MEDITERRANEAN ACTION PLAN
MED POL

UNITED NATIONS ENVIRONMENT PROGRAMME

WORLD HEALTH ORGANIZATION

COASTAL WATER QUALITY CONTROL (MED POL VII)

CONTROLE DE LA QUALITE DES EAUX COTIERES (MED POL VII)

FINAL REPORTS OF PRINCIPAL INVESTIGATORS
RAPPORTS FINAUX DES CHERCHEURS PRINCIPAUX

MAP Tecnnical Reports Series No. 7

UNEP
Atnens, 1986

For bibliographic purposes this volume may be cited as:

UNEP/WHO: Coastal Water Quality Control (MED POL VII). MAP Technical Report Series No. 7, UNEP, Athens, 1986.

Pour des fins bibliographiques, citer le présent volume comme suit:

PNUE/OMS: Contrôle de la qualité des eaux cotières (MED POL VII). No. 7 de la Série des rapports techniques du PAM, PNUE, Athènes, 1986.

This volume is the seventh issue of the Mediterranean Action Plan Technical Reports Series.

This Series will collect and disseminate selected scientific reports obtained through the implementation of the various MAP components: Pollution Monitoring and Research Programme (MED POL), Blue Plan, Priority Actions Programme, Specially Protected Areas and Regional Oil Combating Centre.

Ce volume constitue le septième numéro de la série des Rapports techniques du Plan d'action pour la Méditerranée.

Cette série permettra de rassembler et de diffuser certains des rapports scientifiques établis dans le cadre de la mise en oeuvre des diverses composantes du PAM: Programme de surveillance continue et de recherche en matière de pollution (MED POL), Plan Bleu, Programme d'actions prioritaires, Aires spécialement protégées et Centre régional de lutte contre la pollution par les hydrocarbures.

INTRODUCTION

The United Nations Environment Programme (UNEP), in co-operation with the relevant specialized United Nations Agencies (FAO, WHO, WMO, IOC) , presented to the Intergovernmental Meeting of Mediterranean countries (Barcelona, 1975) a proposal for a Co-ordinated Mediterranean Pollution Monitoring and Research Programme (MED POL).

MED POL was approved and UNEP was requested to implement the Programme, consisting of seven pilot projects, in close collaboration with the relevant specialized United Nations Agencies.

Its pilot phase (MED POL-Phase I) was designed as the precursor of a long-term programme for pollution monitoring and research in the Mediterranean (MED POL-Phase II) to be carried out according to the provisions of the legal component of the Mediterranean Action Plan.

The pilot projects approved at the 1975 Barcelona Meeting as parts of MED POL-Phase I were:

- MED POL I: Baseline Studies and Monitoring of Oil and Petroleum Hydrocarbons in Marine Waters
- MED POL II: Baseline Studies and Monitoring of Metals, particularly Mercury and Cadmium, in Marine Organisms
- MED POL III: Baseline Studies and Monitoring of DDT, PCBs and Other Chlorinated Hydrocarbons in Marine Organisms
- MED POL IV: Research on the Effects of Pollutants on Marine Organisms and their Populations
- MED POL V: Research on the Effects of Pollutants on Marine Communities and Ecosystems
- MED POL VI: Problems of Coastal Transport of Pollutants
- MED POL VII: Coastal Water Quality Control

Subsequent to the 1975 Barcelona Meeting, several other projects were added or considered as collaterals to MED POL to broaden the scope of the programme and to provide the necessary support to it. They were:

- MED POL VIII: Biogeochemical Studies of Selected Pollutants in the Open Waters of the Mediterranean
- MED POL IX: Role of Sedimentation in the Pollution of the Mediterranean Sea
- MED POL X: Pollutants from Land-Based Sources in the Mediterranean

MED POL XI: Intercalibration of Analytical Techniques and Common Maintenance Services

MED POL XII: Input of Pollutants into the Mediterranean Sea through the Atmosphere

MED POL XIII: Modelling of Marine Systems

Participants in the pilot projects were national research centres designated by the States participating in the Mediterranean Action Plan.

The co-ordination of the MED POL-Phase I (1975-1981) was carried out by UNEP as a part of the Mediterranean Action Plan (MAP).

The following United Nations Co-operating Agencies were responsible for the technical implementation of various pilot projects :

- The Food and Agriculture Organization of the United Nations (FAO) through the General Fisheries Council for the Mediterranean (GFCM) (MED POL II, III, IV and V),

- The United Nations Educational, Scientific and Cultural Organization (UNESCO) (MED POL IX and XIII),

- The World Health Organization (WHO) (MED POL VII and X),

- The World Meteorological Organization (WMO) (MED POL XII),

- The International Atomic Energy Agency (IAEA) (MED POL VIII and XI) and

- The Intergovernmental Oceanographic Commission (IOC) of UNESCO (MED POL I and VI)

This volume of the MAP Technical Reports Series is the collection of final reports of the Principal investigators who participated in the pilot project : "Coastal Water Quality Control (MED POL VII)".

INTRODUCTION

Le Programme des Nations Unies pour l'environnement (PNUE), en coopération avec les organismes spécialisés compétents des Nations Unies (FAO, OMS, OMM, COI), a présenté à la Réunion intergouvernementale des pays méditerranéens (Barcelone, 1975), une proposition de Programme coordonné de surveillance continue et de recherche en matière de pollution dans la Méditerranée (MED POL).

Le MED POL a été approuvé, et il a été demandé au PNUE de mettre en oeuvre le programme qui se compose de sept projets pilotes, en étroite collaboration avec les organismes spécialisés compétents des Nations Unies.

Sa phase pilote (MED POL - Phase I) a été conçue comme le prélude d'un programme à long terme de surveillance continue et de recherche en matière de pollution dans la Méditerranée (MED POL - Phase II) à mettre en oeuvre conformément aux dispositions de l'élément juridique du Plan d'action pour la Méditerranée.

Les projets pilotes approuvés à la Réunion intergouvernementale de Barcelone, en 1975, dans le cadre de la Phase I du MED POL, comprenaient:

MED POL I: Etudes de base et surveillance continue du pétrole et des hydrocarbures contenus dans les eaux de la mer

MED POL II: Etudes de base et surveillance continue des métaux, notamment du mercure et du cadmium, dans les organismes marins

MED POL III: Etudes de base et surveillance continue du DDT, des PCB et des autres hydrocarbures chlorés contenus dans les organismes marins

MED POL IV: Recherche sur les effets des polluants sur les organismes marins et leurs peuplements

MED POL V: Recherche sur les effets des polluants sur les communautés et écosystèmes marins

MED POL VI: Problèmes du transfert des polluants le long des côtes

MED POL VII: Contrôle de la qualité des eaux côtières

A la suite de la Réunion de Barcelone de 1975, plusieurs autres projets ont été adjoints ou considérés comme subsidiaires au MED POL en vue d'étendre la portée du programme et de lui assurer l'appui indispensable. Ce sont:

MED POL VIII: Etudes biogéochimiques de certains polluants au large de la Méditerranée

MED POL IX: Rôle de la sédimentation dans la pollution de la mer Méditerranée

MED POL X: Polluants d'origine tellurique dans la Méditerranée

MED POL XI: Inter-étalonnage des techniques d'analyse et services communs d'entretien

MED POL XII: Polluants d'origine tellurique dans la Méditerranée

MED POL XIII: Modélisation des systèmes marins

Les participants aux projets pilotes étaient des centres nationaux de recherche désignés par les Etats prenant part au Plan d'action pour la Méditerranée.

La coordination de MED POL - Phase I (1975-1981) a été assumée par le PNUE dans le cadre du Plan d'action pour la Méditerranée.

Les organismes coopérants des Nations Unies qui étaient chargés de l'exécution technique des divers projets pilotes sont les suivants:

- Organisation des Nations Unies pour l'alimentation et l'agriculture (FAO) par l'entremise du Conseil général des pêches pour la Méditerranée (CGPM) (MED POL II, III, IV et V).

- Organisation des Nations Unies pour l'éducation, la science et la culture (UNESCO) (MED POL IX et XIII).

- Organisation mondiale de la santé (OMS) (MED POL VII et X).

- Organisation météorologique mondiale (OMM) (MED POL XII).

- Agence internationale de l'énergie atomique (AIEA) (MED POL VIII et XI), et

- Commission océanographique intergouvernementale (COI) de l'UNESCO (MED POL I et VI).

Ce volume de la série des Rapports techniques du PAM rassemble les rapports finaux des chercheurs responsables qui ont participé au projet pilote intitulé: "Contrôle de la qualité des eaux côtières (MED POL VII)".

Contents/Table des matières

Centre de Recherche: Centre de Recherches Océanographiques et des Pêches
Jetée Nord Alger
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Chercheur Principal: F. AID

INTRODUCTION

Dans le cadre du projet MED POL VII, le laboratoire de microbiologie-production primaire a entrepris depuis octobre 1980 une surveillance de la pollution bactériologique des plages de la zone touristique comprise entre le Chenoua et Alger.

La région comprise entre le Club des Pins et Tamentefoust a déjà fait l'objet d'une étude bactériologique en 1977 (AID et. al 1979).

ZONES ETUDIEES

La zone d'étude retenue pour le projet est comprise entre le Chenoua et la Jetée Nord du port d'Alger. Les stations ont été choisies au niveau du lieu de baignade. Ce sont d'Est en Ouest:

Stations 1 et 2: zones de baignade à proximité de ports

Stations 3 et 4: plages d'importants complexes touristiques

Elles sont très fréquentées et des égoûts à ciel ouvert s'y déversent toute l'année.

Station 5: plage sans aucune installation balnéaire au milieu de laquelle arrive l'Oued Mazafran

Station 7: Chenoua-Plage, la plus éloignée d'Alger. Elle est considérée comme station de référence. Ce point de prélèvement est commun au projet MED POL II (laboratoire-métaux lourds du CROP).

Station 8: Vivier où sont entreposés par intermittence des crustacés et des coquillages provenant d'autres régions du pays.

MATERIEL ET METHODES

Les germes totaux ont été dénombrés sur gélose à l'extrait de levure après incubation pendant 48 heures à 22°C et 37°C. Pour le reste, nous avons utilisé les méthodes de référence proposées par le projet, et pour les coliformes totaux et fécaux la méthode de séries de dilution en milieu liquide, décrite dans "Directives applicables à la surveillance sanitaire de la qualité des eaux du littoral".

RESULTATS

Voir tableaux joints (Tableaux I, II, III, IV et V).

CONCLUSIONS

Les résultats dont nous disposons ne représentent que 5 mois de prélèvements. Il nous faudrait un cycle annuel complet comprenant en particulier la période estivale correspondant à une grande fréquentation des plages et à des flambées épidémiques.

Au stade actuel de nos travaux nous pouvons dire que la station 8 représente effectivement une station de référence, bactériologiquement propre. Pour le reste de la côte et comme on pouvait s'y attendre, la plus forte concentration en germes fécaux se rencontre dans les zones urbanisées et à proximité des émissaires d'eaux usées.

Tableau I

Octobre 1980 (11)

Station	Heure	Température mer	Strepto-coques fécaux	Coliformes totaux	Coliformes fécaux	Germes totaux 22°C	Germes totaux 37°C
7			0	2	2	0	0
6			0	49	49	3 300	1 800
5			0	2	2	5 000	4 900
4				700	540	72 000	0
3			1 000	3 500	3 500	340 000	300 000
2			0	23	2	0	4 800
1			0	4	2	8 200	17 000
8			-	-	-	-	-

Tableau II

Novembre 1980 (24)

Station	Heure	Température mer	Strepto-coques fécaux	Coliformes totaux	Coliformes fécaux	Germes totaux 22°C	Germes totaux 37°C
7		16,6°C	0	2	2	0	50 000
6		17,4°C	0	540	79	7 000	7 000
5		16,4°C	0	3 500	920	500 000	-
4		17,5°C	2 500	240 000	240 000	240 000	3 700 000
3		18,5°C	920 000	24 000	240 000	2 000 000	-
2		18,1°C	0	1 100	210	20 000	0
1		-	10 000	49	22	0	2 100
8		-	-	-	-	-	-

Tableau III

Février 1981 (15)

Station	Heure	Température mer	Strepto-coques fécaux	Coliformes totaux	Coliformes fécaux	Germes totaux 22°C	Germes totaux 37°C
7	8h40	14,5°C	0	4	2	0	
6	9h45	15°C	0	3 300	1 100	0	5 000
5	10h00	13°C	2 200	220 000	110 000	-	4 000 000
4	10h20	14,5°C	2 700	540 000	17 000	125 000	1 300 000
3	11h00	15°C	22 000	920 000	240 000	60 000	20 000
2	11h15	15°C	0	46 000	700	20 000	0
1	14h00	15°C	0	49	2	0	0
8	10h40	14°C	0	170	70		0

Tableau IV

Mars 1981 (8.3.81)

Station	Heure	Température mer	Strepto-coques fécaux	Coliformes totaux	Coliformes fécaux	Germes totaux 22°C	Germes totaux 37°C
7	8h25	16°C	0	2	2	0	600
6	9h30	17°C	0	2	2	0	700
5	9h40	16°C	0	1 700 000	260 000	25 000	16 000
4	10h15	17,5°C	0	94 000	17 000	9 500	
3	11h05	18°C	100 000	14 000 000	9 400 000	120 000	120 000
2	11h20	18°C	0	2	2		0
1	12h40	16°C	0	17	4	0	0
8	10h45	15°C	0	110	49	0	

Tableau V

Avril 1981 (12.4.81)

Station	Heure	Température mer	Strepto-coques fécaux	Coliformes totaux	Coliformes fécaux	Germes totaux 22°C	Germes totaux 37°C
7	8h15			-	-		
6	9h30		0	2	2	0	40 000
5	9h45		1 600	3 500	920	0	20 000
4	10h05		-	540	46	1 800	-
3	11h50		-	460	130	4 600	20 000
2	11h00		-	130	11	-	-
1	13h45		-	140	21	-	120 000
8	10h30		-	700	33	-	-

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A. RECREATIONAL WATER MONITORING

INTRODUCTION

Alexandria is the main summer resort of Egypt. The population of the city is about 2.5 million and in summer it receives about half a million tourists who come to its beaches for recreation.

