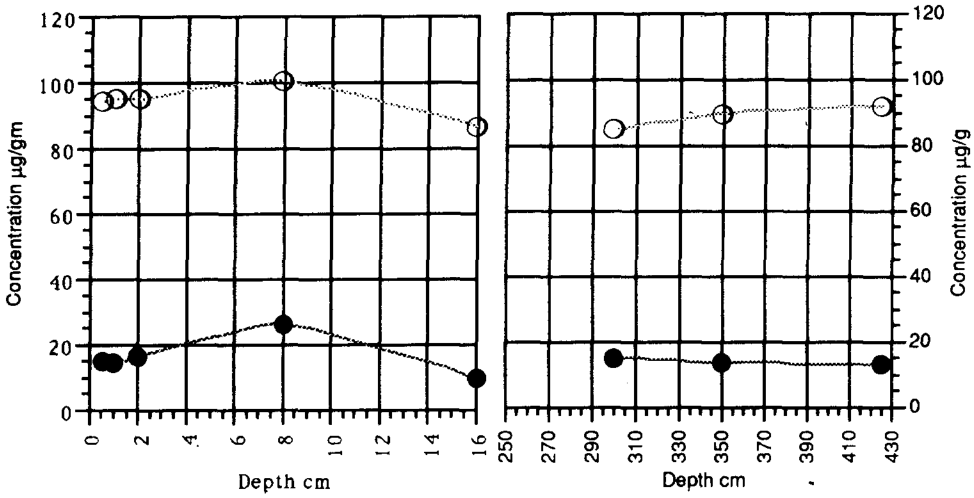

Fig. 5c Vertical core profile of copper (-●-) and zinc (-○-) concentration (µg g^{-1} dry wt) in core no. 97.

distinct regions: *1.* the Fly Delta where metal levels are high (mean values of Cu=28, Pb=13, Zn=91 µg g^{-1}); and *2.* in the adjacent shelf environment where metal levels are relatively low (mean values of Cu=8.2, Pb=2.8, and Zn=23 µg g^{-1}).

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Erratic Occurrence of Benthic Fauna in a Shallow Mediterranean Area: an Indirect Effect of Manmade Disturbance

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The area studied is the innermost part of Atalanti Bay in the North Evoikos Gulf, a landlocked, semi-enclosed embayment located in the west Aegean Sea. Geological data bear evidence of current transport and erosion in shallow environments in this area (Anastasakis & Filippas, 1988). A small island in the Bay was connected to the mainland by a recently constructed causeway. A pilot survey in July 1985 revealed the occurrence of some species characteristic of deeper Mediterranean communities (Peres, 1982). In an attempt to identify possible factors responsible for their establishment, these benthic assemblages were subsequently studied for an annual cycle.

Five stations were chosen which were sampled regularly at bimonthly intervals from September 1985 to July 1986 (Fig. 1). Sampling depths ranged from 0.5 m to 12 m (Table 1). At each station three samples were collected from a small boat by means of a 0.05 m^2 Ponar grab. The environmental characteristics of the sampling stations are shown in Table 1.

In total, 169 species were identified. The ten numerically most important species of each station together with their densities at all the stations are shown in Table 2. Many of the species which were abundant in the area, such as *Lumbrinereis latreilli*, *Notomastus latericeus*,

TABLE 1

Environmental parameters.

Station	Depth (m)	Sediment type	% Sand	% Silt	% Clay	Salinity ‰	Temperature °C
3	3.5	Sandy silt	15	57.6	27.4	35.9–36.6	11.3–27.7
9	9.5	Sandy mud	17.6	48.3	34.1	36.9–37.5	12.8–25.4
12	12	Sandy silt	12.4	60.5	27.1	36.9–37.5	12.7–25.6
14	8	Mud	4.5	50.9	44.6	36.8–37.6	12.8–25.6
18	0.5	Sandy mud	38.6	26.2	35.2	35.2–39.4	11.1–28.5

