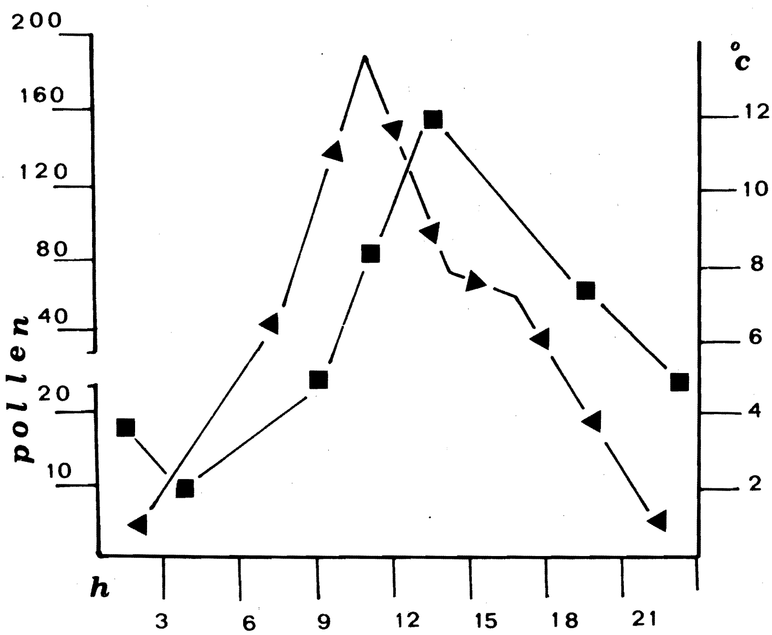

Fig. 4 – Circadian periodicity of Casuarina pollen (■ ■ ■) and daily temperature ▲▲▲ in Cagliari. Average value: junary 1981-1985.

Durham 1951; Charpin *et al.* 1962; Cornillon *et al.* 1972) considered them responsible for pollinosis, could throw some light on the numerous cases of bronchial asthma of non-identified aetiology. As far as *Ailanthus* is concerned, no precise epidemiological data are available even if its pathogenic role has been suggested by Ballero et al. (1985) in some cases of respiratory allergies. Consequently a more detailed allergologic investigation of this species seems expedient.

Conclusions

In this work the airborne pollen concentrations of three exotic tree species have been examined with a view to evaluating their behaviour in an ecosystem substantially different from their native one. These species, which flourish spontaneously in the original habitat in very diverse climatic and ecological environments are well represented inthe atmosphere of Cagliari by their pollen grains. In the context of the local plant associations, their position is instrusive and out of place and likewise their pollens which are potential sources of allergic pathologie, Consequently, prior to introducing new plant species the negative, and sometimes violent, impact, environmental and otherwise, that these species can have on people predisposed to allergies to their pollens need to be evaluated in order to ensure their proper management in the area.

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Composition and structure of planktonic and benthic communities as a basic information in fishpond culture

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ABSTRACT

Zooplankton and zoobenthos of two fishponds were studied in order to define their seasonal patterns and community structures. The ponds P1 and P2, of similar depth and surface, were interconnected, annually fertilized and mostly utilized for grey mullet rearing. P2 was less eutrophic than P1 which received further nutrient inputs from the surrounding cultivated area by means of a drainage canal.

A total of 25 zooplanktonic species and 14 zoobenthic taxa was recorded, most of which were typical of eutrophic waters. The comparison of the invertebrate fauna between the two ponds showed a strong similarity in the qualitative composition and significant differences in density of some taxa and in the community structure.

The results suggest that the analysis of these communities can be a good tool to monitor eutrophication in fishponds in the same way as observed in lakes, and could provide some basic information to improve fishpond management.

Introduction

Aquaculture practices play a determinant role in the productivity of fishponds, where several interventions can be made up. Some of them, such as introduction of artificial food and manuring, can bring about an appreciable productive improvement on the low levels of the food chain. These treatments, frequently used in fishponds management, are the most important factors affecting the structure of the invertebrate fauna, which represents the fundamental source of natural food for fish (Shaw and Mark, 1980; Zaret, 1980; Zur, 1980; Whiteside *et al.*, 1985). Biological studies on zooplankton and zoobenthos may therefore provide basic information to test the functionality of the system in order to enhance fish production.

This investigation was made to analyze the seasonal variations and the structure of the invertebrate communities in two artificial fishponds, with respect to the eutrophication influence. Our study assumes a further interest considering the scarcity in Mediterranean regions, and more particularly in Italy, of data concerning the invertebrate fauna of these freshwater ponds frequently studied in other countries (Hillbricht-Ilkowska, 1966; Lellák, 1969; Wróbel. 1972; Dimitrov, 1977; Grygierek and Wasilewska, 1979; Fry and Osborne, 1980; Šeda 1985).

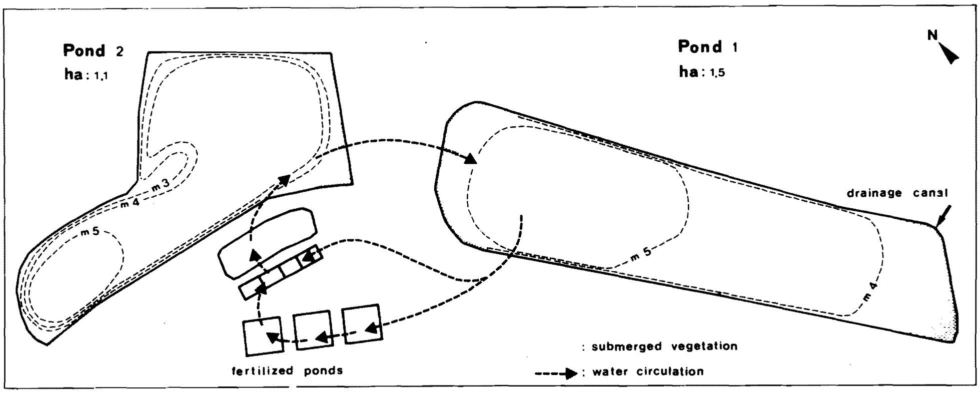


Fig. 1 – Map of the ponds and diagram of water flow.

Study area, material and methods

The ponds, located near Rome, were initially used for game fishing and, from 1977, exclusively for fish culture. The two ponds (P1 and P2, Fig. 1) had similar size and depth, and were interconnected and subject to a similar treatment. A series of small ponds for fry culture was situated near P2. They were annually fertilized with manure and urea, and treated with hydrated lime and Dipterex. The water flow carried the fertilizers from the small ponds to the two ponds (Fig. 1). Furthermore, only P1 was fed by a canal draining the water from the surrounding cultivated soil. This direct input of nutrients increased the eutrophication in P1, where higher B.O.D. and total P values, and lower oxygen contents were observed (Table 1). The temperature measurements (Fig. 2) showed similar profiles in the two ponds.

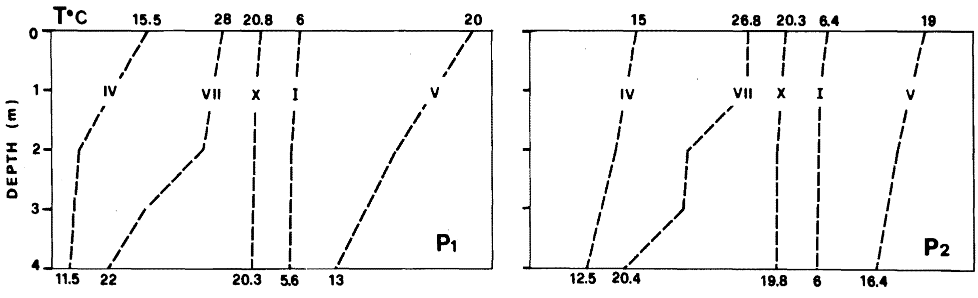


Fig. 2 – Temperature profiles in the two ponds.

Fish fauna comprised 13 species in both ponds, except for the planktivorous *Aristichthys nobilis,* present in low density only in P1. The dominant species were *Mugil cephalus* and *Liza ramada,* annually restocked. Selective fishing was carried out in order to enhance the population of grey mullet.

Zooplankton was collected every month (two times in July) and zoobenthos every two months from April 1979 to May 1980. Zooplankton was sampled with a net (width of mesh 50 µ) at the depths of 0.50m and 3m in two transects in each pond. Horizontal hauls were taken for 200m in P1 and 100m in P2. The material was fixed in 5%

formalin and later made up to 200 ml. Individuals were identified and counted, and data expressed per m^3 as mean density of the two subsamples.

Benthic organisms were collected with an Ekman grab (surface area: 225 cm^2) in six points of each pond at the depth of 5 ± 1m. The sediment was washed through a 0.28 mm sieve and the residue fixed in 10% formalin. Organisms were counted, identified and their wet weight determined. The mean values of the six samples per pond were expressed as ind/m^2 and g/m^2. Shannon diversity (H) and evenness (e) indices (Pielou, 1969) were applied in order to analyze the community structure. $\bar{T}$-test on paired comparisons (Eason *et al.*, 1980) was used to evaluate the significance in differences of densities, biomasses and diversities of the invertebrate fauna between the ponds. PSc index (Whittaker and Fairbanks, 1958) was adopted to detect community similarities between the ponds.

Table 1. Values of total P, dissolved oxygen and B.O.D. in May 1980.

	P1		P2	
sample depth (m)	3	4.5	3	4.5
Total P (µg/l)	300	300	220	200
Dissolved oxygen (mg/l)	6.2	0	8.6	1.8
B.O.D. (mg/l)	4.0	9.0	2.0	4.0

Results and discussion

1. Zooplankton

a) Composition

Zooplankton included 25 species (Tab. 2): 19 rotifers, 5 cladocerans and 1 copepod. Their seasonal changes of the planktonic species are reported in a previous paper (Ferrara and Mastrantuono, 1982), so we only report here the main trend of the groups (Fig. 3) and of the most important species.