Part of the city sewage is being discharged into the sea through some outfalls along the coast as shown on the Figure 1. The discharges into the sea take place through a major outfall and 18 minor outfalls which are basically emergency relief but in fact are also used in summer to relieve the consistently overloaded condition of the sewerage system.

Within the framework of the MED VII the High Institute of P. Health, Alexandria University is carrying out a monitoring programme sponsored by the Egyptian Academy of Science.

AREAS(S) STUDIED

A coastal line of about 20 kms length is being monitored in order to study the pollution of the recreational waters and its hazards to human Health (Fig.1)

Samples from 20 beaches along Alexandria coast have been collected since 1976.

MATERIAL AND METHODS

The following parameters were measured:

- Temperature, DO, salinity, conductivity and pH
- Total coliforms, faecal coliforms (*E. coli*), faecal streptococci;
- Hydrographie studies: currents (speed and direction) wind (speed and direction);
- Sewage discharge, quantity and characteristics.

The methods used for the measurement of the parameters were those recommended by the "Guideliness for Health related Monitoring of Coastal water quality" (WHO, Copenhagen 1977).

Initially and up to 1978 the multiple tube method was used for the microbiological parameters. The filtration method as agreed in MED VII has been applied and used since 1978.

RESULTS AND THEIR INTERPRETATION

Most of the monitored beaches showed high coliform counts and also high streptococci counts which indicated heavily polluted sea-water as is shown on Table I. The table gives the mean bacterial counts during summer and winter.

Epidemiological Studies:

A retrospective study was carried out to find out if there is a relation between the state of pollution of the beaches and the occurrence of typhoid among bathers. The results of this study showed that there was a significant risk of contracting typhoid from bathing in the polluted water and the most affected were the young age group. This is true since the minor outfalls discharge directly into the beach waters, a matter that results in close contact between the bathers and the faecal matter.

This study proved that these minor outfalls are a real hazard to the health of those frequenting the beaches. Therefore, it was recommended that these outfalls should be closed immediately to protect the public health.

Another study is being carried out to find a relationship between the state of pollution of the beaches and skin diseases.

CONCLUSIONS

From the results so far obtained the following conclusions can be drawn:

(a) Monitoring of the beaches should continue.

(b) The discharge of the minor outfalls should be stopped and long outfalls as recommended by the Master plan should be constructed as quickly as possible.

(c) After the construction of the appropriate long outfalls monitoring of the beaches should be carried out during the summer.

(d) Public Health Authorities should realize that there is a possible risk of contracting diseases from bathing in sewage-contaminated water.

B. SHELLFISH CULTURE AREA AND SHELLFISH FLESH MONITORING

INTRODUCTION

The exploitation for human consumption of bivalve molluscs such as clams, mussels and oysters presents special health problems. Large quantities of molluscs can be produced in relatively small areas, and have become an important source of marine protein.

Sea-water is often subject to sewage pollution. The pollution may range from micro-organisms present in sewage, to heavy metals and other hazardous substances derived from industrial sources (WHO, 1974). A large proportion of the molluscs from these areas are eaten raw or only lightly processed, with a risk that human enteric diseases may be transmitted. Deseases that have been transmitted by the consumption of polluted molluscan shellfish include typhoid, paratyphoid fever and food poisoning (WHO, Chichester and Graham 1973).

AREAS(S) STUDIED

The sewage of Alexandria city is being discharged untreated into the sea resulting in great pollution of the beaches. A major outfall of 150,000 m^3/day is located at Kait Bay area (El-Halaka). Minor outfalls are located at Gleem and El-Mandara beaches discharging 5000 and 4000 m^3/day of raw sewage (Figure 1.).

The aim of this study is to determine the effect of water pollution along Alexandria beaches on the hygienic quality of shellfish.

Two types of beaches were chosen to represent different levels of faecal pollution.

1. Polluted beaches where sewage outfalls are present, such as El-Halaka, Gleem and El-Mandara.

2. Relatively unpolluted beaches where no sewage outfalls exist such as Miami and El-Maamoura.

MATERIAL AND METHODS

A total number of 60 samples of bivalve molluscs (oysters, clams, mussels) were collected for bacteriological examination in clean plastic bags. Bacteriological examinations were done within one hour after collection.

Preparation of sample for examination:

(a) Cleaning the shells: All growth and loose material were scraped off from the shell under running water of drinking water quality, then the cleaned shellfish were placed in clean containers.

(b) Removal of shell contents: The shellfish was opened by using a sterile knife, the adductor muscle was cut from the upper flat shell and the shell liquor and flesh drained into a sterile beaker.

(c) The samples were weighed to the nearest gramme, and an equal amount by weight of sterile phosphate-buffered dilution water was added and ground in the Laboratory blender.

Bacteriological methods:

Total Viable count: The total load of bacteria was estimated using Dyer and Snow medium (1946).

Coliforms: Presumptive tests were done using melten violet red bile agar at 35 $\pm$ 1°C for 48 hours and confirmed by using brilliant green lactose bile broth at 36 $\pm$ 1°C for 24 - 48 hours. (Nickerson and Sinskey, 1972).

Faecal streptococci: Were detected by azide medium and confirmed by Bromothymol blue broth (Tiecco, 1964).

<u>Salmonella sp</u>. were detected by the procedure of FADOU (1966).

Staphylococcus aureus: were detected by using Giolliti and Cantani medium (El-Ahwal, at al., 1974).

RESULTS AND THEIR INTERPRETATION

The bacteriological examination of water samples collected from different beaches at Alexandria are presented in Table II. This table shows that high coliform counts were found at the polluted areas, while relatively unpolluted areas showed low coliform counts. Faecal streptococci were isolated in high numbers at the following areas: 87.5% at El-Halaka, 75% at Gleem and 80% at El-Mandara during summer season. Faecal streptococci were also 50% and 33.3% at Miami and El-Maamoura beaches respectively during the summer season.

Seasonal variation was obvious, showing highest coliform counts during summer and lowest counts during winter except at El-Halaka and El-Mandara beaches, the lowest counts 2800 and 1100 respectively being found during spring (see Table II).

The results of bacteriological examination of shellfish samples collected from Alexandria beaches are presented in Table III. From this table it is shown that high total plate counts were found in shellfish samples collected from polluted beaches of El-Halaka, Gleem and El-Mandara.

The lowest counts were observed in samples collected from unpolluted beaches of Miami and El-Maamoura respectively.

The table further gives the coliform count (MPN/100 gm), and the percentage of samples where E. coli, faecal streptococci, Cl. perfringens, Staphylococcus aureus and Salmonella sp., respectively are detected.

Cl. perfringens were detected only at the polluted beaches while none were found in samples collected from Miami and El-Maamoura beaches respectively. The detection of clostridia species in market shellfish may create a public health problem due to the possible presence of toxigenic members of this group.

Straphylococci were not isolated from the unpolluted beaches, while they were detected in the polluted ones. Therefore, coagulase positive staphylococci have been considered as a potential indication of health hazards in shellfish.

Salmonella were isolated from 20% of the samples examined at El-Halaka beach. Only S. typhi in both strains were isolated.

Figures 2 and 3 show respectively the total plate count and the coliform count in shellfish collected from Alexandria beaches.

The seasonal variation of bacteriological examination of shellfish samples collected from Alexandria beaches is shown in Table IV. This table shows that high bacterial counts were found during summer time and the lowest during winter. Also coliform counts (MPN/100 mg) were high during summer and the lowest during winter.

E. coli was high during summer time at 70% and the during spring at 13.3% while Strep. faecalis was higher during summer at 60% and lower during winter (15%).

Cl. perferingens showed the same picture, 40% during summer and 5% during winter.

Staph. aureus was also high during summer (30%) and low during the winter (6%).

Figures 4 and 5 show the seasonal variation respectively of total plate count and of the coliform count in shellfish collected from Alexandria beaches.

The two strains of *Salmonella typhi* were isolated during summer time and no Clostridia organisms were isolated at any other season.

The correlation coefficients between the coliform count of water samples examined and shellfish samples collected from the same area (r=0.9277) and also in the case of *Streptococcus faecalis* of the same samples, were highly significant (r=0.9282). However the correlation coefficient of the seasonal variation with the coliform count was not significant (r=0.4678); it was also not significant (r=0.7860) with the faecal streptococci counts.

CONCLUSIONS

Shellfish for consumption depend upon the quality of the culture area where they breed. In highly polluted water, pathogens were detected in shellfish making them dangerous to health. On the other hand a relatively small number of faecal organisms in the culture area should not be taken to imply that shellfish harvesting is unsuitable. Shellfish from thighly polluted areas should follow some sort of treatment before they are put on the market. An alternative measure is to reduce the pollution in the culture areas.