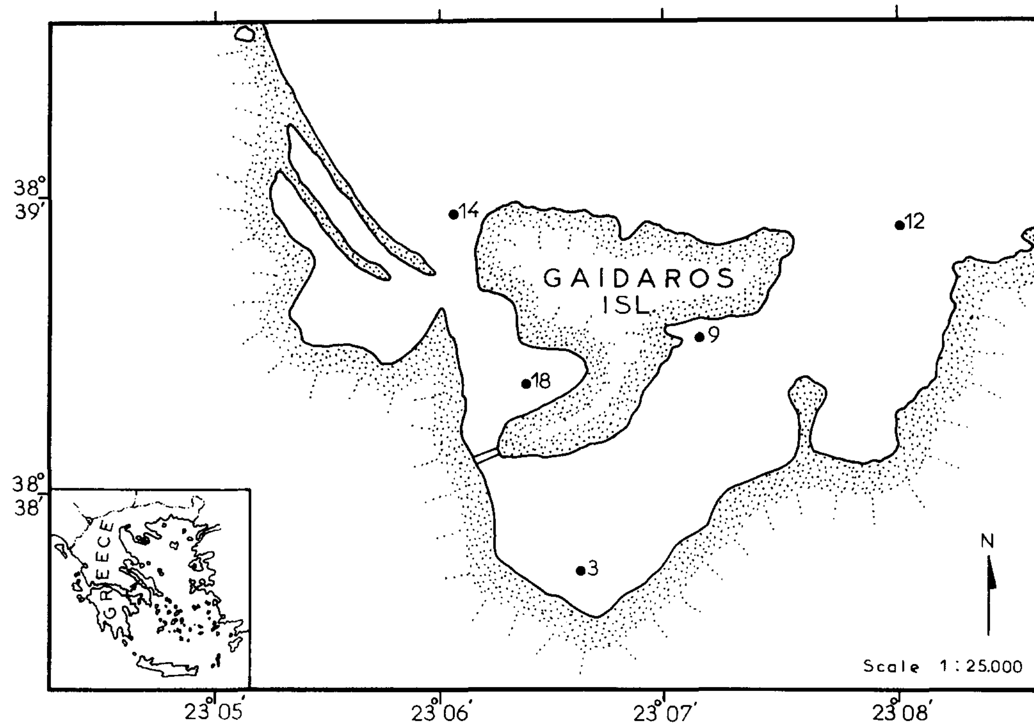

Fig. 1 Sampling area.

Corbula gibba, *Abra alba*, and *Nucula turgida*, are species with wide ecological requirements, characterized as indicators of environmental instability (FAO/UNEP, 1985). Others, such as *Tellina distorta* and *Thyasira flexuosa*, are considered as indicators of organic pollution (Pearson & Rosenberg, 1978).

Apart from these widely distributed species, the shallow stations 3, 9, and 18 were dominated by some species normally found in the deeper zones in the Mediterranean (Peres, 1982). *Mysella bidentata* was numerically important at station 3; *Abra nitida* was dominant at stations 3 and 18; and *A. prismatica* was the second most abundant species of station 18. At station 9, the mud loving species *Melinna palmata*, usually found in muddy communities of the sublittoral, was numerically important. In general, the fauna of all the stations, with the exception of station 18, consisted of species usually occurring in fine sediments. At station 18, in the presence of *Cymodocea*, some species usually associated with vegetation occurred, such as the amphipods *Gammarus insensibilis* and *Microdeutopus gryllotalpa*, and the polychaete *Platynereis dumerilli*.

Multivariate analysis applied to the data showed that temporal differences were less important then spatial differences.

The temporal variations in the number of species and individuals for stations 3, 9, and 18 which had the deep water species are given in Figs 2a, b. In general, the greatest number of species was observed in the deeper station 9 and the lowest number of species in the shallower station 18. The number of species at stations 9 and 18 peaked in January and May. The numbers of individuals also showed an increase in January, though the highest densities occurred in May. The high number of individuals in this month is due to the settlement of *Gammarus insensibilis* at station 18 and to large numbers of *Lumbrinereis latreilli* at station 9. In the same month there was settlement at station 3 of *Abra nitida* and *Corbula gibba* whose densities changed from 15 to 229 indiv. m^{-2} and from 39 to 170 indiv. m^{-2} respectively. A further increase in the number of individuals at this station occurred in July with the settlement of *Mysella bidentata*.

The benthic fauna in Atalanti were not typical of the shallow-muddy-sand bottoms of the Mediterranean as described by Peres (1982), except for station 18 which had a fauna resembling more closely the muddy sand organismic assemblages with metaphytes (*Cymodocea*).

The numerically most important species found in Atalanti fall into four categories, as follows:

1. Species with wide ecological requirements, characteristic of unstable environments (*Lumbrinereis latreilli*, *Notomastus latericeus*, and *Corbula gibba*).

2. Species characteristic of deep water communities

TABLE 2

Total number of species and individuals per station and sampling time. The ten most abundant species at each station and their densities at all stations are shown.