Rotifers were the dominant group in number of species (18 in P1 and 19 in P2) and in density values (81% in P1 and 45% in P2 of the total zooplankton). The higher abundances in the ponds occurred in winter and spring, when also the species richness increased. Both qualitative and quantitative reduction was observed in summer. *Keratella cochlearis* and *Polyarthra dolicoptera-vulgaris* were the most abundant species in each pond (Tab. 2). Other species, such as *Synchaeta stylata, Pompholix sulcata, Anureopsis fissa* and *Brachionus angularis* occurred in higher number only in P1, while *Keratella quadrata* and *Filinia terminalis* were more abundant in P2. The remaining taxa had generally low densities. On the whole, the rotifer population was characterized by typical species of highly eutrophic waters, such as *K. cochlearis. K. quadrata* and *B. angularis* (Pejler, 1957; De Beauchamp, 1965). Although total densities of this group did not differ significantly in the two ponds, P1 can be defined a typical rotifer pond, due the high percentage of these organisms in the zooplankton.

Cladocerans constituted 17% of the total community in P1 and 24% in P2, with low numbers in superficial waters and high densities at 3m. The small cladoceran *Bosmina longirostris* was the dominant component in P1, followed by *Ceriodaphnia pulchella*. In P2, *Daphnia longispina, Bosmina longirostris* and *Diaphanosoma brachyurum* showed higher abundances. In this pond *D. longispina* was very abundant in spring and early summer, replaced by *D. brachyurum* in late summer. This seasonal succession can be attributed to phenomena of feeding competition, caused by the almost identical size of these larger cladocerans (Hrbácek, 1977). Although the densities of cladocerans were similar in the two ponds, *B. longirostris,* a good indicator of eutrophy (Brooks, 1969), was dominant in P1, A greater specific diversification was observed in P2.

Copepods, represented only by the calanoid *Eudiaptomus padanus etruscus,* constituted 2% of the total zooplankton in P1 and 31% in P2. As the differences in

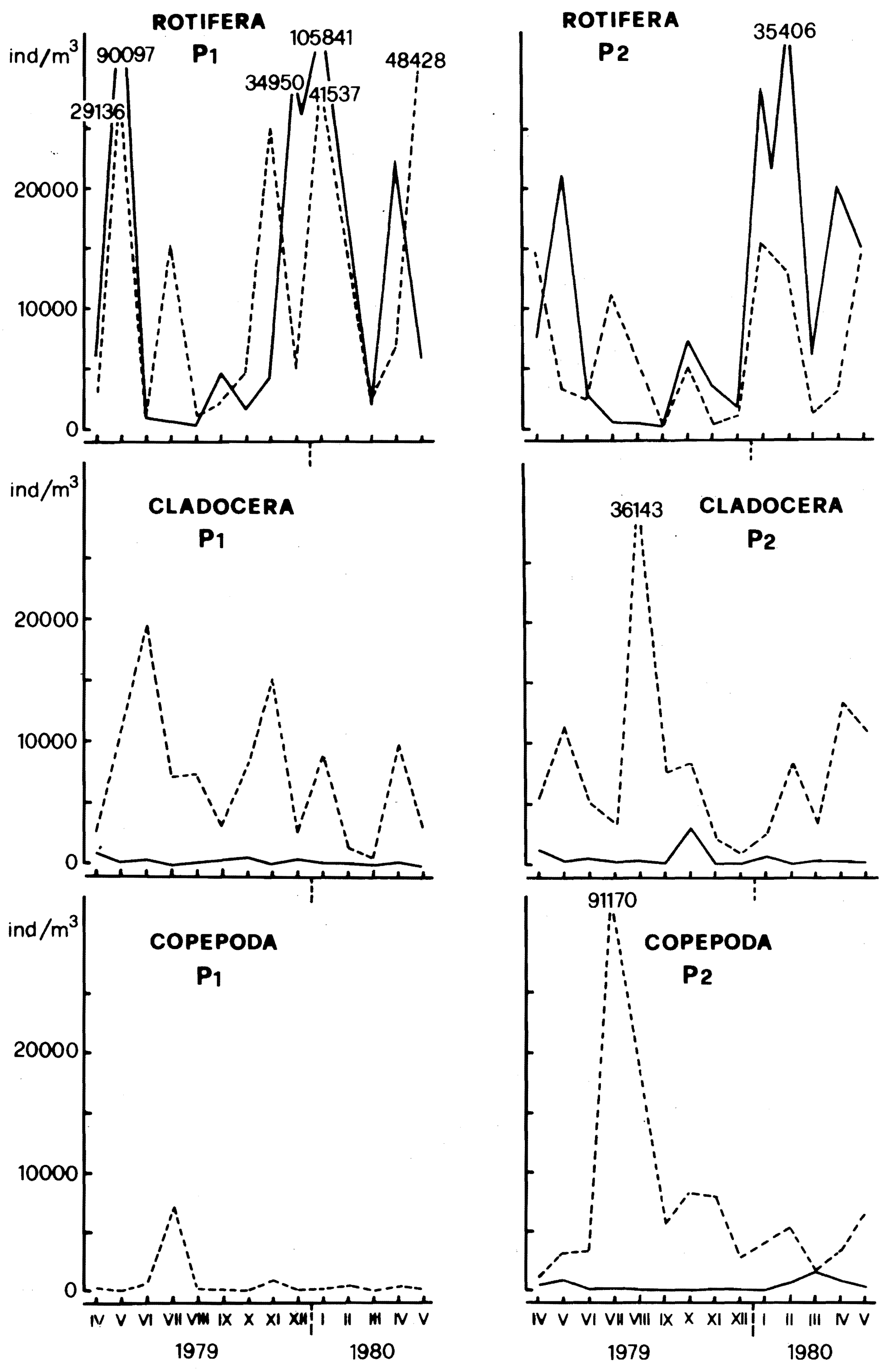


Fig. 3 – Seasonal variations in density of rotifers, cladocerans and copepods at 0.50m (———) and 3m (------) in P1 and P2. Numerical values of copepods at 0.50m in P1, as unremarkable, are not graphed.

Table 2. List and annual average densities (ind/m³) of the zooplanktonic species in the two ponds.

	P1		P2	
sample depth (m)	0.5	3	0.5	3
Rotatoria				
Brachionus angularis Gosse	515	1095	90	40
Keratella quadrata (O.F. Müller)	22	61	738	2281
Keratella cochlearis (Gosse)	9332	5654	3738	1314
Anureopsis fissa (Gosse)	1011	430	390	36
Trichotria pocillum (O.F. Müller)	0	0	2	2
Colurella colurus (Erhemberg)	2	1	3	6
Lecane luna (O.F. Müller)	4	1	3	0
Cephalodella sp.	4	0	15	0
Ascomorpha agilis Zacharias	82	11	131	219
Gastropus minor (Rousselet)	16	10	2	0
Asplanchna priodonta Gosse	118	2321	322	708
Synchaeta stylata Wierzejski	4942	1144	951	103
Poliarthra dolicoptera-vulgaris gr.	2886	2681	2687	271
Testudinella patina (Hermann)	2	0	2	0
Pompholix sulcata Hudson	1992	475	994	133
Filinia terminalis (Plate)	223	287	611	914
Conochilus unicornis Rousselet	11	9	17	84
Collotheca balantonica Varga	139	56	9	7
Rotaria trisecata (Weber)	4	34	0	32
Cladocera				
Diaphanosoma brachyurum Liévin	2	304	6	1894
Daphnia longispina (O.F. Müller)	37	833	20	2844
Ceriodaphnia pulchella Sars	58	1078	49	653
Moina micrura Kurz	1	58	13	584
Bosmina longirostris (O.F. Müller)	202	4980	443	2475
Copepoda				
Eudiaptomus padanus etruscus (Losito)	42	627	340	11205

abundances of this species between the ponds were significant ($p<0.01$), *E. padanus etruscus* was the component clearly diversifying the two zooplanktonic communities. The higher eutrophication in P1 can be the main factor negatively affecting the density of this species. According to some authors (Patalas, 1972; Janicki *et al.*, 1979), calanoids show decreasing densities when eutrophication increases, probably because of their superior filtering capacity on low densities of algal cells, occurring in less eutrophicated waters (Mc Naught, 1975).

As observed in other water bodies (Hillbricht-Ilkowska and Weglenska, 1970; Gliwicz, 1977), such quantitative differences in the total zooplankton can be in agreement with a higher eutrophication in P1, which favoured both a numerical increase of microfilterers (rotifers and small cladocerans) and a reduction of macrofilterers (larger cladocerans and calanoids).

b) Diversity and similarity

Zooplankton diversity (Table 3) showed annual average and range values relatively low and very similar in the ponds. Evenness values (Table 3) generally appeared very low, displaying a community structure with dominance of a few species.

The values of PSc showed an intermediate similarity at 0.50m (annual average: 57.5%), mainly due to the dominance of rotifers in both ponds, and a lower similarity at 3m (annual average: 37.2%), due to the differences in density of some cladocerans and of *Eudiaptomus* between the ponds.

Table 3. Mean and range values of zooplankton diversity (H) and evenness (e) in the two ponds.

	depth		P1	P2
H	0.50m	min.	0.77	0.76
		mean	1.84	2.00
		max.	2.66	2.75
	3m	min.	1.39	0.82
		mean	2.16	2.20
		max.	2.99	2.82
e	0.50m	min.	0.06	0.06
		mean	0.18	0.16
		max.	0.69	0.22
	3m	min.	0.08	0.05
		mean	0.20	0.15
		max.	0.75	0.18

2. Zoobenthos

a) Composition

A total of 14 taxa, 12 of which common to both ponds, was found in the bottom (Table 4). Density and biomass values of the total fauna and of each group are reported in Figures 4, 5 and Table 5. Chironomids and chaoborids accounted for 47% in P1 and 69% in P2 for densities, 96.5% in P1 and 96.2% in P2 for biomasses of all organisms collected. Oligochaetes, benthic cladocerans, ceratopogonids and nematodes were mainly present in relatively low densities and in very low biomasses. No significant differences were found in density and biomass of the total fauna between the ponds, but t-test applied on densities excluding April data, where cladocerans reached an exceptionally high abundance in P1 (12000 ind/m²), indicated a significantly higher density ($p<0.05$) in P2 than in P1.