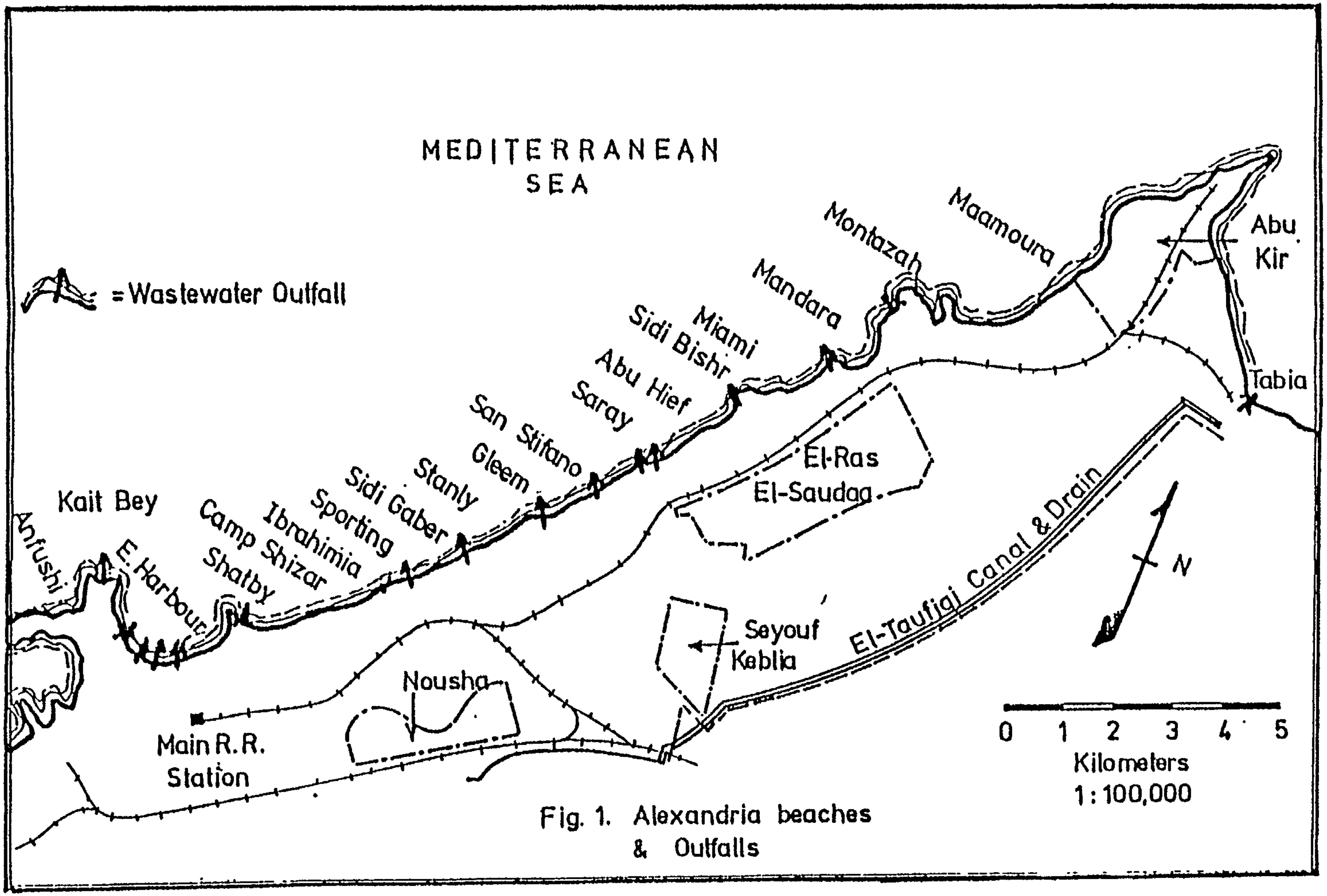

Fig. 1. Alexandria Beaches and Outfalls

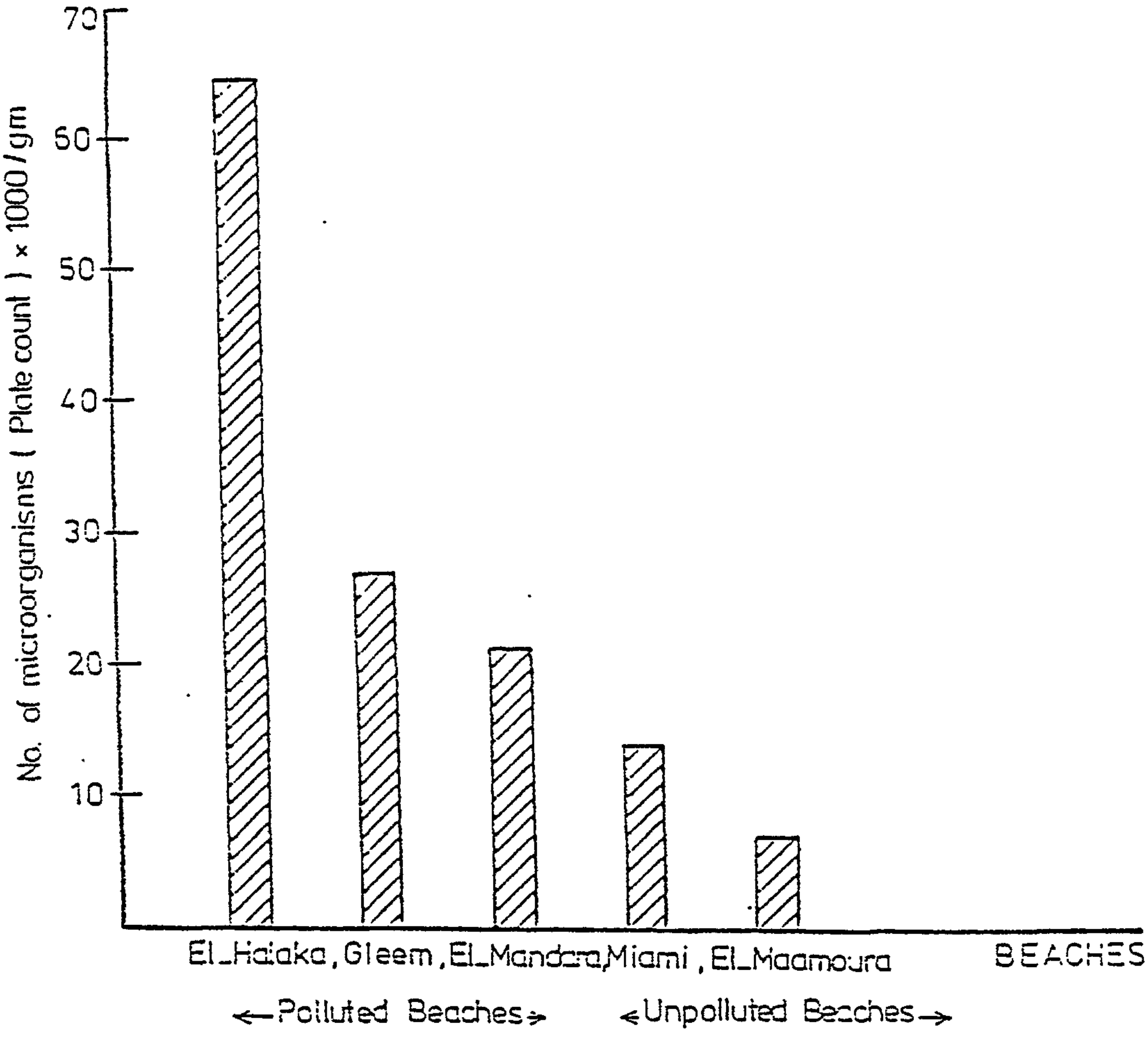

Fig. 2. Showing the total plate count of shellfish collected from Alexandria Beaches

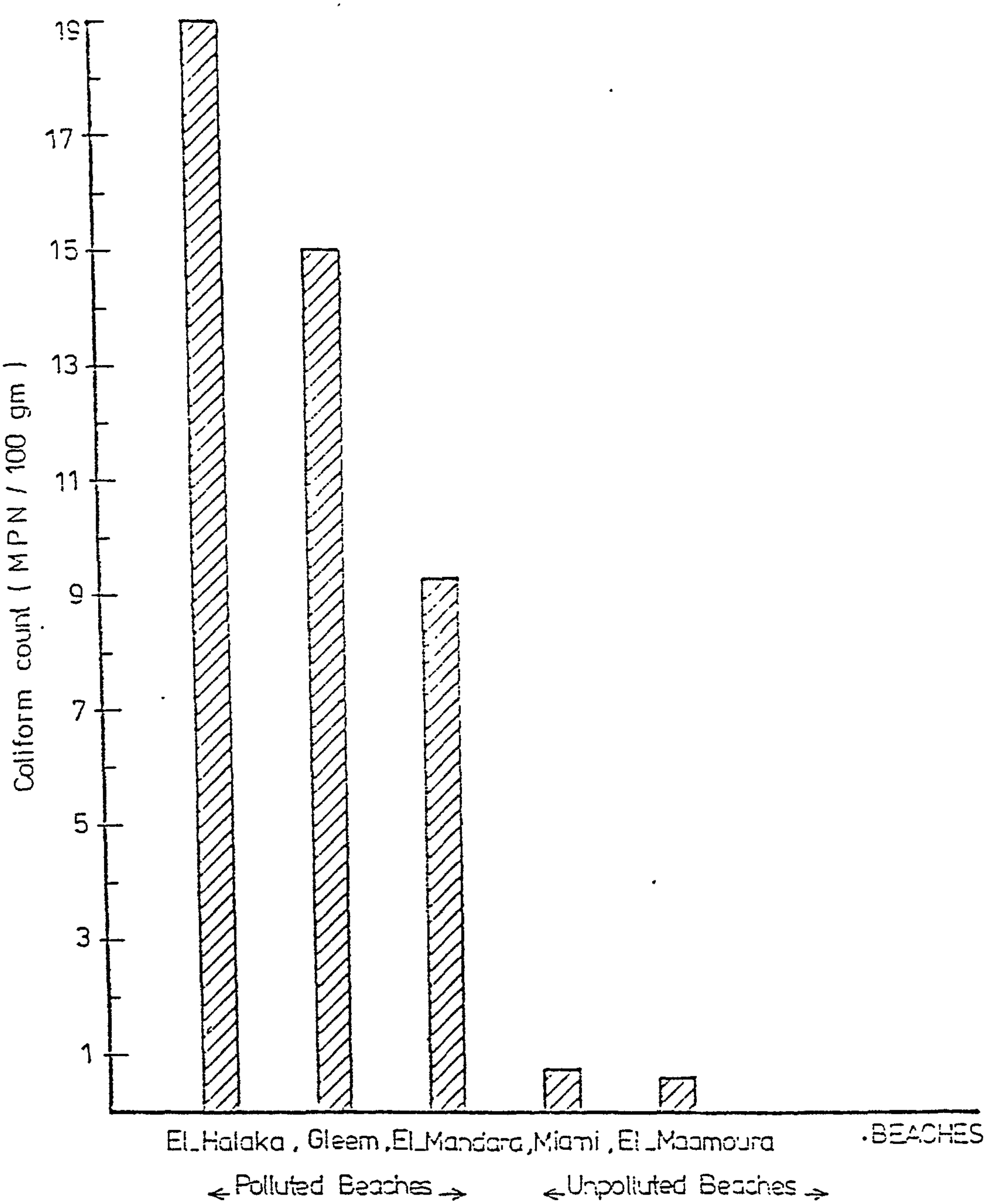

Fig. 3. Showing the coliform count (MPN/100 gm) of shellfish collected from Alexandria Beaches

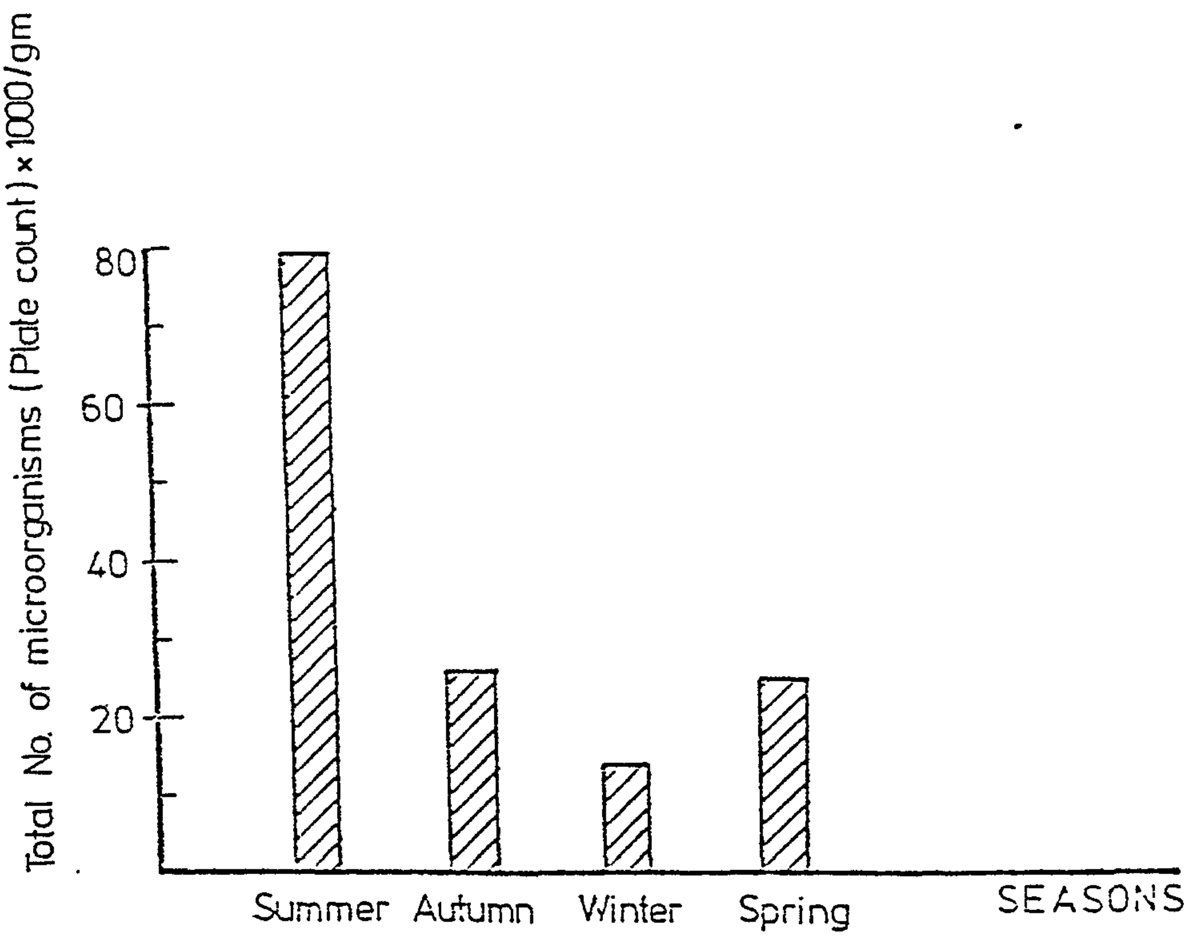

Fig. 4. Showing seasonal variation of plate count of shellfish from different areas of Alexandria Beaches.

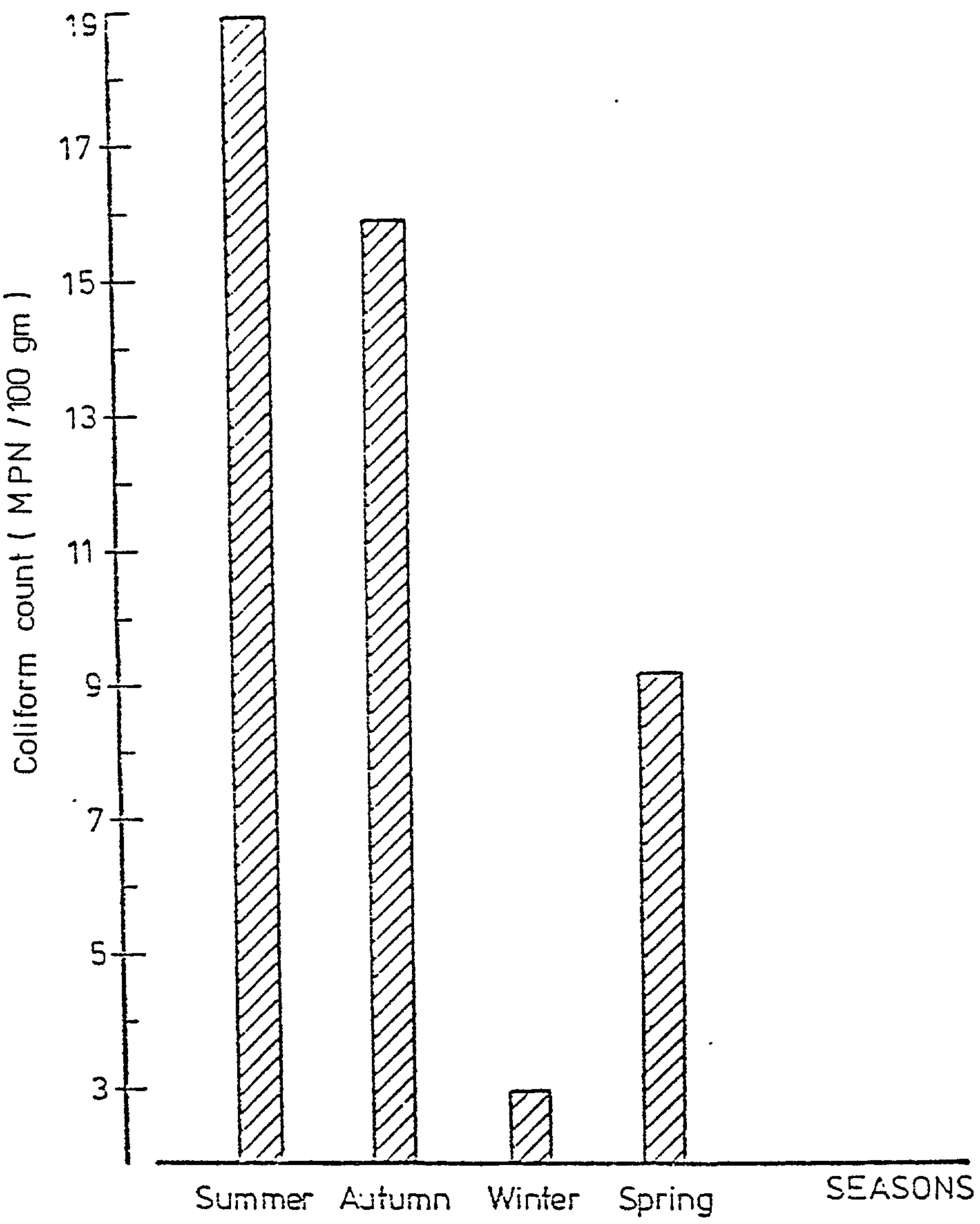

Fig. 5. Showing seasonal variation of the coliform count (MPN/100 gm) of shellfish from different areas of Alexandria Beaches.