	Station 3						Station 9						Station 12					Station 14					Station 18					
	Sep	Nov	Jan	Mar	May	Jul	Sep	Nov	Jan	Mar	May	Jul	Sep	Nov	Jan	May	Jul	Sep	Nov	Jan	May	Jul	Sep	Nov	Jan	Mar	May	Jul
Number of species	24	24	36	28	34	43	28	34	43	30	42	25	38	19	58	8	21	50	29	47	22	40	19	17	20	16	21	15
Number of indiv. per m	1080	770	821	651	1746	2546	903	1088	1236	496	1598	770	844	355	1147	96	414	1687	792	2035	392	1887	947	1095	733	962	2368	821
Lumbrinereis latreilli	429	252	237	266	289	437	377	503	377	67	607	289	163	74	229	30	111	644	252	503	133	533		81	7	15	30	
Mysella bidentata	74	44	67	30	37	733	15	67	15					7						15		141						
Ehlersia cornuta	89	59	22	59	126	89	7				30		22		15													
Notomastus latericeus	22	37	44	7	148	118	52	7	81	59	141		44	44	81		52	126	74	81	7	81			7	37		
Abra nitida		15		15	229	104				30	52	7	15		44					22			118	96	133	503	15	15
Abra prismatica	74	148	37	22	44	22		7	22		30	7	7		7		15	30	7	22		15						7
Polycirrus medusa	104	30	22	15	59	133	15	7	7		15											7						
Corbula gibba		15	30	30	170	74	37		81	22	59			7	7			7	7	37	7	22				7		
Abra alba	37	15		7	81	163							15															
Leucothoe spinicarpa	74	15			44	52	7	7	15		22	81		15				7	15	7	15	30		118	59	30	81	
Eunice vittata			30	22	7		30	15	104	30	22	22	7		22		15	15								7		
Lumbrinereis gracilis	7	7			44	30	81	44			44	59	44	22				15	44	15	15	44					52	
Ampelisca diadema	15	22	15		44	30	15	7	67		52	52	22	15	30	7	22	15	15	52	15	44		67	37		15	59
Melinna palmata			15		7	15	30	7	52	22	74				15	15		30	37	59	37	7						
Upogebia pusilla						7		111	7			15							15			15						
Tellina distorta							15	15	44		15		15	7	15				7	59		22						
Thyasira flexuosa							15			7			111		15					7	7	30						
Pisidia longimana												59	52		59		7											
Nucula turgida			7	7	30	30		7	7		30	7	52	22	7		7	81	22	89		155						
Golfingia vulgaris	7	7	15	7	30	15	7	7	7		15		7	22	30		7			22		44						
Amphiura chiajei						7			15	7	7				44		15	7				15						
Leptochellia savignyi							7			7		7	15		44							7	15	30			15	126
Nucula nucleus							37		37				22			15		30	37	104	15	81						
Sternaspis scutata							7			30				44	7			22	15	163	7	52						
Loripes lacteus	7	7	15	7					7		7				7		7	96	22	74		30						
Aricidea fauveli			22		37	30		7									15	60	22	52	30	104						
Cossura coasta																		37	44	30		111						
Tharyx heterochaeta	37	22	7	15	22	15	37	15	7		22		15	7	7		7	52	30	30		30						
Gammarus insensibilis			22	7	22				7	15		30				7		7			7		37	392			1258	281
Microdeutopus gryllotalpa						52			7			22			15			7	7				30	37	148	7	451	30
Asterina gibbosa																							170	104	7	7	148	111
Tharyx marioni			7		7	22		7		7	7				30			7	7	15				7	37	200		
Platynereis dumerilli																							37	44	89	22	37	
Armandia cirrosa			15							7	7								7	118			30		74	74	15	
Dexamine spinosa												15												22			118	52

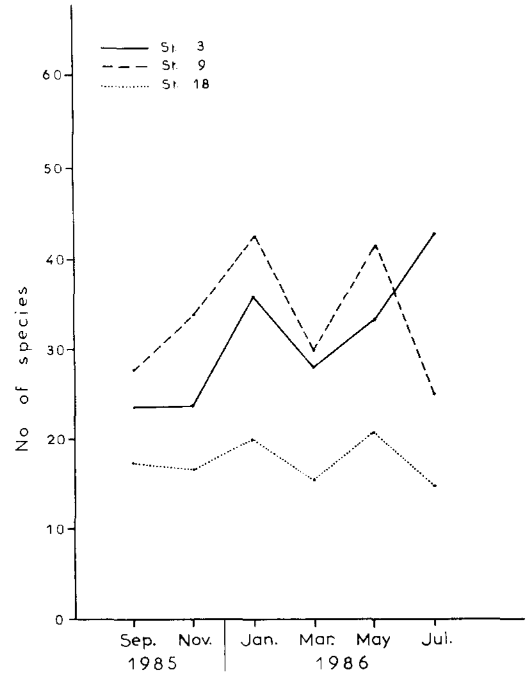

Fig. 2a Temporal variations of the number of species at the shallow stations 3, 9, and 18.