Chironomids constituted the most abundant group both in density and in biomass, reaching 32% and 72% of the total fauna in P1 and 45% and 59% in P2, respectively. T-test showed a significant difference ($p<0.05$) between densities of chironomids in the ponds, but not between their biomasses. Densities and biomasses showed similar trends in the ponds, with a great variation during the year (see CV% values). Figure 5 shows the highest chironomid values in winter, their period of emergence more concentrated in spring and a remarkable reduction of larvae in summer. This reduction, typical of eutrophic waters, was more accentuated in P1, where the larval recolonization of the bottom was slower than in P2. The most common genera were: *Procladius, Chironomus plumosus* gr, and *Cladopelma,* frequently found in eutrophic waters (Bryce and Hobart, 1972; Saether, 1979; Bazzanti and Seminara. 1987). The different proportion of *C. plumosus* on the total chironomids (37.1% in P1 and 15.5% in P2) clearly indicated the greater eutrophication of P1.

Chaoborids reached the highest abundances in summer and the lowest ones in autumn and spring. Their fluctuations were opposite to those of chironomids. Numerical and weight values of *Chaoborus flavicans* were different in the two ponds, with a significant predominance in P2 ($p<0.05$). Recent observations (Stenson, 1978) detected a great ability of this species to escape predation, thanks to the extremely trasparent body and to the possibility of finding shelter in the bottom, where anaerobic conditions reduce the predation pressure. The summer maximum density of larvae in

Table 4. List of benthic taxa collected in the two ponds.

Nematoda (only in P1)

Oligochaeta
- *Dero digitata* (Müller)
- *Limnodrilus hoffmeisteri* Claparède
- *Limnodrilus claparedeianus* Ratzel (only in P2)
- Immature tubificids without hair chaetae

Cladocera
- *Iliocryptus* sp.

Chironomidae
- *Procladius*
- *Tanypus*
- *Chironomus plumosus* gr.
- *Chironomus*
- *Polypedilum nubeculosum* gr.
- *Cladopelma*
- *Microchironomus*

Ceratopogonidae
- *Palpomyia*

Chaoboridae
- *Chaoborus flavicans* (Meigen)

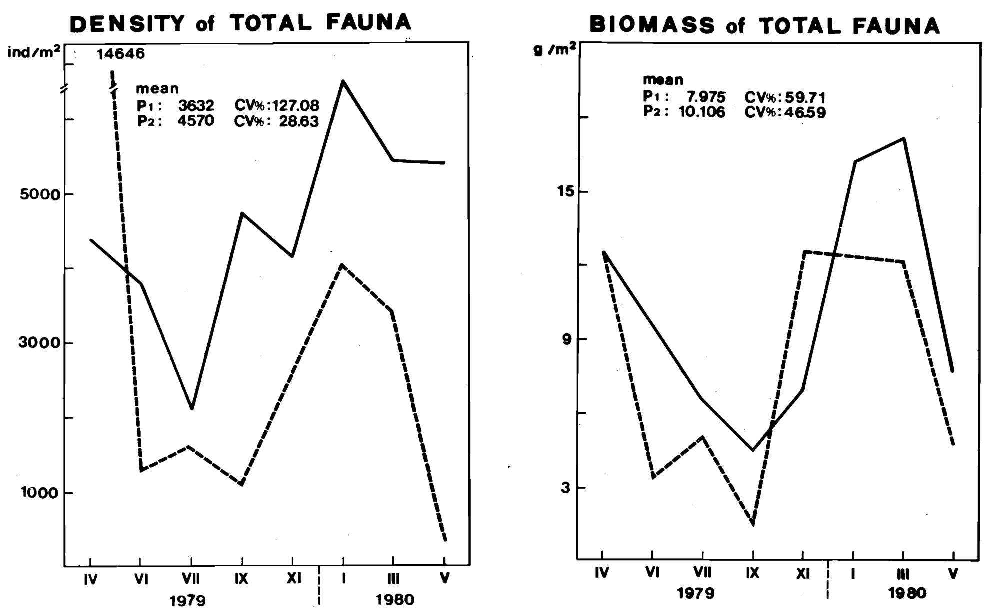


Fig. 4 – Seasonal variations in density and biomass of the total fauna in P1 (- - - -) and P2 (———). CV% = coefficient of variation.

P1 and P2 could be ascribing to a reduced feeding activity of fish on the bottom (Cataudella, pers.comm.).

Oligochaete densities, due almost exclusively to *Dero digitata,* showed significant numerical ($p < 0.01$) and weight ($p<0.05$) dominances in P2. As already observed by some authors (Lellàk, 1969; Ali *et al.,* 1977), numerical scarcity of oligochaetes in both ponds was probably related to competition with detritivorous chironomids.

Figure 5 shows the comprehensive low densities of cladocerans, ceratopogonids

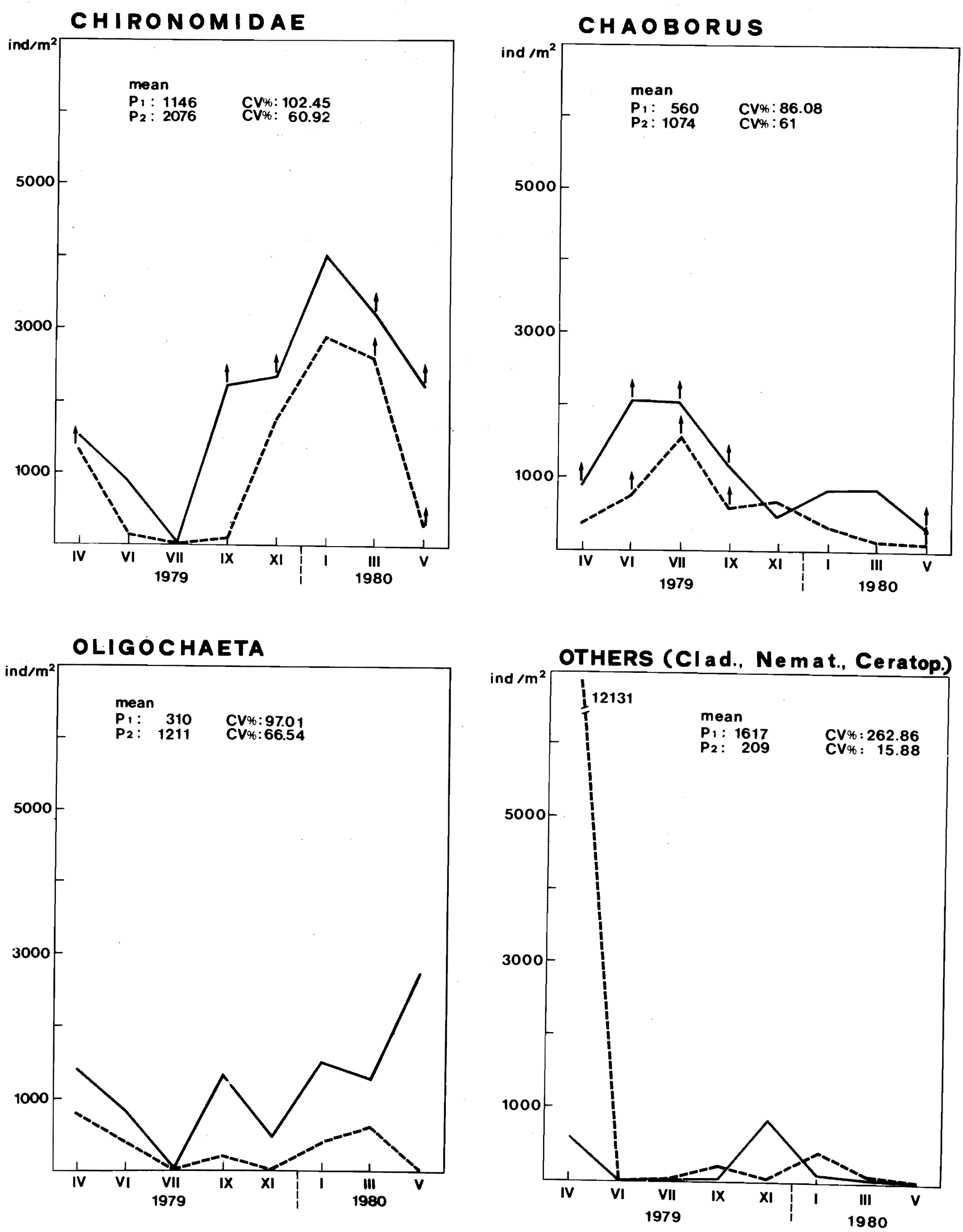


Fig. 5 – Seasonal variations in density of the benthic groups in P1 (– – – –) and P2 (————). CV% = coefficient of variation. Arrows indicate emergence period.

and nematodes, occurring in very low biomasses (Table 5). No significant differences were observed in density and biomass of the three groups between the ponds.