Table I Geometric mean for Bacteriological Results

In Winter and summer

No	Beach.	Winter		Summer.	
		Coliform MPN / % Fecal	Fecal Strept. / % Confirmed	Coliform MPN / % Fecal	Fecal Strep / % Confirmed
1 -	El Anfouchi	1660 / 57	2884 / 78	2455 / 66	4266 / 79
2 -	El-Halaka	44668 / 15	31623 / 81	38904 / 65	31623 / 76
3 -	Yachtclub	1023 / 74	1047 / 76	1445 / 72	3162 / 85
4 -	El-Kashafa	2754 / 72	3236 / 76	3236 / 69	4677 / 85
5 -	El-Mahkama	6166 / 64	8128 / 72	15488 / 74	15488 / 55
6 -	El-Shatbi	1230 / 63	2818 / 69	263 / 68	1778 / 78
7 -	Camp Cesar	1148 / 48	2630 / 74	1690 / 74	3090 / 79
8 -	Ibrahimia	1995 / 65	3236 / 83	1862 / 74	1622 / 87
9 -	Sporting	25119 / 57	117490 / 85	11481 / 79	22387 / 89
10-	Sidi Gaber	2884 / 62	4467 / 81	1349 / 62	3981 / 87
11-	Stanley	891 / 76	661 / 52	323 / 54	1412 / 57
12-	Gleem	4571 / 38	10000 / 85	27542 / 67	58884 / 78
13-	San-Stephano	1175 / 49	3388 / 68	1288 / 57	4169 / 81
14 -	El-Saray	912 / 49	3631 / 79	1778 / 54	3802 / 87
15 -	Abou-Heif	107 / 39	1148 / 68	776 / 41	4365 / 85
16 -	Sidi-Bishr	302 / 44	1660 / 71	2138 / 59	2128 / 91
17 -	Miami	190 / 28	1259 / 54	851 / 52	4169 / 93
18 -	Mandara	8128 / 35	17378 / 47	26303 / 62	21380 / 83
19 -	Montaza	46 / 18	407 / 54	316 / 36	933 / 79
20 -	Maamoura	46 / 22	245 / 43	85 / 23	871 / 76

Table II

Water Analysis for Coliform & Faecal streptococci % of different Beaches of Alexandria

	Spring		Summer		Autumn		Winter	
	Count MPN/100 ml.	faecalis %	Count MPN/100 ml.	faecalis %	Count MPN/100 ml.	faecalis %	Count MPN/100 ml.	faecalis %
Halaka	2800	31.25	240.000	87.5	28000	56.25	6000	50
Gleem	2100	20	60	75	9000	63.35	750	56.25
El-Mandara	1100	20	90	80	3400	60	2400	40
Miami	210	20	1100	50	750	40	28	10
El-Maamoura	120	13.3	450	33.3	93	20.6	29	6.6

Table III

Results of Bacteriological Examination of Shellfish Collected from Alexandria Beaches

Beaches	Total Plate Count x 1000			Coliform MP/1000 gm			*E. coli* %	*Strept. faecalis* %	*Cl. perfringens* %	*Staph. aureus* %	Salmonella %
	Min	Mean	Max	Min	Mean	Max					
Halaka	12	64.6	200	6.1	19	35	60	70	40	20	20
Gleem	16	26.9	42	3.6	15	29	62.5	35.5	17.5	17.5	0
El-Mandra	15	21.3	40	0	9.3	22	35.1	21.2	7.4	14.8	0
Miami	2	14	35	0	0.76	6.1	20	10	0	0	0
El-Maamoura	0.2	7.0	10	0	0.6	6.1	10	3	0	0	0

Table IV

Results of Seasonal Variation of Bacteriological Examination of Shellfish from different areas of Alexandria Beaches

	Total Plate Count x 1000			Coliform MP/1000 gm			E. coli	Strept. faecalis	Cl. perfr-ingens	Staph. aureus	Salmonella
	Min	Mean	Max	Min	Mean	Max	%	%	%	%	%
Summer	26	79	200	3.6	19	35	70	60	40	30	20
Autumn	2	26	36	0	61	22	20	33	13.3	6.6	0
Winter	0.2	14	25	0	3.1	22	20	15	5	6	0
Spring	15	25	44	0	9.3	35	13.3	206	6.6	20.6	0

Centre de Recherche : Institut scientifique et techniques des pêches maritimes
SETE
France

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Introduction :

L'Institut des Pêches Maritimes de Sète participe au programme MED POL VII depuis novembre 1978 dans le cadre de la surveillance des zones conchylicoles de la côte Méditérranéenne. En fait ces tâches sont habituellement les notres et nous avons toujours surveillé régulièrement la salubrité des parcs d'élevage des étangs de Thau et de Leucate, reconnus salubres et étant deux zones conchylicoles les plus importantes du littoral méditerranéen français.

En ce qui concerne la Rade de Toulon, il existe une faible activité d'élevage de moules, mais la zone étant reconnue insalubre notre contrôle portait sur des prélèvements effectués après purification dans une station appropriée fonctionnant au chlore. Suite à notre participation au projet MED POL VII nous avons entamé une surveillance mensuelle sur les parcs. Cependant, d' octobre 1979 à mars 1981 il n'a pas été possible de continuer à assurer des prélèvements dans l'étang de Leucate en raison d'une maladie qui a détruit la totalité des produits d'élevage de cet étang. Cette maladie semble liée à la présence surabondante d'une algue microscopique dont on connaît mal, pour l'instant, son mode d'action ainsi que les causes de son apparition et de son maintien.

En ce qui concerne la rade de Toulon, la faible activité d'élevage de moules déjà signalée au cours de années précédentes a encore diminué d'intensité en 1980, de sorte qu'il n'a pas été possible d'avoir des prélèvements réguliers et exploitables dans cette zone d'élevage.

ZONE(S) ETUDIEE(S)

Les zones étudiées faisant l'objet du présent rapport sont :

1. Etang de Thau (Fig. 1)

Lat. 43° 24' 5" N
Long. 3° 38' E

Caractéristiques géographiques:

L'étang de Thau, d'une superficie de 7 500 ha environ, a une longueur maximale de 19,5 km et sa plus grande largeur atteint 4,5 km. La profondeur moyenne est de 5 mètres environ et la profondeur maximale de 9 à 10 m. L'étang de Thau communique avec la mer à ses deux extrémités, par les canaux de Sète et par le grau de Pisse-Saumes à Marseillan.

Les échanges avec la mer dépendent partiellement de la marée très faible, mais surtout des pressions atmosphériques et des vents.

Caractéristiques hydrologiques:

Le régime thermique est très étroitement lié aux températures de l'air, températures moyennes habituellement de 4°C, (janvier - février) à 28°C (juillet - août).

La salinité moyenne s'établit aux environs de 34°/oo avec des minima et maxima suivant les périodes, de 25°/oo et de 38°/oo.

L'étang de Thau reçoit les eaux du Canal du Midi, du Canal de Sète au Rhône, et de nombreux ruisseaux comme la Vène, le Pallas, le Nègue-Vaques, le Soupié, pour ne citer que les plus importants.

Caractéristiques météorologiques:

Vents dominants : N.O. (320°)
Pluviométrie moyenne : 650 mm

En ce qui concerne la zone conchylicole celle-ci occupe 1 300 ha dont 352 ha réels de parc d'élevage.

L'échantillonnage d'eau et coquillage est effectué sur 12 stations (de T 6 à T 17), plusieurs fois par mois.

2. Etang de Leucate (Fig. 2)

Lat. 42° 51' N
Long. 3° 03' E

Caractéristiques géographiques:

L'étang de Leucate occupe une superficie de 5 000 ha et a une profondeur moyenne de 3 mètres, avec des profondeurs maximales de 4,5 m. L'étang de Leucate communique avec la mer par les graus de Leucate et de Port-Barcarès.

Caractéristiques hydrologiques:

Comme pour Thau les variations thermiques ont une amplitude considérable, de 4° à 28° environ. La salinité suivant les années et périodes peut varier de 22°/oo à plus de 40°/oo. Cet étang reçoit essentiellement les eaux douces des ruisseaux de Fontdame et Font-Extramer, dans sa partie méridionale. Les salinités de la partie septentrionale sont généralement plus élevées.

Caractéristiques météorologiques:

Vents dominants : W (Tramontane)
Pluviométrie : 600 mm

Les parcs à coquillages occupent 32 ha. L'échantillonnage se fait sur 6 stations (L 8 à L 13) plusieurs fois par mois.

3. Rade de Toulon (Fig. 3 et 4)

Caractéristiques géographiques:

Lat. 45° 05' N
Long. 5° 58' E

La rade de Toulon constitue en fait l'avant-port naturel de Toulon. Une activité conchylicole s'est installée, essentiellement dans la baie du Lazaret, zone des profondeurs maximales de 5 mètres environ.

Caractéristiques hydrologiques:

Les variations hydrologiqes de la Rade de Toulon sont beaucoup moins sensibles que celles d'un étang. La rade se caractérise par des valeurs plus constantes et plus stables, semblables à celles de la mer. Les températures varient de 8° à 23°C environ. La salinité est assez stable (autour de 37^{o}/oo) car la rade de Toulon ne reçoit pas de rivières. Les eaux usées des agglomérations de Toulon, La Seyne et St. Mandrier sont rejetées en mer au cap Cicié et ont peu d'influence sur la pollution de la rade. Par contre, de par son environnement très urbanisé, la Rade de Toulon reçoit de multiples rejets plus ou moins clandestins, sans compter les pollutions liées aux bateaux de la flotte de guerre.

En ce qui concerne les pollutions industrielles, elles sont occasionées essentiellement par l'arsenal de Toulon et ses activités de réparations navales et par les chantiers Navals de la Seyne-sur-Mer.

Les parcs de Toulon sont par conséquent reconnus insalubres, et ses moules doivent submir un traitement épurateur avant d'être commercialisées.

Caractéristiques météorologiques:

Vent dominant: Nord (36°) - Mistral
Pluviométrie : 700 mm

L'échantillonnage se fait sur 7 stations (RT 1 à RT 7) une fois par mois.

MATERIEL ET METHODES

La surveillance régulière des trois zones étudiées porte essentiellement sur les polluants bactériens, considérés comme des germes-test de la contamination fécale : Coliformes totaux et Escherichia Coli et des facteurs hydrologiques (température, salinité, et O_2 dissous).

Depuis notre participation au programme, la recherche des streptocoques fécaux est également pratiquée régulièrement.

Les méthodes que nous employons sont basées sur la recherche du MPN aussi bien pour les eaux que pour les coquillages. Le milieu utilisé pour la recherche des Coliformes totaux et fécaux est le bouillon lactosé bilié, au vert brillant avec incubation à 37°C. Pour la recherche d'E. coli on utilise la méthode de Mackenzie, avec repiquage des tubes positifs sur le même milieu et sur eau peptonée, à 44°C. Il faut remarquer que cette méthode n'est utilisée dans notre laboratoire que depuis juillet 1978, avant la méthode pratiquée par l'I.S.T.P.M. était celle de Vincent avec ensemencement sur bouillon de même nom, à 41,5°C, méthode donnant directement E. coli.

En ce qui concerne les streptocoques fécaux, leur recherche est faite également par la méthode MPN, en utilisant successivement les milieux de Rothe et Litsky.

La salinité est dosée par la méthode classique de Mohr et les oxygènes dissous par celle de Winckler.

RESULTATS ET LEUR INTERPRETATION

Les paramètres habituellement mesurés lors de nos tournées de contrôle sanitaire sont : T , S°/oo, coliformes totaux, Escherichia coli et streptocoques fécaux.

Depuis 1978, notre contrôle s'est beaucoup intensifié au niveau des établissements d'expéditions à terre, au détriment de notre contrôle sur les parcs d'élevage.

Les résultats que nous présentons portent sur l'ensemble de nos contrôles.

La classification des résultats bactériologiques est faite en fonction des normes en vigueur en France :

- pour les coquillages : coliformes fécaux/100 ml de chair + liquide intervalvaire.

satisfaisants	: de 0 à 300
suspects	: 300 à 1000
très suspects	: 1001 à 3000
défavorables	: à partir de 3000

- pour l'eau : coliformes fécaux/100 ml d'eau.

  Les limites suivantes ont été appliqées :

satisfaisant	: moins de 10
suspects	: 10 à 100
défavorables	: à partir de 100

Les Tableaux I, II, III, IV, V et VI donnent la répartition par classes de contamination des eaux et des coquillages en Escherichia coli pour les étangs de Thau et Leucate pour les années 1976, 1977 et 1978.

Les Tableaux VII, VIII, IX, X, XI et XII donnent la répartition par classes de contamination des eaux et des coquillages en Escherichia coli, en coliformes totaux et en streptocoques fécaux pour les Etangs de Thau et Leucate pour la période janvier - septembre 1979. Les Tableaux XIII, XIV, XV, XVI, XVII, et XVIII donnent la même répartition par classes de contamination pour l'étang de Thau et pour la période de novembre 1979 à mars 1981.