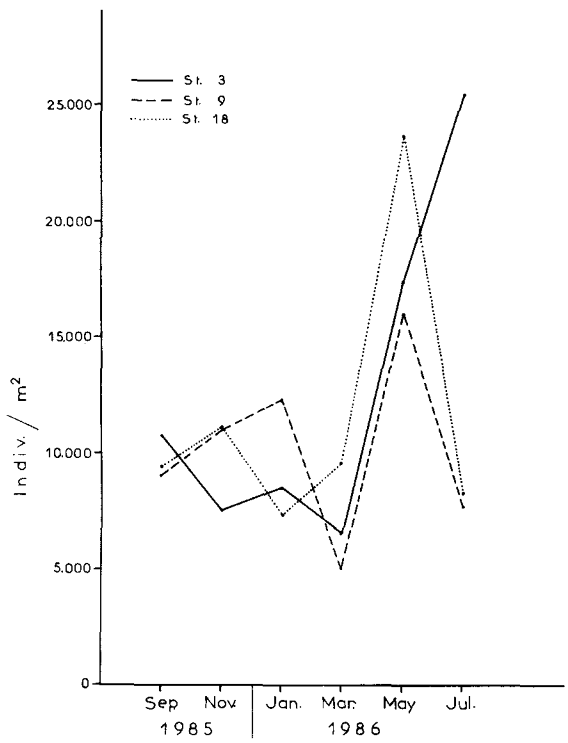

Fig. 2b Temporal variations of the number of individuals at the shallow stations 3, 9, and 18.

(*Mysella bidentata*, *Abra prismatica*, and *Abra nitida*).
3. Species characteristic of the shallow muddy sands (*Loripes lacteus*, *Asterina gibbosa*).
4. Species associated with vegetation (*Gammarus* spp. and *Platynereis dumerilli*).

It is believed that originally the muddy sand community extended over the greater part of the area. The recent construction of the causeway which stopped the water circulating round the island resulted in the formation of eddies (N.C.M.R., 1987). This, in turn, increased siltation in the area. A high energy environment and a low siltation rate at some time in the past is witnessed by the extended dead coral aggregations (*Cladocora caespitosa*) noticed at station 12.

Increased siltation must have had three main effects:
1. Regression of the *Cymodocea* from the eastern part of the bay. Regressions of phanerograms caused by increased siltation are also mentioned by Bourcier (1982).
2. Increased instability in the area. This is indicated by the decrease of characteristic species which are substituted by opportunistic species with wide ecological requirements (Bellan *et al.*, 1985). Instability caused by increased siltation rate is also mentioned by Nodot *et al.* (1984).
3. Settlement of deeper mud-loving species transported to the area by water currents at the larval and/or adult stages. Indeed the increase in the number of species and individuals observed both in January and May followed an increase in the abundance of polychaete and bivalve larvae in the plankton (N.C.M.R., 1987). Conversely, the highest number of species and individuals at the shallower stations 3, 9, and 18 in May coincided with the lowest numbers at stations 12 and 14 (Table 2). Given the fact that storm north-easterly winds prevailed prior to the May sampling (data from the National Meteorological Service), the possibility of transportation of adults should not be ruled out. Redistribution of infauna during storms have been shown by Yeo & Risk (1979), while recolonization of disturbed areas by adult macrofauna has been mentioned by Santos & Simon (1980) and Grant (1981). The genus *Mysella* in particular, one of the colonizers in the present case, has been collected by Dobbs & Vozarik (1983) from the water column during a storm in the Long Island Sound.

Conclusively, the species distribution observed nowadays in Atalanti Bay, strongly indicates a disturbance of the environment. The construction of a causeway which, acting as a barrier, changed the water circulation and increased the siltation rate, coupled with transportation of larvae and possibly adults during storms, are responsible for the unusual faunal distribution in the area.