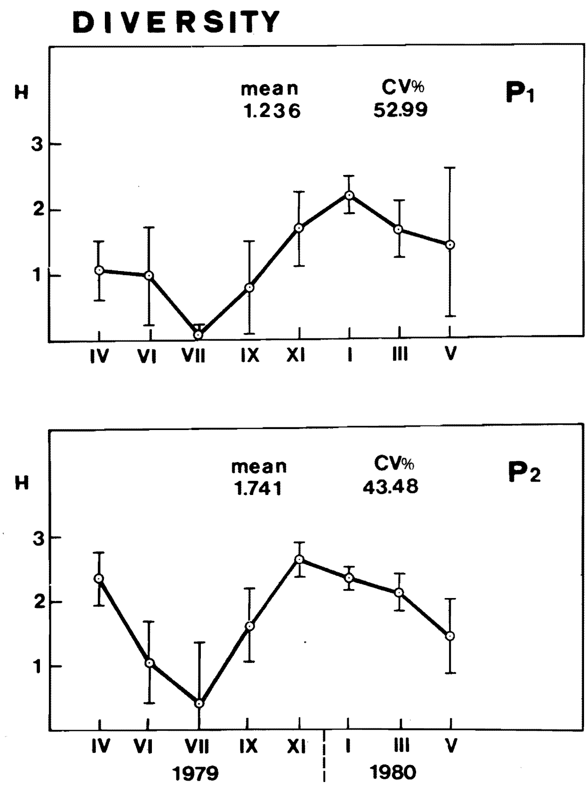
In both ponds, chironomids and chaoborids constituted the bulk of the total benthos. Similar conditions have been recorded in fishponds containing a high presence of temporary fauna (mainly chironomids) (Lellàk, 1969, 1978; Wròbel, 1972; Dimitrov, 1977). It is interesting to observe that the dominance of chironomids both determines a numerical instability of the benthic community and seems to increase fish production. Indeed, chironomid larvae are more easily accessible for fish compared to other organisms such as tubificids (Lellák, 1969, 1978) and have a particularly high protein content (Czeczuga and Gierasimov, 1978).

Moreover, seasonal variations of density and biomass (compare CV% values) of the total benthic fauna and of each group indicated a lower stability (persistence over time) of the community in P1 than in P2.

b) Diversity and similarity

The highest diversity (Fig. 6) was observed in November (in P2) and in January (in P1), mostly due to an increase in the number of chironomid taxa, and the lowest one in July, due to a strong simplification of the total communities. Evenness (Fig. 6) followed a trend similar to the diversity. T-test detected a significant difference ($p<0.05$) in diversity and evenness values between the ponds. The lower community diversification and the less stable diversity and evenness (compare CV% values) in P1 can be in agreement with the higher eutrophication in this pond.

The values of PSc showed an intermediate similarity between the benthic fauna of the two ponds (annual average value: 60.9%). The highest similarity was reached in summer (95.5%) due to the great simplicity of the benthic structure in both ponds.



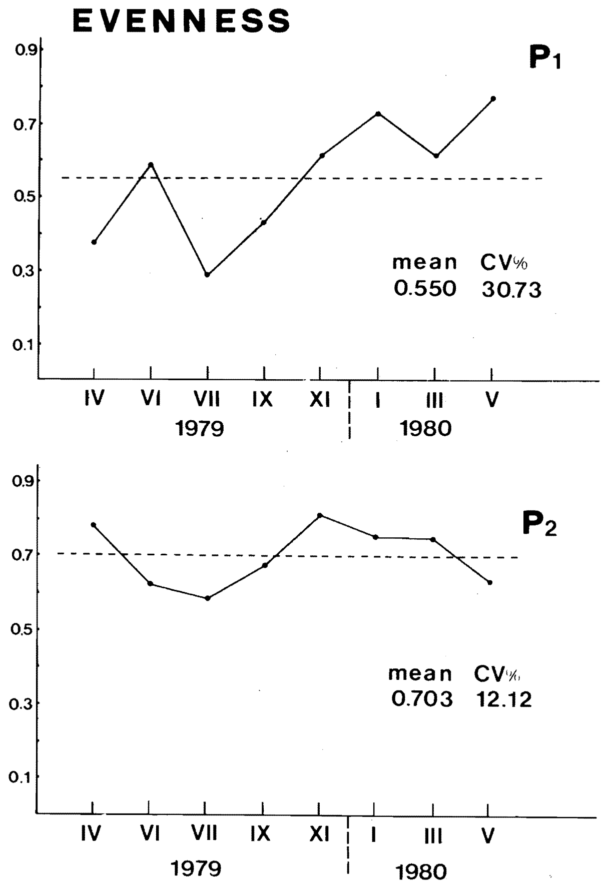


Fig. 6 – Seasonal variations of benthic diversity and evenness in the two ponds. CV% = coefficient of variation. 95% confidence limits are shown by vertical bars.

Concluding remarks

The analysis of the invertebrate fauna in the two fishponds allow us to define some ecological aspects. In both ponds we observed: a) planktonic and benthic communities composed of species typical of eutrophic waters and of a few others with wide ecological valence; b) low planktonic and benthic diversities and evenness, reflecting communities characterized by a few numerically prevailing species; c) benthic communities showing a small number of taxa with a great numerical fluctuation during the year and a strong reduction in summer; d) very high proportions of temporary fauna (Chironomidae and Chaoboridae) with respect to permanent benthos (Oligochaeta).

Although the similar morphological features and the same fertilization treatment of the two ponds, the more eutrophic pond showed: a) a planktonic community composed of lower densities of copepod calanoids (macrofilterers) and numerical dominances of rotifers and small cladocerans (microfilterers); b) a benthic community characterized by lower density and biomass of some groups, by lower diversity, evenness and stability, and by a slower chironomid recolonization of the bottom after summer anoxia.

Table 5. Seasonal variations of benthic biomass (g/m²) in the two ponds. Others: cladocerans, nematodes and ceratopogonids.

	1979					1980			
	IV	VI	VII	IX	XI	I	III	V	mean
P1									
Oligochaeta	0.427	0.222	0.000	0.011	0.006	0.051	0.124	0.004	0.106
Chironomidae	8.676	1.295	0.000	0.048	9.561	10.745	11.345	4.268	5.742
Chaoboridae	2.155	1.829	5.049	1.398	2.937	1.357	0.549	0.374	1.956
Others	1.175	0.000	0.010	0.012	0.016	0.144	0.019	0.024	0.175
P2									
Oligochaeta	0.808	0.211	0.066	0.144	0.099	0.221	0.318	0.680	0.318
Chironomidae	8.020	2.887	0.007	1.219	4.831	12.477	12.695	5.645	5.974
Chaoboridae	3.386	6.406	6.365	3.041	1.852	3.381	4.130	1.405	3.746
Others	0.306	0.000	0.000	0.010	0.079	0.097	0.049	0.018	0.070

Planktonic and benthic communities have long been traditionally used to monitor eutrophication in lakes and play an important role in fish food chain. Our results assume that the analyses of these communities can be a good tool to test the degree of eutrophication also in fishponds. Moreover, the knowledge of the seasonal composition, abundance and structure of these communities can indicate for each pond the best period for fry restocking and the possibility of introducing new fish species according to their food preferences.

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Marine Turtles in the Central Mediterranean Sea

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ABSTRACT

The population of loggerheads in Lampedusa was examined during the nesting season in 1985. After successful nesting, it was observed that 101 eggs were laid, of which 67 hatched.

This study reveals that Conigli Beach is the only remaining rookery of *Caretta caretta* in the central Mediterranean. At least five other nesting sites in Lampedusa were rendered unsuitable for nesting due to buildings and bathing by residents and tourists. *Rattus rattus* was found to be the main predator, besides man, at Conigli Beach.

The capture of one specimen of *Chelonia mydas* near Lampione in summer 1983 is reported.

In spring and summer 1986, loggerheads which were caught by fishermen were examined in Malta for injuries and pollution. Results showed that 19.5% of the examined turtles had injuries on flippers and carapace, and over 20% suffered from physical or chemical pollution.

The capture of two *Eretmochelys imbricata* – one specimen caught in summer 1984 near Lampedusa, and one in 1980 near Gozo – is reported. One leatherback was observed in Lampedusa, close to the shore of Conigli Beach, where it was probably trying to nest. Information on 12 *Dermochelys coriacea,* captured or sighted in Maltese waters between 1970 and 1980, is given.

This study includes a historical review of former reports of turtles in the central Mediterranean. Former detections of *Lepidochelys kempi* and *Chelonia mydas* are also briefly described. The number of loggerheads killed annually is estimated at 150-300 in Lampedusa and 500-600 in Malta.

It is therefore proposed that, if the last loggerhead rookery left in the central Mediterranean at Conigli Beach is to be preserved, this beach should be immediately closed to the public during the nesting period.

Introduction

Seven fairly large islands are situated in the central Mediterranean, namely – the Pelagic Islands: Lampedusa, Lampione and Linosa – the Maltese Islands: Malta, Comino and Gozo, and – the island of Pantelleria.

In 1847, Pietro Calcara was the first to report sea turtles from the central Mediterranean – namely *Caretta caretta* from Lampedusa. He wrote: "Fra i rettili esiste in abbondanza nel mare di Lampedusa la *Chelonia caretta...*" Trabucco (1890), who was probably supported by the data of Calcara from Lampedusa, reported: "In mare abbandonando la:..., *Thalassochelys corticata,* ..." Again in 1890, Gulia reported from Malta: "Comunissima è la *Thalassochelys caretta* di Bonaparte, detta dei maltesi *Fekruna tal-baħar,* la quale talora cresce alla lunghezza di sei piedi: in estate la testuggine di mare si avvicina alle spiagge arenose per deporre un gran numero di uova perfettamente rotonde, dalle quali in men di venti giorni il sole fa sbucciare le piccole testuggini", and Minà-Palumbo (1890): "... frequente in Pantelleria ..." In 1907 Sommier reported again from Lampedusa: "Non rara, nel mare di Lampedusa, e la grande tartaruga marina (*Thalassochelys corticata* Rondel.) ..." Despott (1915) wrote about *C. caretta* from the Maltese Islands: "The loggerhead turtle is very common in our seas and from August to November is taken in large numbers; in spring it also reappears, and has been known during that season to lay its eggs on our unfrequented sandy beaches, especially at Gozo. It is largely used as an article of food by the majority of the population." This report by Despott contains the first remarks about an exploitation of sea turtles in the central Mediterranean. Further reports on sea turtles from the Pelagic Islands are by Lanza & Bruzzone (1960), DiPalma (1978) and Gramentz (1986); and from the Maltese Islands by Despott (1930a,b), Mertens (1968), Bonett (1982) and Lanfranco (1983).