Les Tableaux XIX à XXI donnent la répartition par classes de contaminations des eaux et des coquillages en coliformes fécaux, en coliformes totaux et en streptocoques fécaux pour la Rade de Toulon et pour la période octobre 1978 à octobre 1979.

Les fréquences de contaminations des coquillages et de l'eau par E. coli pour l'etang de Thau et pour les années 1976, 77, 78, et 1979 (janvier à septembre) sont représentées sous forme d'histogrammes dans les Figures 5 et 6).

Les fréquences de contaminations des eaux et des coquillages par E. coli, coliformes totaux et streptocoques fécaux pour l'étang de Thau l'étang de Leucate et la rade de Toulon pour la période janvier à septembre 1979 sont données sous forme d'histogramme dans les Figures 7, 8, 9, 10 et 11.

Ces même fréquences pour l'étang de Thau et pour la période novembre 1979 - mars 1981 sous forme d'histogrammes apparaisiant dans les Figures 12, 13 et 14.

En ce qui concerne l'étang de Thau on constate que dans l'ensemble la pollution bactérienne exprimée en E. coli à fortement baissé en 1978 et ce pour presque toutes les stations. Ceci pourrait etre lié à la cadence de réalisation de travaux d'assainissement programmée autour de l'étang de Thau et en particulier pour la ville de Séte. Cependant les résultats de la période janvier - septembre 1979 présente une pollution bactérienne de l'étang de Thau plus importante qu'en 1978 et beaucoup plus localisée dans le secteur Est proche de Sète (stations 13, 14, 15, 16 et 17) et la station 11 proche de Mèze (Fig 7, 8, et 9) et des rejets de sa station d'épuration. Cette évolution de la contamination est assez incompréhensible si l'on tient en compte la baisse continue de celle-ci depuis 1976, due en partie au gros travaux d'assainissement de la ville de Sète. Les résultats obtenus en 1979 méritent donc attention et permettent d'appuyer nos demandes d'intensification d'assainissement aux administrations et collectivités locales concernées. Il semblerait qu'en 1979 la station d'épuration de Sète n'ait pas fonctionné à plein rendement et que des retours de pollution se soient effectués vers l'étang une étude plus détaillée avec le régime des vents permettra, pensons-nous, de trouver une explication.

De plus le pourcentage de résultats défavorables est particulièrement aggravé par ceux obtenus en janvier où de fortes précipitations (+ de 200 mm) ont entrainé un lessivage important et une pollution généralisée qui a nécessité l'arrêt des expéditions de coquillages pendant dix jours du 20 au 30 janvier jusqu'à ce que le milieu finisse par s'auto-épurer avec l'aide du vent de secteur N-O chassant les eaux douces contaminées vers la mer.

La contamination bactérienne de l'étang de Thau de novembre 1979 à mars 1981 apparait moins importante qu'en 1979 et semble légèrement plus localisée dans le secteur d'élevage proche de Sète.

L'ensemble des résultats montre la bonne qualité des eaux conchylicoles du bassin de Thau ce qui semblerait indiquer que l'effort d'assainissement entrepris depuis ces dernières années commence à porter ses fruits. En effet, seules les stations T 10, T 14 et T17 n'atteignent pas les 80 % de résultats inférieurs à 300 E. coli/ 100 ml.

En ce qui concerne l'étang de Leucate (Fig.8) la situation sanitaire est très bonne, comme les années précédentes.

La Rade de Toulon, par contre, apparaît très contaminée, dans sa majorité ce qui confirme l'insalubrité de cette zone. Nous précisons que malgré notre surveillance, toute la production de moules doit passer dans une station de purification située à St Mandrier, avant d'être commercialisée.

En se basant sur E. coli et les classes de qualité microbiologiques déjà mentionnées on peut établir des états globaux de la contamination par secteur (Figure 15 et Figure 16). La réglementation français afin de déterminer la salubrité d'une zone conchylicole se base sur E. coli et sur 26 prélèvements au moins, autorise un dépassement au-dessus de 300 pour 100 ml de chair, de 5 prélèvements soit 20% environ, dont au maximum 3 en dessous de 1000 et deux seulement en dessous de 3000. On peut constater qu'en 1979, (Figure 16), sur

230 analyses, l'étang de Thau présente une contamination supérieure à 300 E. coli dans 23% des cas, ce qui est à la limite et indique que l'effort d'assainissement et de controle doit être trés soutenu afin de détecter les périodes d'insalubrité aigue et arreter la commercialisation au moindre signe. On peut également constater sur le graphique que la salubrité de l'étang de Leucate est excellente et que celle des parcs de Toulon très déficiente, comme nous l'avons déjà signalé.

CONCLUSIONS

Pour l'étang de Leucate le nombre relativement insuffisant d'observations nous a amené à présenter les résultats globalement sans tenir compte des stations.

En ce qui concerne l'étang de Thau on constate que dans l'ensemble la pollution bactérienne exprimée en E. coli à fortement abaissée en 1978 et ce pour presque toutes les stations. Ceci pourrait être lié à la cadence de réalisation de travaux d'assainissement programmée autour de l'étang de Thau et en particulier pour la ville de Sète. Cependant les résultats de la période janvier - septembre 1979 présente une pollution bactérienne plus importante qu'en 1978 et beaucoup plus localisée.

Il serait intéressant de suivre l'évolution de la contamination bactérienne en fonction de quelques paramètres qui apparaissent déterminants dans l'étang de Thau (vents, pluies) et d'interpréter les résultats à partir d'une présentation statistique.