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THESIS RECORD

Edited by D. V. Ellis

Marine Pollution Bulletin will publish records of university theses relevant to marine pollution in the format shown below. Theses can be from any relevant discipline such as Biology, Chemistry, Engineering, Medicine, Economics, etc. Contributions should be 50–100 word descriptions of thesis content, with emphasis on the marine pollution aspects. They should be sent to the *Thesis Record* editor (Dr. D. V. Ellis, Biology Department, University of Victoria, Victoria, B.C., Canada V8W 2Y2), with a copy of the officially endorsed thesis title page and abstract. Copy of a title page alone may be submitted (by any interested person) in which case the record will consist of author, year, title, degree, university and supervisor. Contributions should be for theses accepted for M.Sc. or Ph.D. degrees during the past five years, although in exceptional circumstances a contribution recording an older thesis will be accepted for publication.

Owen, D. 1989. The scientific basis and operational constraints of applying remote sensing technology to tuna fisheries. M.Sc. University of Newcastle upon Tyne (Supervisor: Dr. A. J. Edwards).

The type of fishery to be dealt with is defined and the tuna species to be studied in detail are introduced. Remote sensing and sensor systems are then defined. A summary of how satellites can be of use in fisheries exploitation and management is followed by an illustration of the difference between environmental assessment and direct monitoring of fish stocks. Fisheries environmental services—the focus of satellite applications to fisheries in this study are then defined. Finally a brief summary of the methods used to survey the literature for this study is provided.

Correspondence to: Mr D. Owen, International Tanker Owners Pollution Federation Ltd, Stable Hall, Stonehouse Court, 87–90 Houndsditch, London EC3A 7AX, UK.

Posangi, J. 1989. A preliminary investigation into the incidence of ciguatera in the Maldive Islands, Indian Ocean. M.Sc. University of Newcastle upon Tyne (Supervisor: Dr. B. E. Brown).

The Laccadive Chacos Ridge consisting of Atolls and associated coral structures, extends southwards from west of southern India to near the centre of the Indian Ocean; the Maldives form the central and largest emergent part of this ridge. In the Maldives coral rock has long been used for construction purposes, with its initial use (pre-20th century) being for mosques, shrines and tombstones. Over the last 80 years the demand for coral rock for building purposes has greatly increased, and on the capital island Malé and on the tourist islands coral rock is now the primary construction material. The mining of corals not only threatens the conservation of fishery resources, but also a rapidly expanding tourist industry, land suitability and possibly the outbreak of ciguatera, which can cause problems to inhabitants since their staple diet is fish. This present project is concerned with man-made disturbance to the reef in the Maldives and the possibility of incidence of ciguatera as a result.

Correspondence to: Dr. J. Posangi, Muscular Dystrophy Laboratories, General Hospital, Newcastle upon Tyne NE4 6BE, UK.

Pranoto, I. 1989. Influence of crude-oil, oil-dispersants and source-species on mangrove microbial decomposers *in vitro*. M.Sc. University of Newcastle upon Tyne (Supervisor: Dr. N. V. C. Polunin).

Laboratory 'microcosm' experiments were carried out to evaluate bacterial numbers on decomposing leaf-litter from different mangrove species both with and without crude-oil or dispersant. There were significant differences in microbial numbers from different species of mangrove leaf-litter, notably an increase in flasks with *Avicennia marina* over those with *Rhizophora stylosa* and *Sonneratia alba* and those without litter (control). Addition of oil tended to stimulate bacterial numbers and dispersant tended to suppress them. Some practical techniques for assessing numbers of mangrove detrital bacteria have also been evaluated.

Correspondence to: Mrs I. Pranato, The Office of State, Minister for Population and Environment, Jl Merdeka Barat 15, Jakarta 10110, Indonesia.

Tongsom, M. 1989. Water quality management study: the Gulf of Thailand approach. M.Sc. University of Newcastle upon Tyne (Supervisor: Dr. B. E. Brown).

The coastal zone of the Gulf of Thailand is a major focus for Thailand's development policy. Coastal waters of the Gulf of Thailand have had multiple uses over centuries. Because the Gulf is sheltered and offers easy access to the capital Bangkok, it is now developing rapidly as a site of industrial expansion. Water quality management, thus, has to be effective in order to both conserve the marine environment and at the same time serve coastal developments which are rapidly expanding. This study attempts to evaluate the present water quality management in Thailand and to propose future effective water quality management for the Gulf of Thailand. Chapter 1 considers the general water quality management framework accepted in developing countries, which may in turn offer some useful lessons for Thailand. Water quality management in the Gulf of