Materials and Methods

The work at Conigli Beach, Lampedusa, which lasted 97 nights, began on 21 June 1985 and ended on 26 September 1985. During this period, beach controls were made every 15 - 25 minutes throughout the night.

Juvenile and adult turtles were tagged with self-piercing monal metal tags of the National Band & Tag Co., U.S.A. The tags were attached to the trailing edge of the left fore limb of the nesting female on her way back to sea. Two circular fences were erected to protect the clutch. The first fence, enclosing an area approximately 80cm in diameter, afforded protection against different predators on Conigli Beach and provided a means to count the hatchlings. The second fence, enclosing on area approximately 150cm in diameter, was erected to prevent intrusion by people. All the hatchlings were allowed to run from the nest to the sea. They were then gathered and, the next morning, they were taken by dinghy to a point approximately 0.8 nautical miles away from their native beach. The hatchlings were released here to avoid *Larus argentatus* and to eliminate the risk of traversing a sea lane in frequent use by the local fishermen.

In Malta, 101 specimens of living *Caretta caretta* were examined during the periods March-May and June-October 1986. These turtles were caught by Maltese fishermen either unintentionally – on hooks baited for *Xiphias gladius* or in nets intended for *Coryphaena hippurus* – or they were purposely caught from the water surface using a lance. The turtles were bought, examined, tagged with red plastic tags of Dalton Supplies Ltd., U.K. and released from vantage points on the island.

Both types of tags used show the return address of the Musée Océanographique de Monaco on the back. The nomenclature of Boulenger (1889) and Loveridge & Williams (1957) was used in counting the epidermal plates of the carapace, i.e. nuchal, vertebral, costal, marginal and supracaudal.

Geography of beaches and reasons for decline

Lampedusa (Fig. 1)

Sea turtles have often been observed laying their eggs at Conigli Beach, Cala Croce, Cala Guitgia, Cala Francese and possibly Cala Pisana before 1940-1950. At present, Cala Pisana is a dirty beach, 15m long and 17m wide. It is littered with stones, dust and human refuse. This beach was originally four to five times as long, probably 33m by 35m. Use of this beach as a nesting site in the past is not certain, however one sea turtle was found there in 1920-1925.

Turtles were observed laying eggs at Cala Francese prior to 1970. In 1970-1978 a beach house was built here. A stone wall, built 12m from the sea almost all along the 50m long beach, prevented the turtles from laying their eggs.

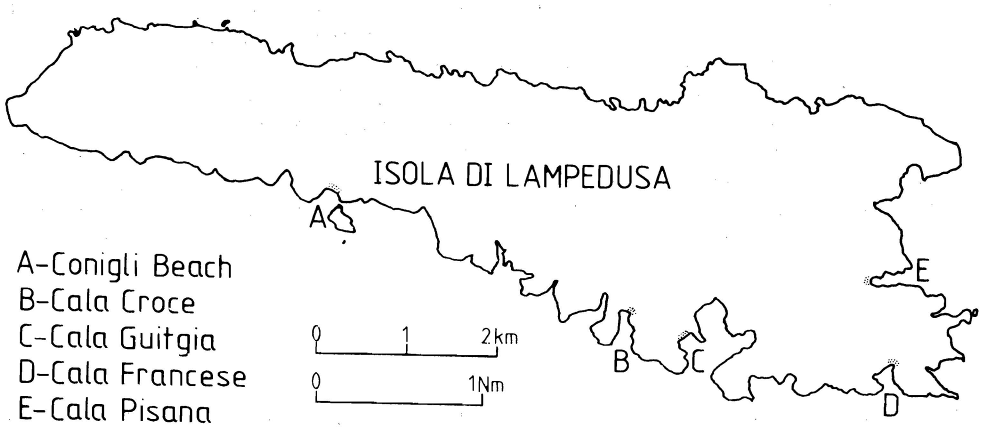

Fig. 1 – Map of Lampedusa showing the former and recent loggerhead rookeries.

Marine turtles were last observed to successfully deposit their eggs at Cala Guitgia in 1970. This 95-100m long beach, which varies in width from 17 to 25m, is the second most important tourist attraction in Lampedusa after Conigli Beach. Tourists seldom visit the beach at night. Hotel and restaurant lights around the beach and the harbour next to it are probably the cause for the turtles' disappearance.

Cala Croce is a widely-used tourist beach 35m long and 20-23m wide. The last observations of sea turtles here were made between 1975 and 1980. Conigli Beach is approximately 130m long and 12-26m wide. At its western end there is an area of $180m^2$ strewn with fist-size stones, from the surface to deep down. This hinders the turtles' digging to the extent that eggs cannot be successfully deposited in this restricted area. At present, it is the most visited beach in Lampedusa – during August 1985, 280-300 people were counted by day and 30-50 people were counted by night. The islanders still remember the large number of sea turtles that used to come to the beach. A few decades ago, eggs and hatchlings were common toys with children. The inhabitants think that since 1950, turtle numbers have steadily decreased. It is their widespread belief that the turtles completely disappeared during the last 5 - 10 years.

Linosa

A resident of Lampedusa reported to me the nesting of a loggerhead on the beach of Cala Pozzolana di Ponente in summer 1965/70. This beach is about 150m long and 9m wide. The egglaying was photographed by the observer, but it was not possible to verify the nesting. Inhabitants' statements, about the presence of sea turtles at Cala Pozzolana di Ponente, are contradictory. Hatchlings were never reported from the beach.

Sommier (1908) reported *C. caretta* in Lampedusa, but not in Linosa. He would have certainly reported the latter if he had any indications of their presence there.

Females do occasionally enter this beach, but today there are no signs of regular nestings.

Gozo

The beach of Ramla l-Hamra, situated on the north coast of Gozo, represents a former rookery for *C. caretta*. It is approximately 300m long and 20-50m wide. There are dunes on the east side and rocks on the west side of the backland.

Gulia (1890) reported the deposition of eggs on the Maltese Islands. He did not, however, refer to any beaches. Despott (1915) too reported the deposition of eggs. His report mentions the island of Gozo without specifying any beaches. It seems likely, however, that he was referring to the beach at Ramla l-Hamra. There has been record of loggerheads breeding at Ramla l-Hamra since 1930 (Schembri pers. comm.).

Although the sea turtles are still hunted legally on the Maltese Islands, the main cause for the turtles' entire disappearance seems to be the large number of resident and tourist bathers.

Pantelleria

During the present study, I could not visit the island of Pantelleria. Minà-Palumbo (1890) made the first report of sea turtles in Pantelleria. He reported frequent sightings of *C. caretta* on the Island, but he did not specify whether these were offshore aggregations or nestings. To my knowledge, this report represents the only record of sea turtles on this island.

***Caretta caretta* at Conigli Beach, Lampedusa**

The first female to nest in 1985 came on 27 June at 0335hr. After a track of 8m, it laid 101 eggs, the size of which was 40-41mm ($\bar{x}=40.4$mm, $n=30$). The turtle was tagged on its way back to the sea (ME 5102). On 19 July (after 23 days), this turtle reappeared at 1150hr. It made two attempts to dig an egghole, but both failed because of the stones on the beach. Its way back to the sea was probably influenced by a bonfire on the eastern part of the beach. A bodypit was made on the way, but activity ended soon. The curved carapace length and width of ME 5102 were 78cm and 69cm respectively.

On 2 September 1985, at 0700hr, a tourist found a loggerhead soon after its second attempt to lay eggs was hindered by stones. As the tourist inspected the turtle more closely, the loggerhead was frightened and made for the sea. This female may not have been ME 5102 since the tourist examined it very closely but did not see any tag.

The clutch of ME 5102 began to hatch on the night between 31 August and 1 September, after an incubation period of 66 days. The hatching was complete on 8 September, after 74 days of incubation (Fig. 2). Hence the incubation period had an arithmetic mean of 68.1 days ($n=63$). 78 turtles hatched, averaging a 77% hatching

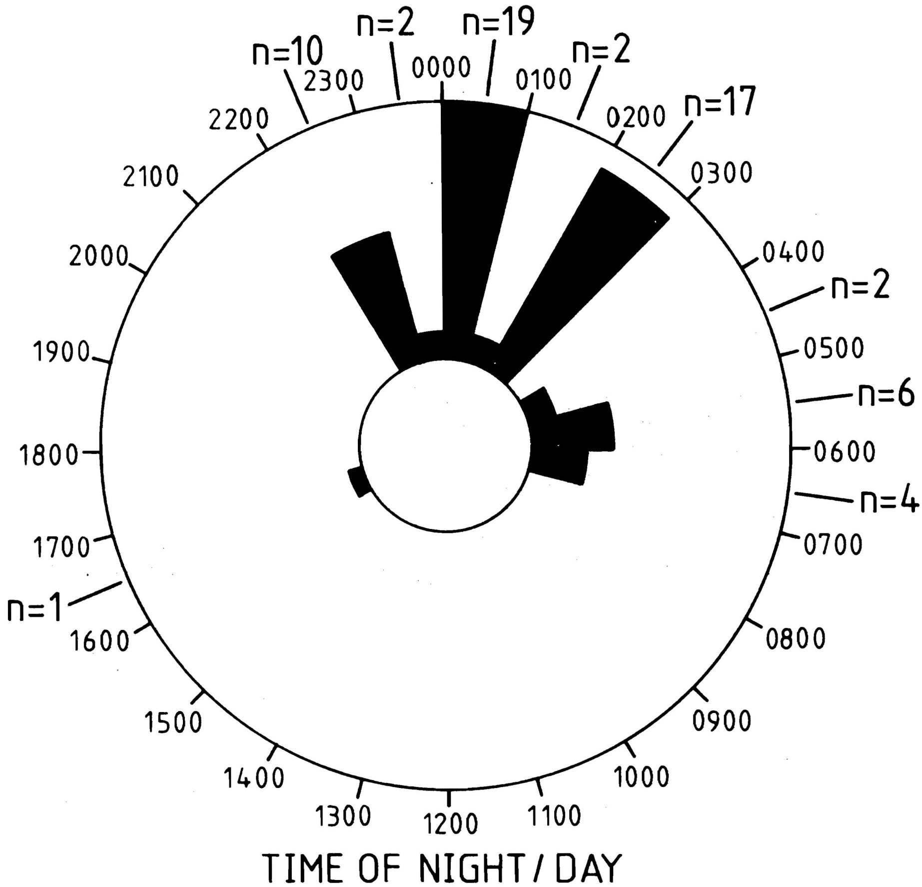

Fig. 2 – Hatchtime distribution of 63 **Caretta caretta** *hatchlings from the clutch of ME 5102.*

success. Of these, 63 were observed hatching: 62 hatched during the night or early morning and one turtle hatched in the afternoon (Fig. 2).