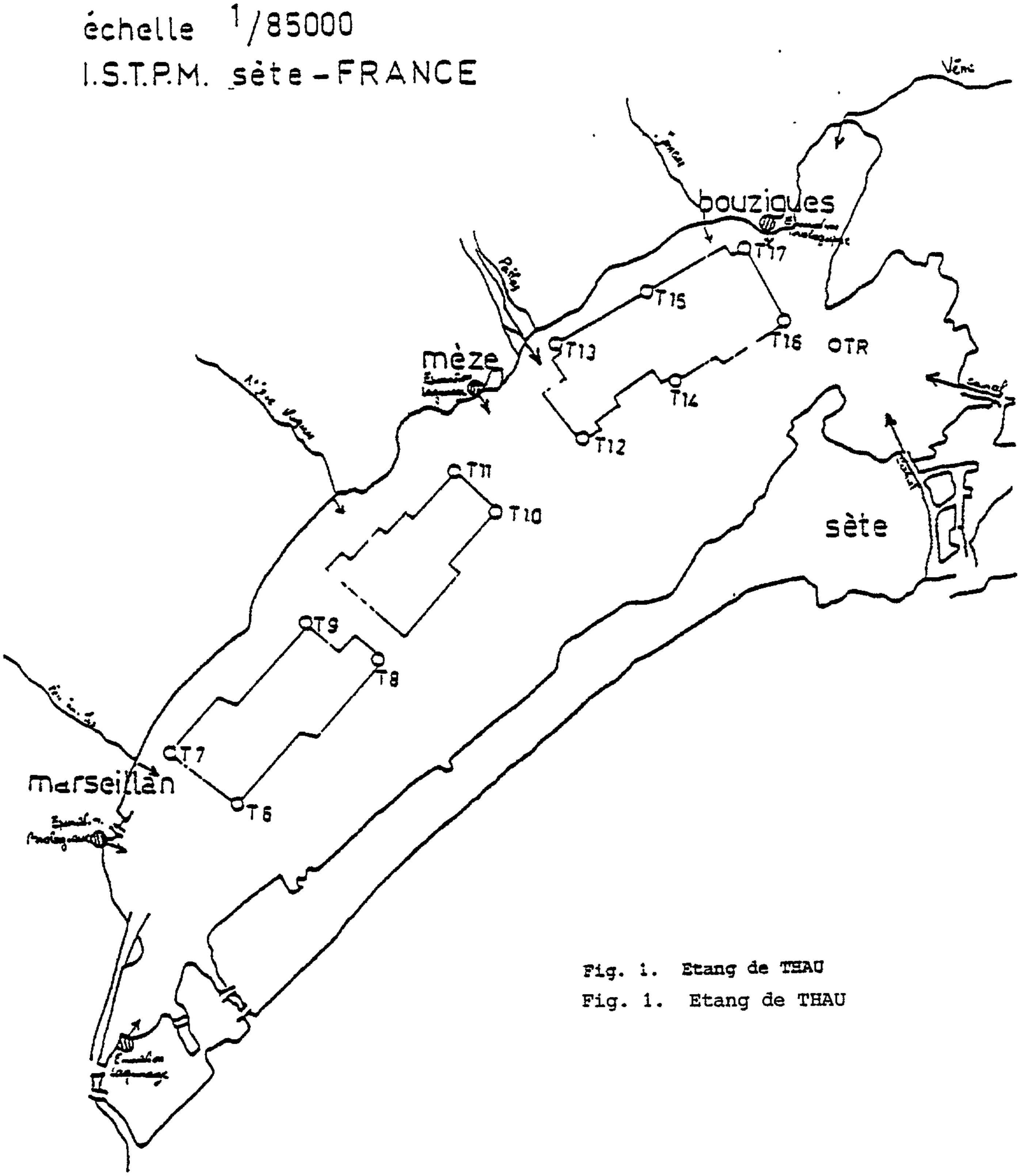


Fig. 1. Etang de THAU

Fig. 1. Etang de THAU

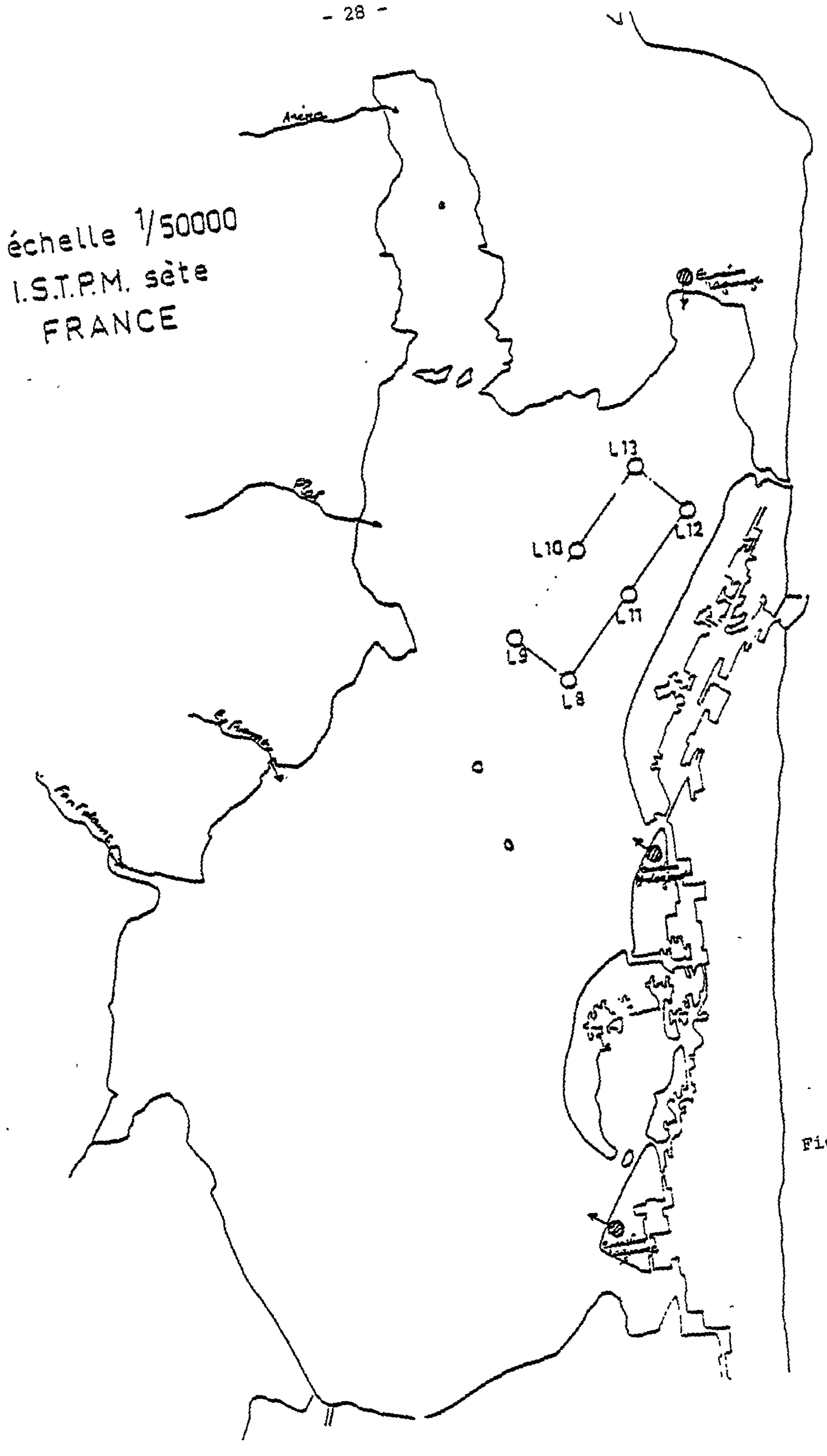


Fig. 2. Etang d
LEUCATE

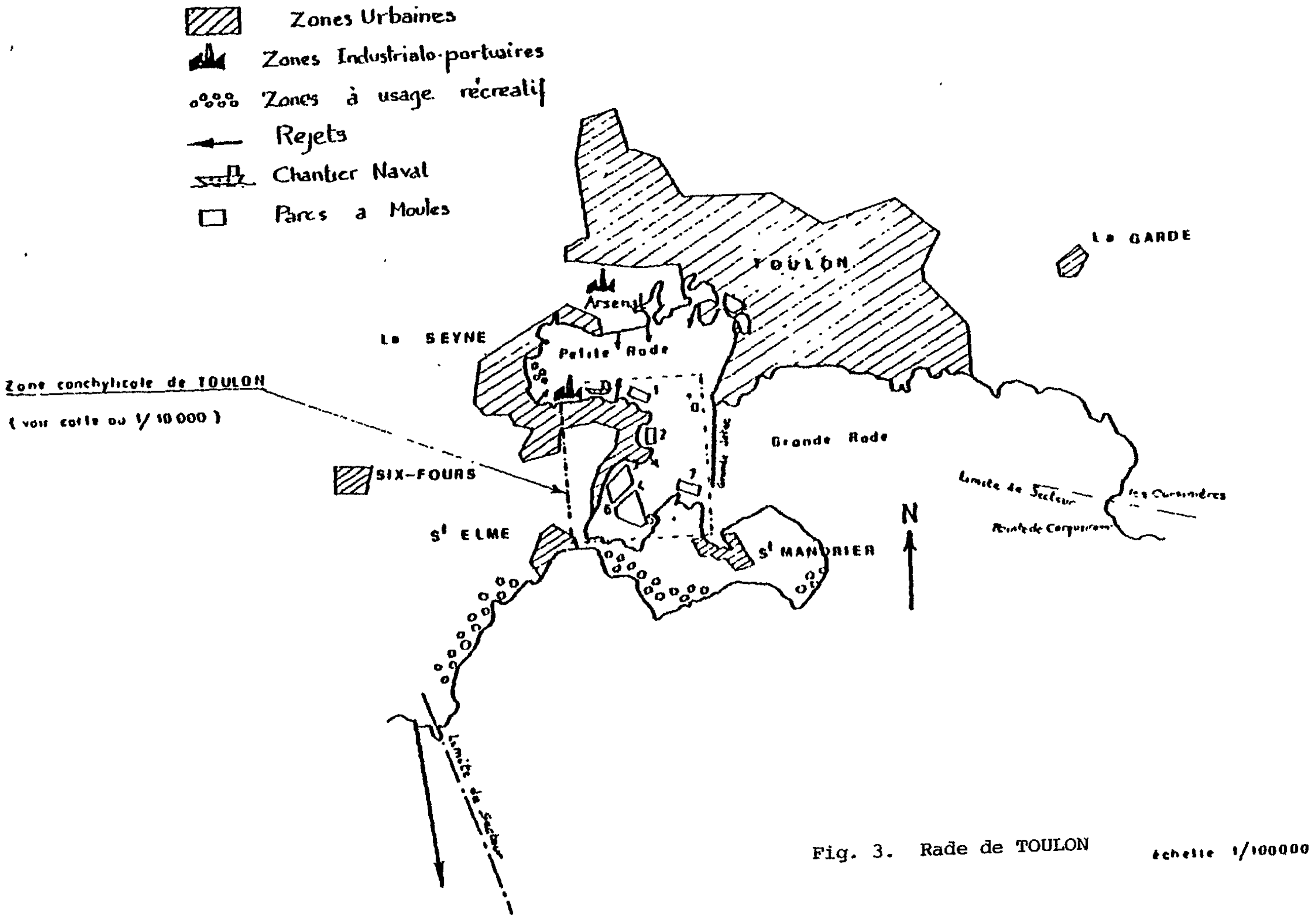


Fig. 3. Rade de TOULON échelle 1/100000

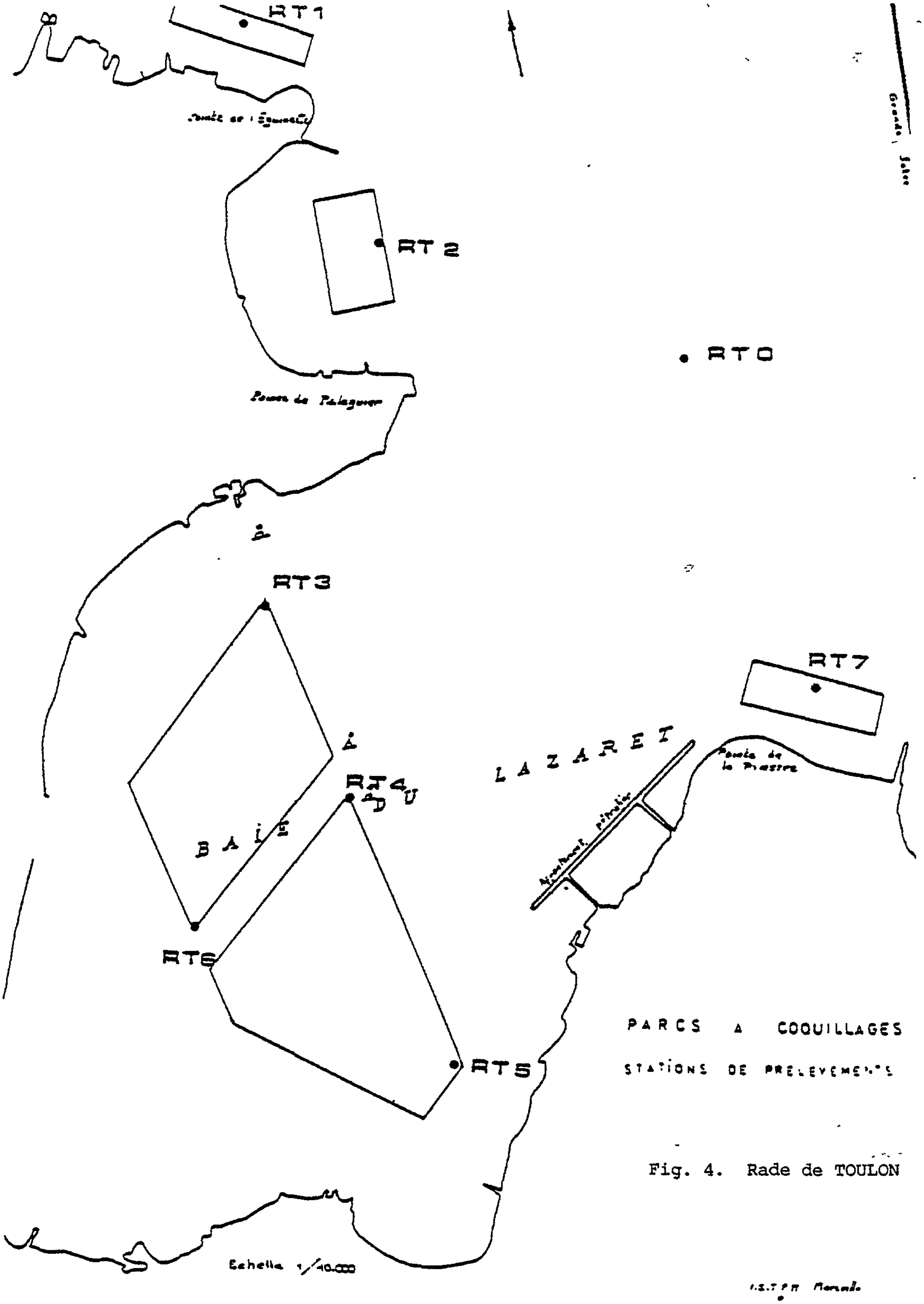


Fig. 4. Rade de TOULON

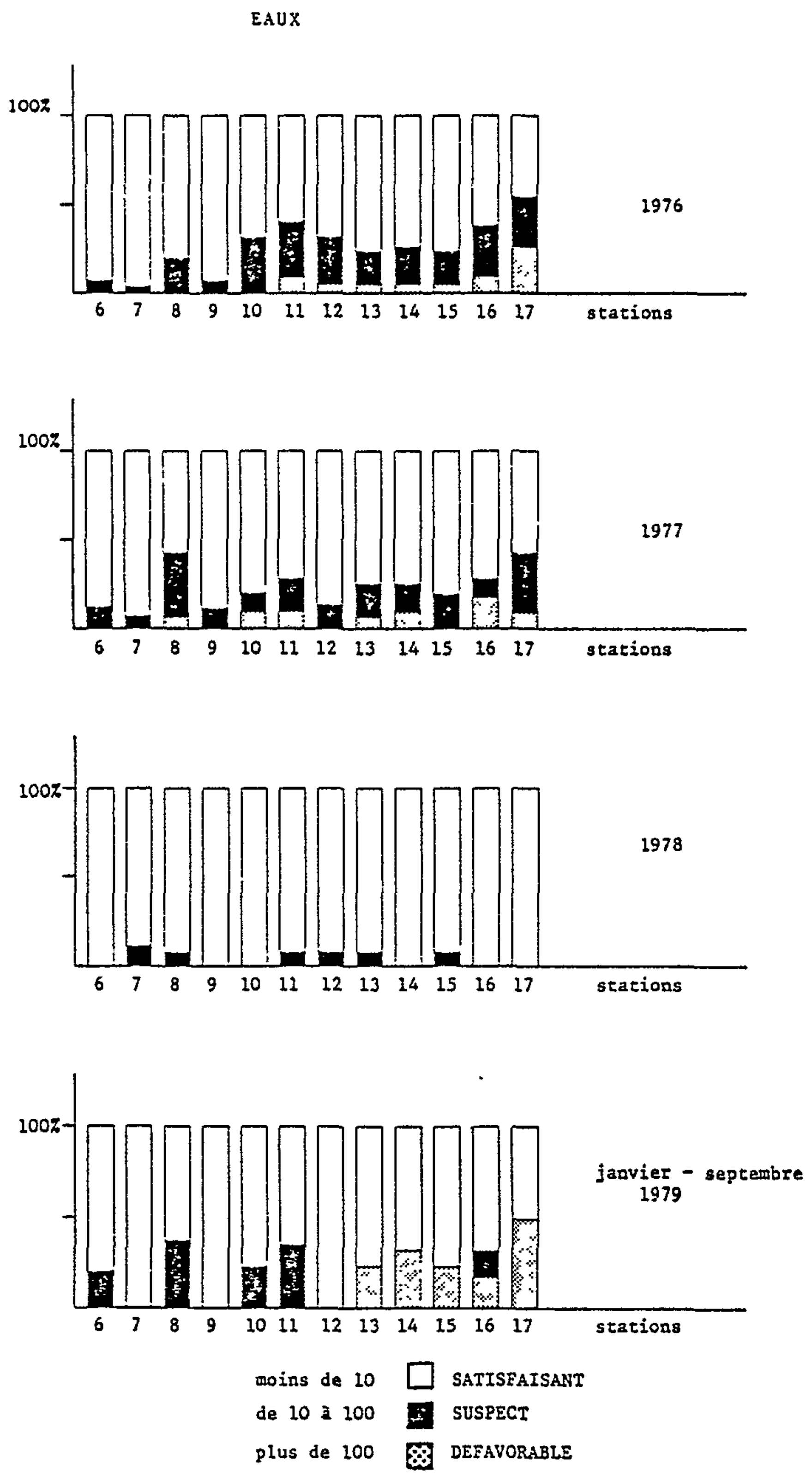


Fig. 5. Fréquences de contamination des eaux par *E. coli* pour l'étang de THAU selon 3 classes de contamination

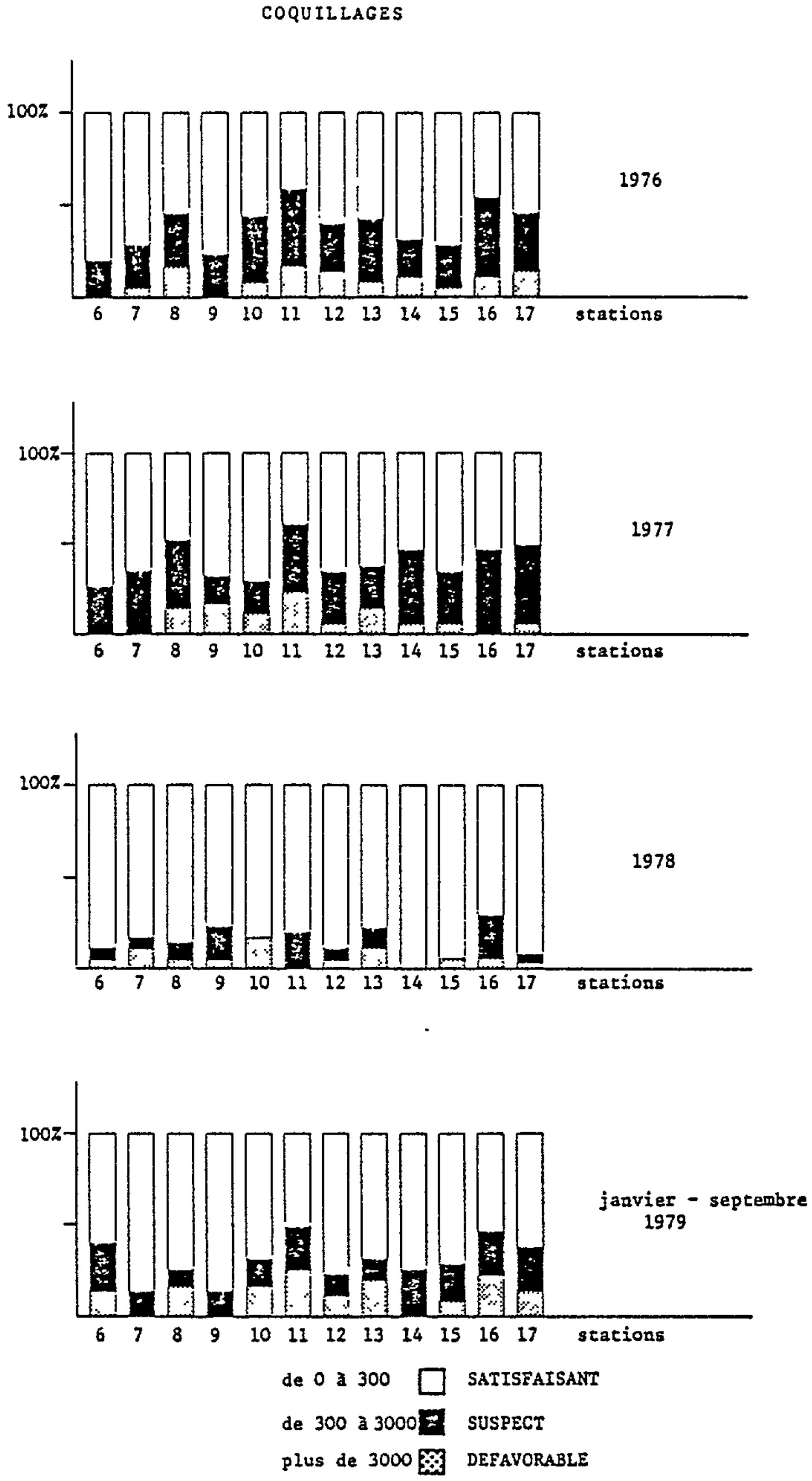


Fig. 6. Fréquences de contamination des coquillages par E. coli pour l'étang de THAU selon 3 classes de contamination