Like all other hatchlings that I examined in the Mediterranean, all of the observed hatchlings from this clutch were greyish when dry and black when wet. A morphological and morphometrical examination was carried out on 52 of the hatchlings. The marginal plate distribution of the hatchlings was 11 L/11 R 63%, 12 L/12 R 23.1%, 12 L/11 R 5.8% and 13 L/12 R 1.9%. The inframarginal plate distribution of the hatchlings was 4 L/4 R 48.1%, 4 L/3 R 26.9%, 3 L/3 R 23.1% and 3 L/4 R 1.9%. The relation of marginal and inframarginal plates, given in Fig. 3, shows a 11 L/11 R and 4 L/4 R predominance. The hatchlings' straight carapace length measured 40-46mm ($\bar{x} = 43.4$mm) and weighed 15-19g($\bar{x} = 17.3$g).

Caretta caretta in Malta

All of the 101 turtles studied in Malta had their carapacial and plastral plates examined. Teratological features of the costal, vertebral and marginal plates were

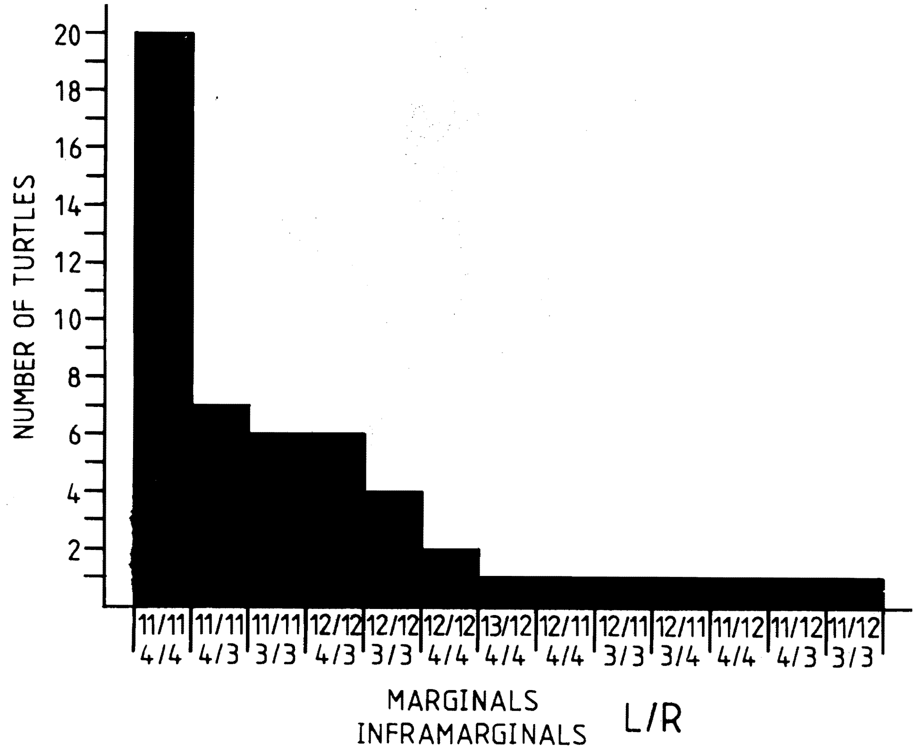

Fig. 3 – Distribution of the marginals/inframarginals of 52 **Caretta caretta** *hatchlings from the clutch of ME 5102.*

evident on 12 turtles (12%). In two turtles, the nuchal plate was entirely divided into two parts, while in another two, it was partly divided, with the seam starting from the cranial end. A supernumerary, restricted to the posterior section of the carapace, was observed on 9 turtles. In contrast, the other 3 turtles had supernumerary plastral plates in the anterior section of the shell.

In Malta, 123 loggerheads, consisting of living turtles and "shell-trophies", were scrutinized for marginal plate distribution. Of these, 68 specimens of *C. caretta* (55%) showed a predominant 12 L/12 R distribution. A more detailed overview of this subject is given in Fig. 4.

A group of 82 loggerheads were examined for injuries caused by predators. The damage suffered by 16 of the specimens (19.5%) ranged from insignificant little notches on the rear flippers and posterior marginal plates, to entire loss of one of the extremities. The entire loss occurred in 4 turtles (4.9%). In both M575 and M753, the left rear flippers were missing (Fig. 5), while in M506 and M525, the right fore flippers were cut off. (Fig. 6).

Apparently, turtles are able to survive the severe damage caused by the loss of an entire flipper, mainly because of the rapidity with which their blood coagulates. Not only do they survive the loss of a hind limb, which is used mainly for guidance, but also the loss of a fore flipper, which is their major swimming organ. The survival of turtles after losing an extremity was previously reported by Barth (1962) and Bustard (1972).

All four turtles seemed to be in good condition. It was difficult to decide when they were injured, since they were all old and well healed. However it seemed unlikely that their injuries occurred when they were very young. Turtles M506 and M525 were both

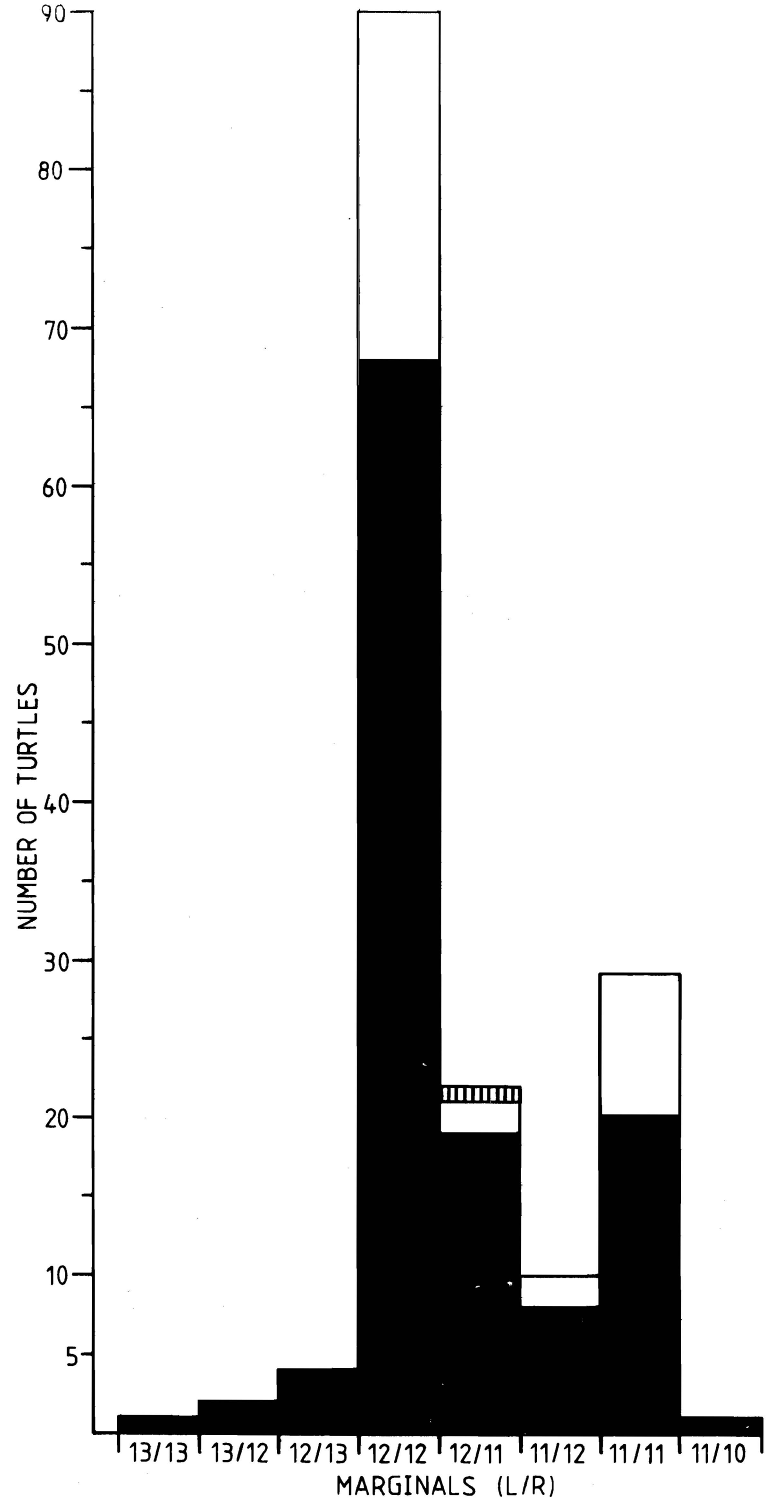

Fig. 4 – Marginal shield distribution of 159 examined loggerheads which were captured by Lampedusan fishermen (white), Maltese fishermen (black) and the nesting female from Conigli Beach (striated).

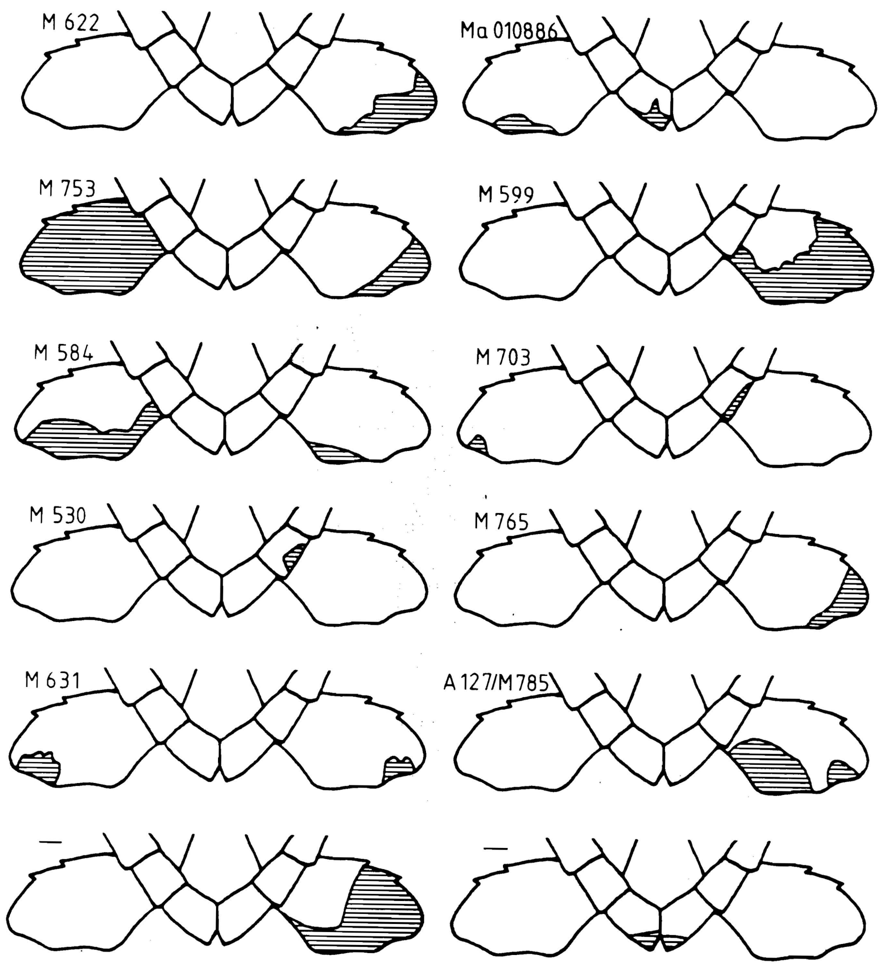

Fig. 5 – Injuries of 12 ***Caretta caretta*** *captured around Malta. Missing parts striated.*

obviously handicapped in swimming speed and diving when they were released. The size distribution of the injured turtles is given in Fig. 7. Turtle M506 measured: straight carapace length/width 45.9/38.7cm and curved carapace length/width 49/46cm, while M525 measured: straight carapace length/width 53.5/45cm and curved carapace length/width 58.5/55cm.

Over 20% of the 99 loggerheads examined for pollution were contaminated with plastic or metal litter and petroleum hydrocarbons (Gramentz 1988).

Chelonia mydas

Lampedusa

In summer 1983, Lampedusan fishermen caught one adult green turtle from the surface water near Lampione using a lance. The turtle was reported as being bigger and different from other loggerheads which were usually captured. It was too heavy to be lifted in the small boat – it was estimated to weigh 150kg – so it was released. The turtle was clearly identified from photographs as *Ch. mydas*.

Fig. 6 – M525 with right fore flipper missing.

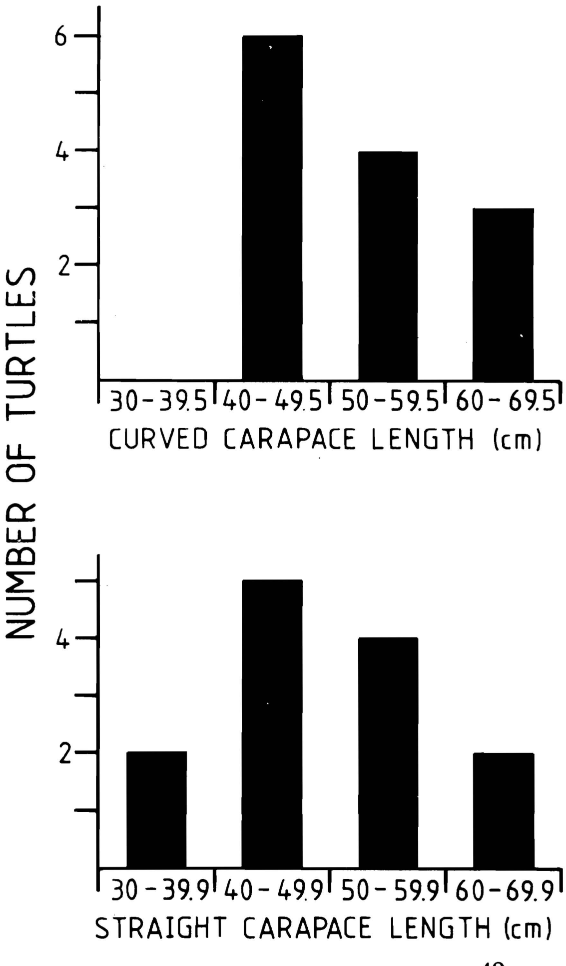

Fig. 7 – Size distribution of 13 ***Caretta caretta*** *found with injuries.*

Malta

An immature specimen of *Ch. mydas* was caught about one mile from the mouth of the Grand Harbour of Valletta (Despott 1930a, b) on 12 October 1929. The meat of this turtle was sold, and its carapace was given to the National Museum of Natural History in Mdina, from where it was lost in World War II. Some populations of green turtles living outside the Mediterranean Sea are known to be long distance migrants. However the green turtles in the Mediterranean live predominantly in the warmer eastern basin. Their rookeries are in Turkey (Geldiay *et al.* 1982), Cyprus (Demetropoulos & Hadjichristophorou 1981, 1982) and Israel (Sella 1981). There are no known green turtle rookeries in the Mediterranean west of 28°E Latitude. Rookeries were detected in the Adriatic Sea (Nardo 1864, Camerano 1891), in Greek waters (Margaritoulis *et al.* 1986), and in small numbers in other parts of the Mediterranean and the Black Sea (Beskov & Beron 1964).

Eretmochelys imbricata

In 1909, Mourgue reported the capture of one specimen of *Eretmochelys imbricata* from Marseille, France. This was the first reported capture of this species in the Mediterranean.

Lampedusa

One hawksbill was caught near Lampedusa by local fishermen in 1984 (details of the date and location are not available). Although this was illegal, the turtle was killed. Its carapace was sold as a trophy to a resident in Palermo, Sicily, who has kept it since. The curved carapace length and width of this specimen are 47cm and 39cm. It has a 11 L/11 R marginal plate distribution.

Malta

In September 1980, a hawksbill was caught by Maltese fishermen approximately 5 nautical miles east of Gozo (Vella-Gaffiero, pers. comm.). It was taken to the National Museum of Natural History in Mdina, Malta, where it was preserved. The curved carapace length and width of the specimen are 49cm and 41cm respectively. It has a 11 L/11 R marginal and 4 L/4 R inframarginal plate distribution.

The locations of origin of the detected migrants are not known since *Eretmochelys imbricata* does not breed in the Mediterranean Sea. It is likely that they came from the nesting sites on Seil Ada Kebir Island in the Suakin Archipelago, Sudan (Ross & Barwani 1982; Hirth & Latif 1980) in the Red Sea and on Perim and Jabal Islands, P.D.R. Yemen (Hirth & Carr 1970; Frazier 1982) in the Indian Ocean. Several marine organisms have found their way into the central area of the Mediterranean via the Suez Canal. Hence, these specimens of *E. imbricata* probably followed this route.

Lepidochelys kempi

Malta

On 12 October 1929, a specimen of *L. kempi* was captured about one mile from the mouth of the Grand Harbour in Valletta, Malta. It was brought to Dr. Giuseppe Despott, the curator of the National Museum of Natural History, together with a specimen of *Ch. mydas,* which was caught in the same area on the same day. He erroneously identified both turtles as *Ch. mydas* (Despott 1930 a,b). A detailed report by Brongersma & Carr (1983) however shows that the former turtle was *Lepidochelys kempi.*

Dermochelys coriacea

Bleakney (1965) and Lazell (1980) discussed the migration route of both sexes of *D. coriacea* from their mating and nesting grounds along the north coast of South America. Since these turtles feed mainly on *Cyanea capillata*, which travels northward along the Gulf Stream, they migrate along the east coast of North America.

Lazell (1980) suggested to follow the southward migration of *D. coriacea* along the European Atlantic coast. Data from Brongersma (1972) and Duguy (1983) gave evidence of this migration. Further indications of this route are given by nine detections of *D. coriacea* on the Portuguese coast between 1978 and 1983 (Pereira, pers. comm.), and by Pasteur & Bans (1960), who reported leatherbacks on the Moroccan Atlantic Coast off Ed-Dâr-El-Beida (Casablanca) and Cap Beddouza (C. Cantin). These turtles probably swim to their mating and nesting grounds via the Canary and North Equatorial Currents.

It seems probable that the Mediterranean specimens are members of the southward migration who accidentally enter the Mediterranean through the narrow Straits of Gibraltar. They cannot reorientate themselves to leave this area and hence they are trapped.

Lampedusa

Dermochelys coriacea was observed twice during the 1985 survey on the island of Lampedusa.

1) On 14 July 1985, a leatherback was observed, at 0310hr, during a patrol. It was 2-3m from the beach, heading towards the land. The turtle kept this position without moving for almost three minutes. It then turned south-east and swam or drifted in the direction of Isola dei Conigli, where it disappeared at 0325hr. I estimated that the turtle was 180-200cm in total length.