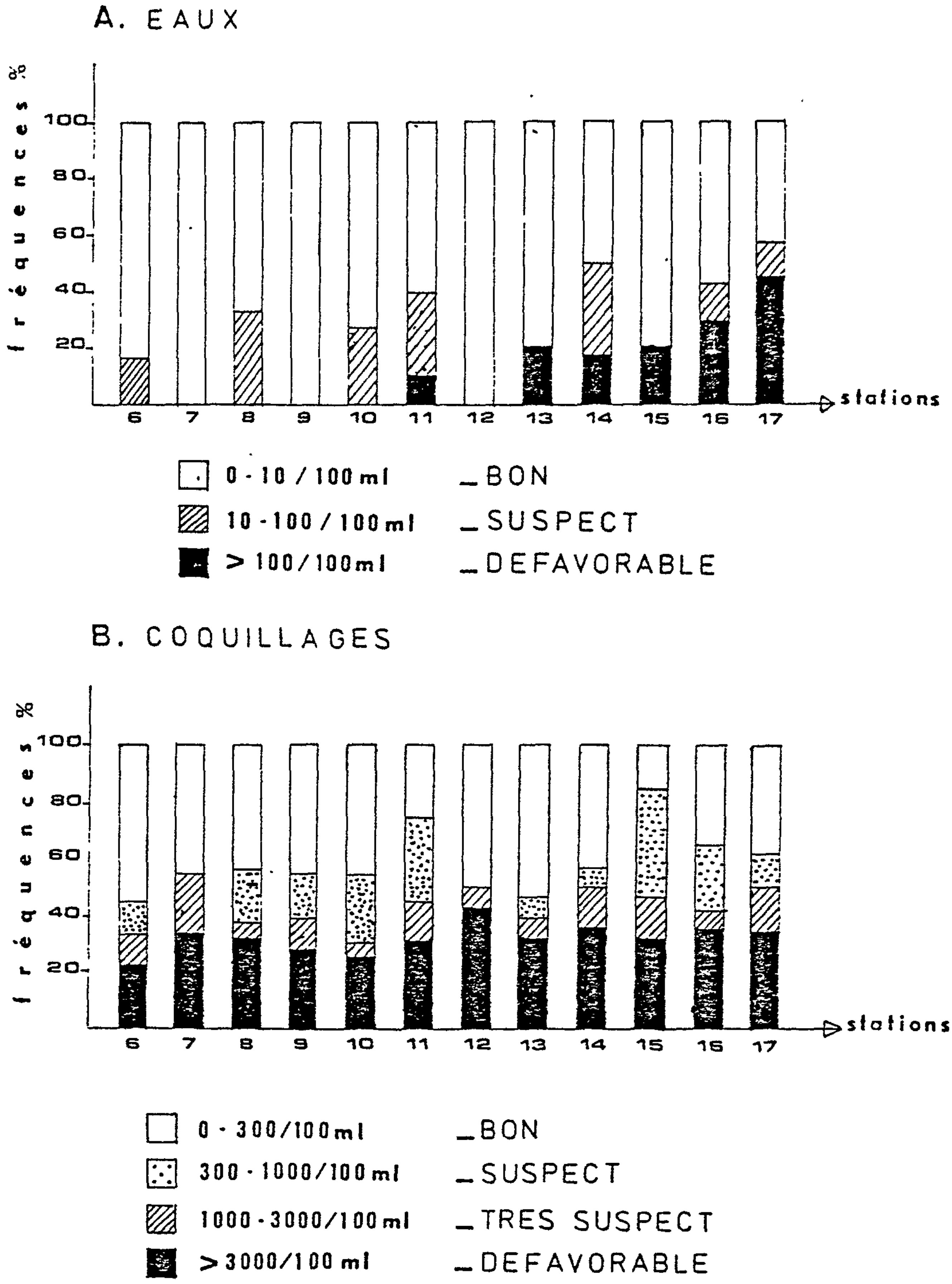
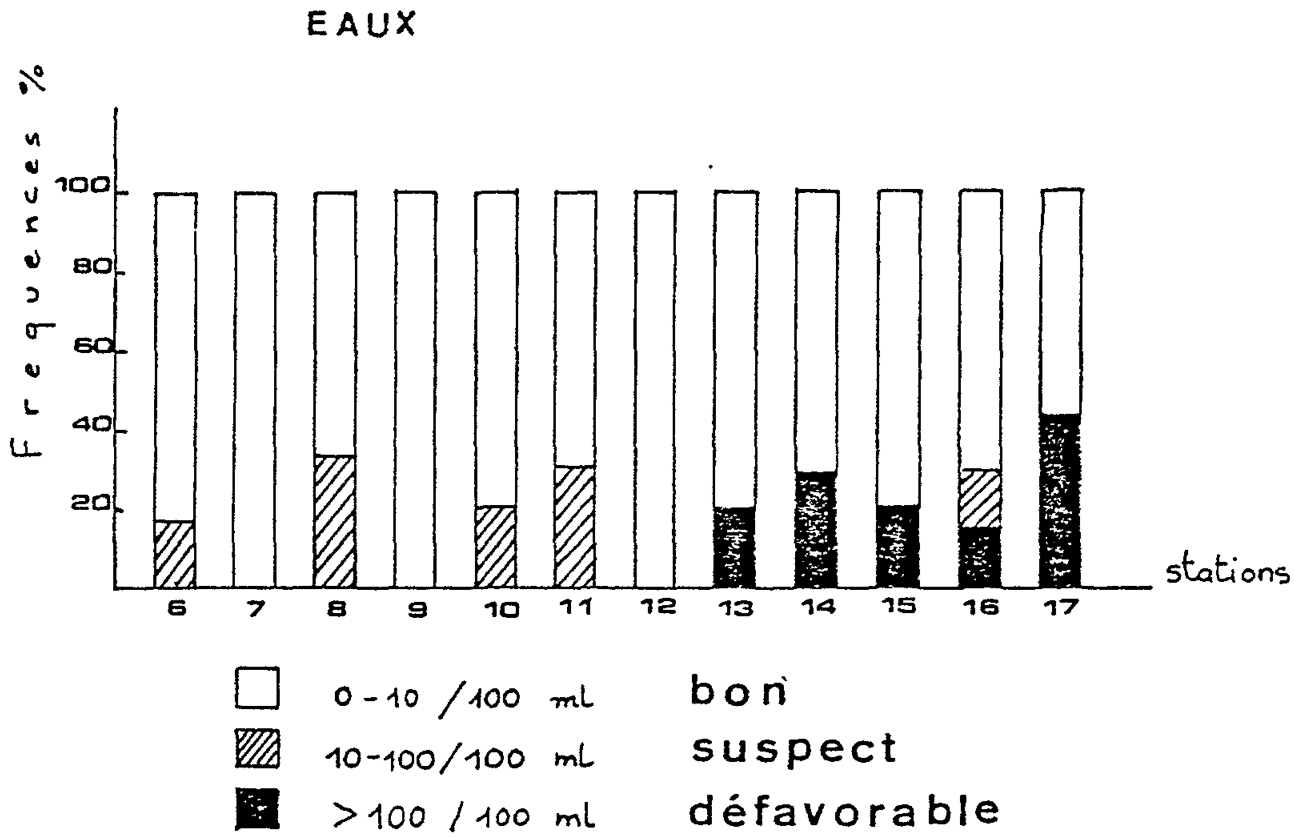


Fig. 7. Etang de THAU. Coliformes totaux



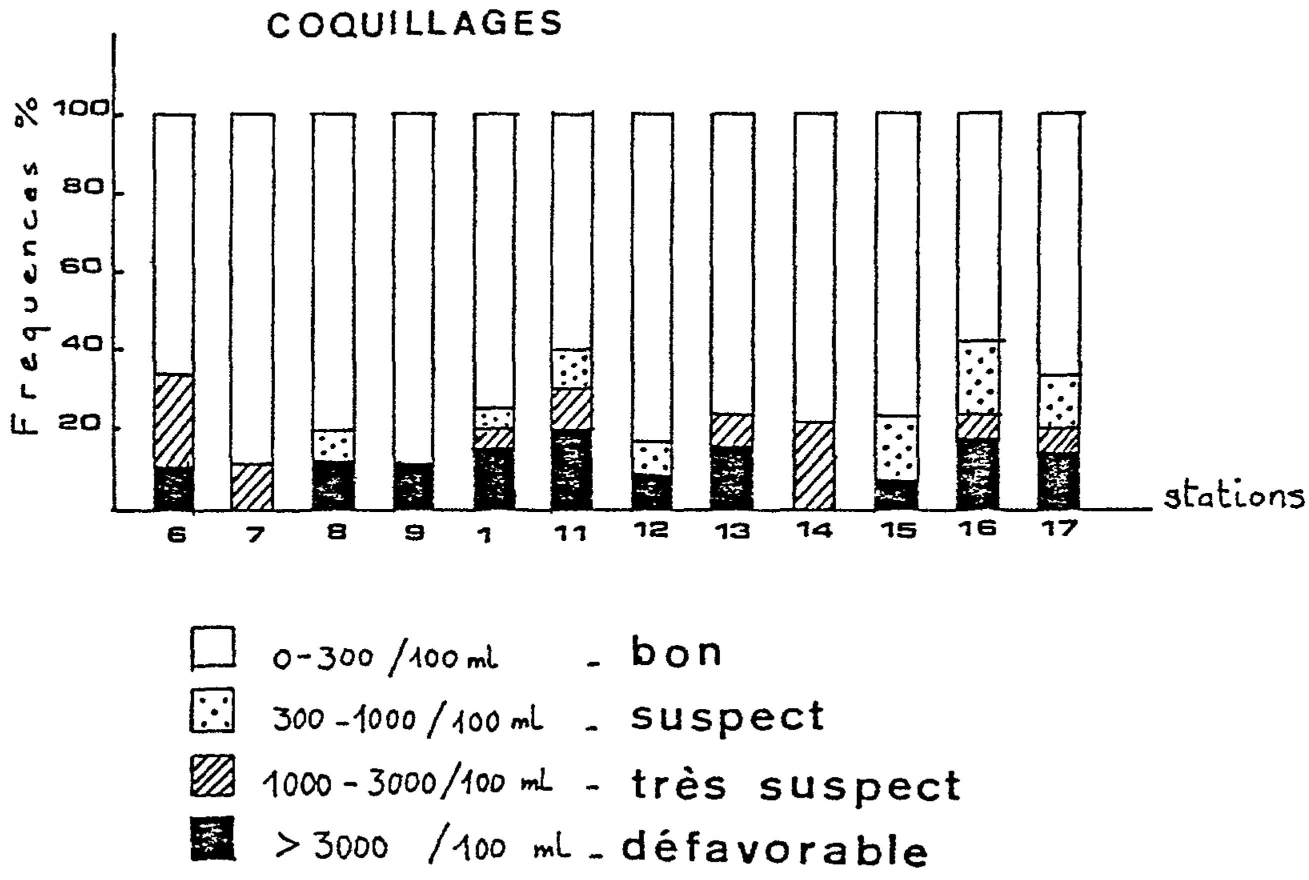
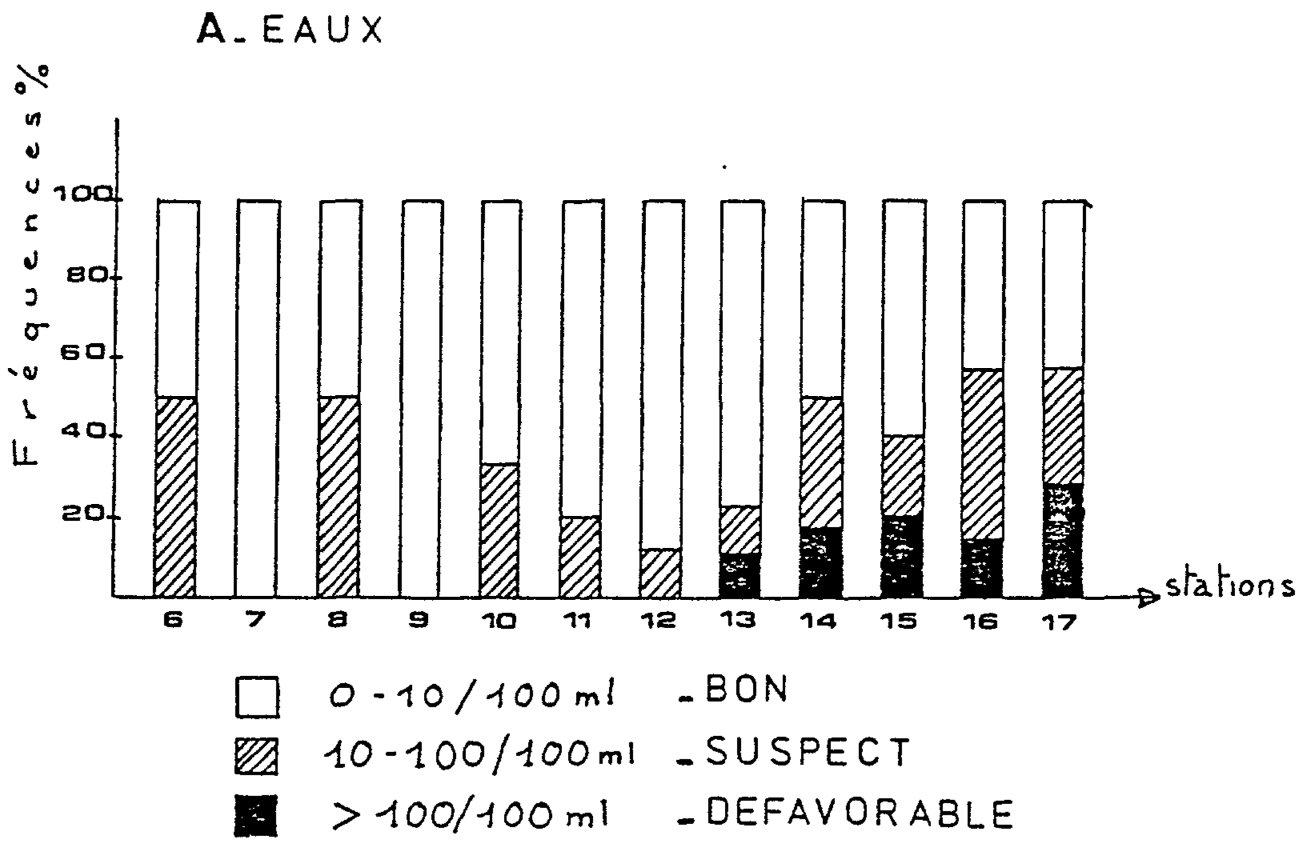