The search for tracks required considerable attention since nightly patrols were carried out mostly without lights. In fact, this turtle was seen at a distance of 4-5m just as it was about to leave the water. The observation was continued lying down. However, the movement on the beach probably accounted for its turning back to the sea rather than making a landing.

2) On 19 August 1986, tourists on the ferry connecting Lampedusa and Linosa to Sicily observed one leatherback turtle. The tourists' attention was first attracted by a loggerhead just after the ferry left Lampedusa from Linosa (approximately 2 nautical miles away). They then saw the leatherback, probably an adult, about 20m further away. As long as it was in sight, it was swimming on the surface, rather slowly, seemingly escaping from the boat.

The first detection of a nesting attempt by *D. coriacea* in the Mediterranean Sea on 30 June 1963 at Palmachim, Israel, was reported by Sella (1982). Bruno (1978) reported oviposition by a leatherback on Macconi beach in Sicily. Though these observations in Israel, Sicily and Lampedusa represent exceptional cases, it seems probable that these turtles do try to nest in the Mediterranean. Mrosovsky & Pritchard (1971), Frair *et al.* (1972), Greer *et al.* (1973) and Mrosovsky (1980) discuss the physiological adaptations of *D. coriacea* which enable these turtles to survive in temperate areas. Factors which reduce, or even prevent, development during incubation may be the reason why no juvenile specimens were even caught.

Malta

The following is a list of occasions on which *Dermochelys coriacea* was sighted or caught in Maltese waters from 1970-1980.

1) 5 August 1970: A leatherback was caught by fishermen at a point about 10

nautical miles off Żurrieq. It was estimated to be about 195cm long and to weigh 320-360kg. It was captured using a spear which caused a continuously bleeding lacerated wound, 10cm by 15cm. The turtle, which survived the wound, was brought to Maltaquarium, in Malta. It died here on 6 August 1970 as a result of external haemorrhage. (Anon. 1970 a, b, c; Lanfranco 1983; Caruana, pers. comm.).

2) 22 March 1970: A specimen about 135cm long and weighing approximately 101kg, was landed at Żurrieq by local fishermen. Information about the exact location of the capture and the fate of this turtle is not available (Galea 1972; Lanfranco 1983).

3) 9 October 1975: No details are available of the sighting at the Strand, Sliema (Lanfranco 1983).

4) 13 May 1976: No details are available of the sighting/catching at Marsaxlokk (Lanfranco 1983).

5) 3 July 1976: A specimen, measuring around 195cm in length and 300kg in weight, was captured and killed by fishermen around Filfla. It was transported to the Natural History Museum in Mdina, where its preservation was attempted (Lanfranco 1983).

6) August 1976: A turtle, probably an adult leatherback, was observed by fishermen who were fishing 8 nautical miles south-east of Delimara Point. It surfaced close to the boat, swam towards it and even knocked its head against the hull. The turtle dived as the fishermen moved from the stern to the bow to catch it.

7) 9 November 1976: A turtle, 185cm long, was captured somewhere around Gozo. It was taken to the University of Malta where the skeletal material and visceral organs were preserved (Lanfranco 1983). In August 1986, I tried to examine this material, but it has disappeared and is certainly lost.

8) 3 June 1977: A dead specimen, 185cm long, was found at Spinola Bay (Lanfranco 1977).

9) 13 July 1977: One specimen was captured off Marsaxlokk. No further details are available (Lanfranco 1983).

10) November 1978: A leatherback was found entangled in the ropes of a palm tree "kannizzata" used to catch *Coryphaena hippurus* at a point approximately 70 nautical miles south of Malta. The estimated carapace length was 180cm and the weight was 300kg. The turtle was killed and left there by fishermen.

11) July 1979: A turtle was captured on the long line for *Xiphias gladius* about 10 nautical miles south-east of Malta. It was estimated to have a carapace length of 210cm and carapace width of 90cm. It was brought into Marsaxlokk Harbour and tied to the quay, where it died a week later. The carcass was taken to sea and drowned.

12) End of July 1980: A specimen was found entangled in the line for *Xiphias gladius* about 81 nautical miles south-east of Malta. The estimated carapace length was at least 180cm and the weight was about 400kg. The turtle was released after five crew members failed to lift it onto the boat. One crew member filmed the attempt to lift the turtle.

Predators at Conigli Beach

The principal predator of Conigli Beach is *Rattus rattus. Larus argentatus* and *Ocypode cursor* are other predators. *Larus argentatus* is found on the beach at sunrise and sunset. It remains on Isola dei Conigli and nearby rocks overnight. *Rattus rattus* can be found, in great numbers, everywhere all night long. For many years, it has been observed by inhabitants to catch hatchlings. Both species benefit from the refuse left by tourists.

Ocypode cursor occurs relatively frequently on Conigli Beach. Its predatory effects were reported by Hill & Greene (1971), Mortimer (1983) and Kabraji & Firdous (1984). Ghostcrabs, and their holes and tubes, were found all along the beach. However there was no increase in their concentration around the clutch.

Although Feral domestic dogs are found in great numbers on Lampedusa, they were seldom seen at night on Conigli Beach.

Fishery

Lampedusa

Italian law forbids the capture of sea turles. However, once they are caught accidentally on the longline for *Xiphias gladius*, they are seldom released again. Occasionally, in summer, one fishing boat may catch as many as six turtles per day/night by spearing them in the surface water. If the shell is not going to be sold as a trophy or souvenir, the turtle is killed at sea and only a few kilograms of meat are smuggled in.

Two living specimens of *Caretta caretta* were retreived from fishermen during summer 1985. They were tagged (ME 5101 and ME 5104) and released. 32 preserved specimens, most of which were exposed in restaurants, were examined. These were captured between 1968 and 1985 at a distance of 15-25 nautical miles from Lampedusa. Argano (1979) estimated that the number of turtles killed in Lampedusa is 100-500 per year. Since such activity is illegal, it is difficult to get information from fishermen. However, it seems likely that the number of turtles killed around the island is 150-300 per year.

Malta

In Malta, no laws have yet been enacted to protect sea turtles. Nor are there any regulations which limit the amount of turtles that can be caught.

Bonett (1982) counted 92 loggerheads at the Valletta Fish Market from January to December 1981. These were counted at midday and therefore represent only those which were left unsold, since turtles are killed and sold early in the morning. Many Malta Agricultural and Fishery Abstracts 1959-1967 record part of the catch for the years 1959-1966. The actual weight sold was noted for 1960-1964 (Table 1). The declared values, however, represent minimum values since dealers are often observed not to fill in the vouchers so as to get better profits. Hence most of the turtles sold do not appear in the statistics.

Argano (1979) estimated that 100-500 turtles are caught annually in Malta.

In summer of 1986, 20 loggerheads were counted during 10 visits to the Valletta Fish Market. Six of these were bought and released.

Another 91 turtles were counted at Marsaxlokk, the most important fishing village in Malta. Of these, 76 were bought and released. The 91 turtles do not represent the whole catch, as 50-60 other turtles were killed during the time of examination. One loggerhead was provided by residents who obtained it from fishermen at Wied iż-Żurrieq. Out of 101 loggerheads that were examined, 74 had swallowed the hook from the longline on which they were caught. Of the 83 turtles actually bought, 66 had swallowed the hook as evidenced by the nylon cord still protruding from the mouth. The hooks in 13 of the 66 specimens were stuck well into the gullet, and were therefore removed surgically. Details of the operation will be published elsewhere. Hence 53 turtles were released with at least one hook in their mouth. These turtles were inadvertently hooked on the longlines intended for swordfish. These lines mainly use *Scomber scombrus* as bait. This also attracts *C. caretta.* During the swordfish season, in spring and summer, about 1500-2500 loggerheads are captured by Maltese fishermen. When the turtle swallows the hook and bait, the line is cut off and it is released. Sometimes, the turtle is killed to retrieve the hook. Certainly, 500-600 loggerheads

Table 1 – Weight of turtles sold at the Valletta Fish Market from 1960-1964 (cwts/kg).

	J	F	M	A	M	J
1960	4/200	4/200	4/200	12/600	14/700	4/200
1961	–	–	4/200	8/400	7/350	4/200
1962	–	–	–	–	–	–
1963	–	–	–	–	–	–
1964	–	–	–	–	–	–

	J	A	S	O	N	D	Total
1960	7/350	13/650	7/350	11/550	5/250	4/200	89/4450
1961	7/350	13/650	5/250	3/150	–	–	51/2550
1962	–	6/300	–	–	–	–	6/300
1963	–	–	6/300	–	–	–	6/300
1964	–	5/250	14/700	10/500	–	–	29/1450

are killed every year in Malta. Carapaces are sold on weekends at local markets and in souvenir shops.

Conservation measures needed

Conigli Beach, in Lampedusa, is the only rookery of *C. caretta* left in the central Mediterranean Sea. A very small population of females is left – 1-2 nestings per year or 5-7 per three year cycle. If no conservation measures are taken immediately, there is a danger that the last rookery in the central Mediterranean will come to an end. Killing of loggerhead turtles must be absolutely forbidden on the Maltese Islands, and the law for their protection must be enforced by local authorities in Italy. Conigli Beach must definitely be closed, both to tourists and residents of the Island, from May to October, day and night, if turtles are to survive on Lampedusa.

Protective laws however, cannot change the practice of fishing for swordfish in Lampedusa, Malta, Gozo or Sicily. An enormous amount of turtles are hooked every year during the swordfish fishing season. If these are released by the fishermen, the swallowed hook remains in the pharynx or stomach. Occasionally, turtles, having two or three hooks in different stages of corrosion, are recaptured. Although the majority of turtles captured are not killed by the fishermen, they are potentially in danger of death anyway, depending on the position of the hook. A method must therefore be found whereby the number of turtles caught during swordfish fishing is considerably reduced.

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