Fig. 8. Etang de THAU. Coliformes fécaux



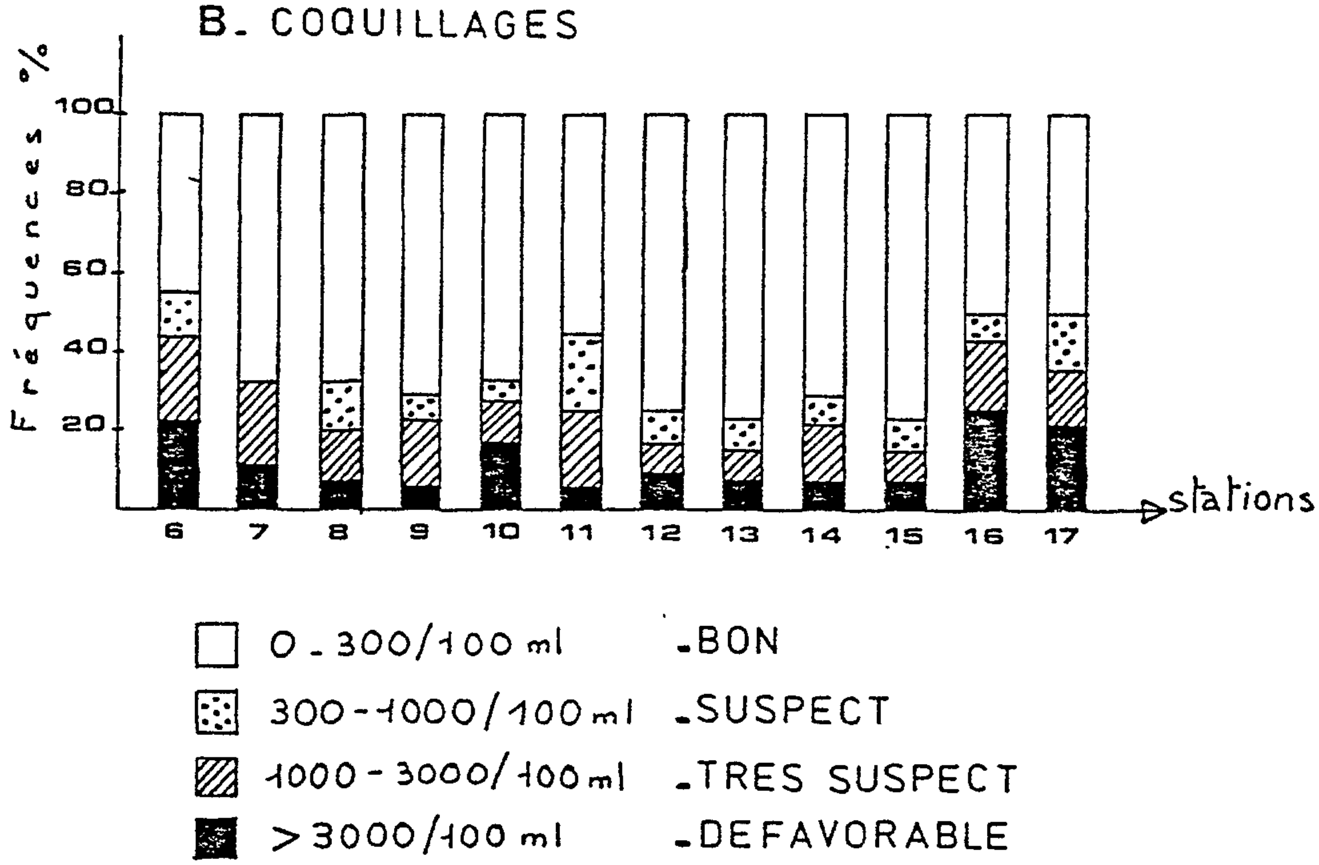


Fig. 9. Etang de THAU. Streptocoques fécaux

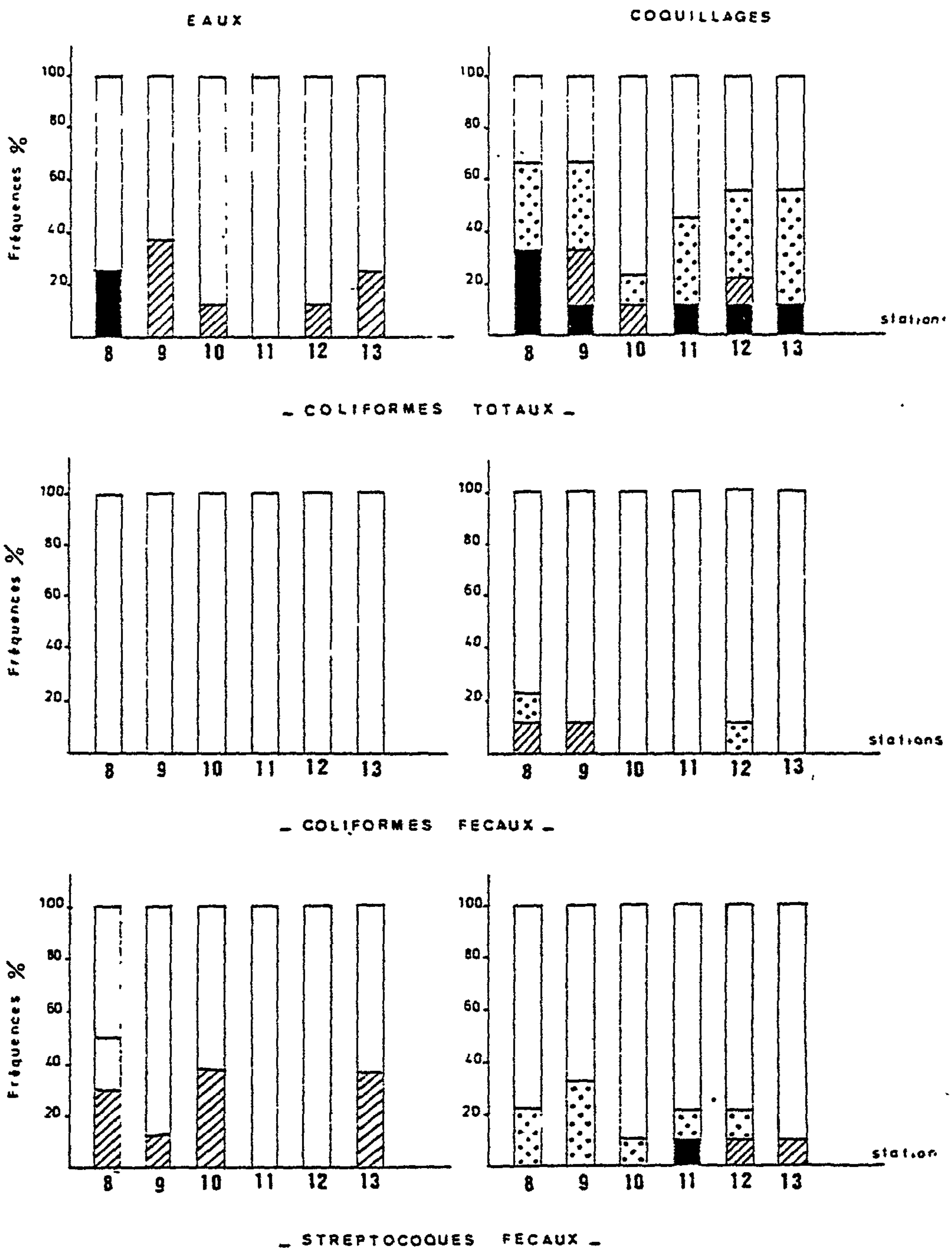


Fig. 10. Etang de LEUCATE

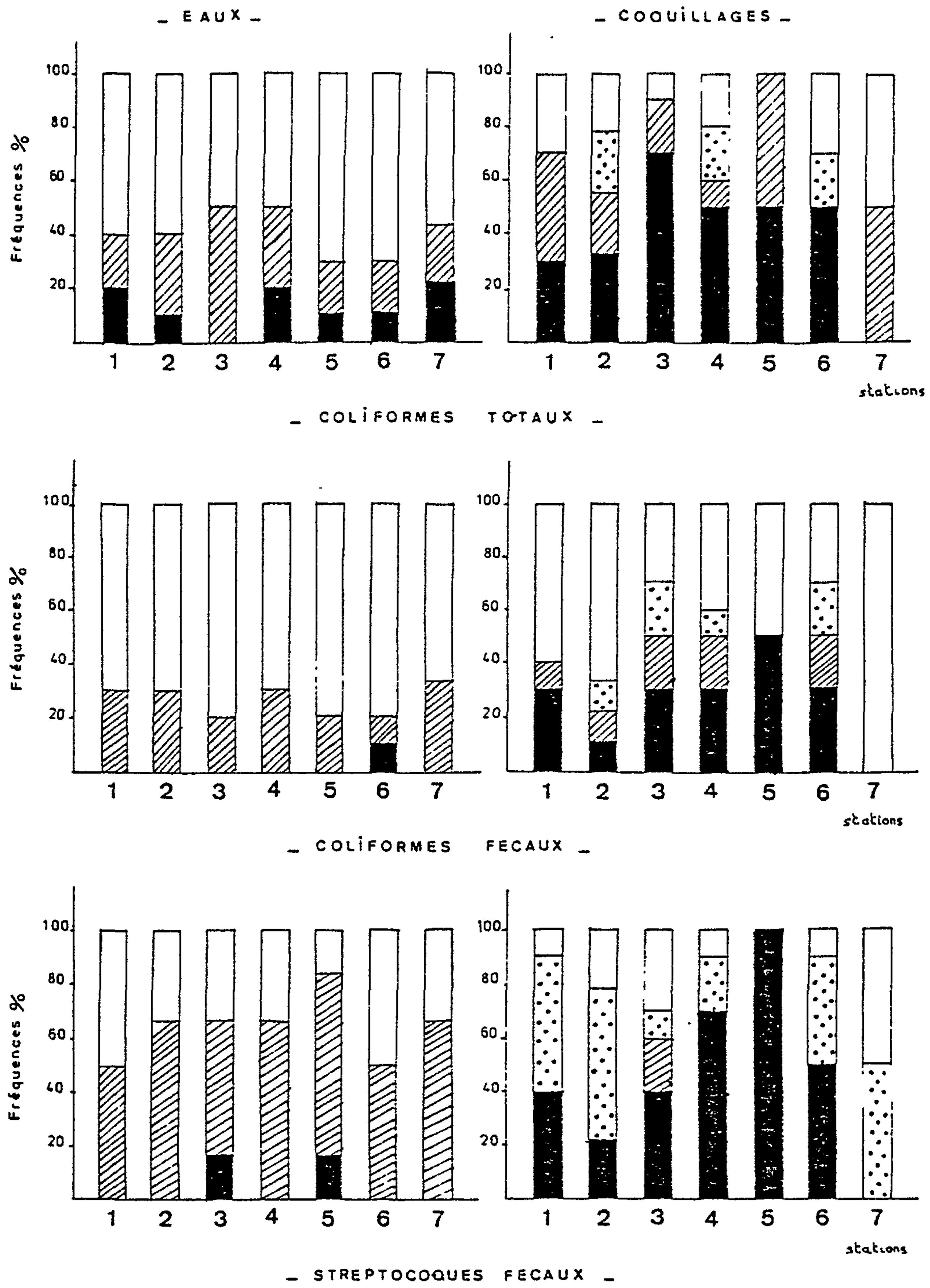


Fig. 11. Rade de TOULON

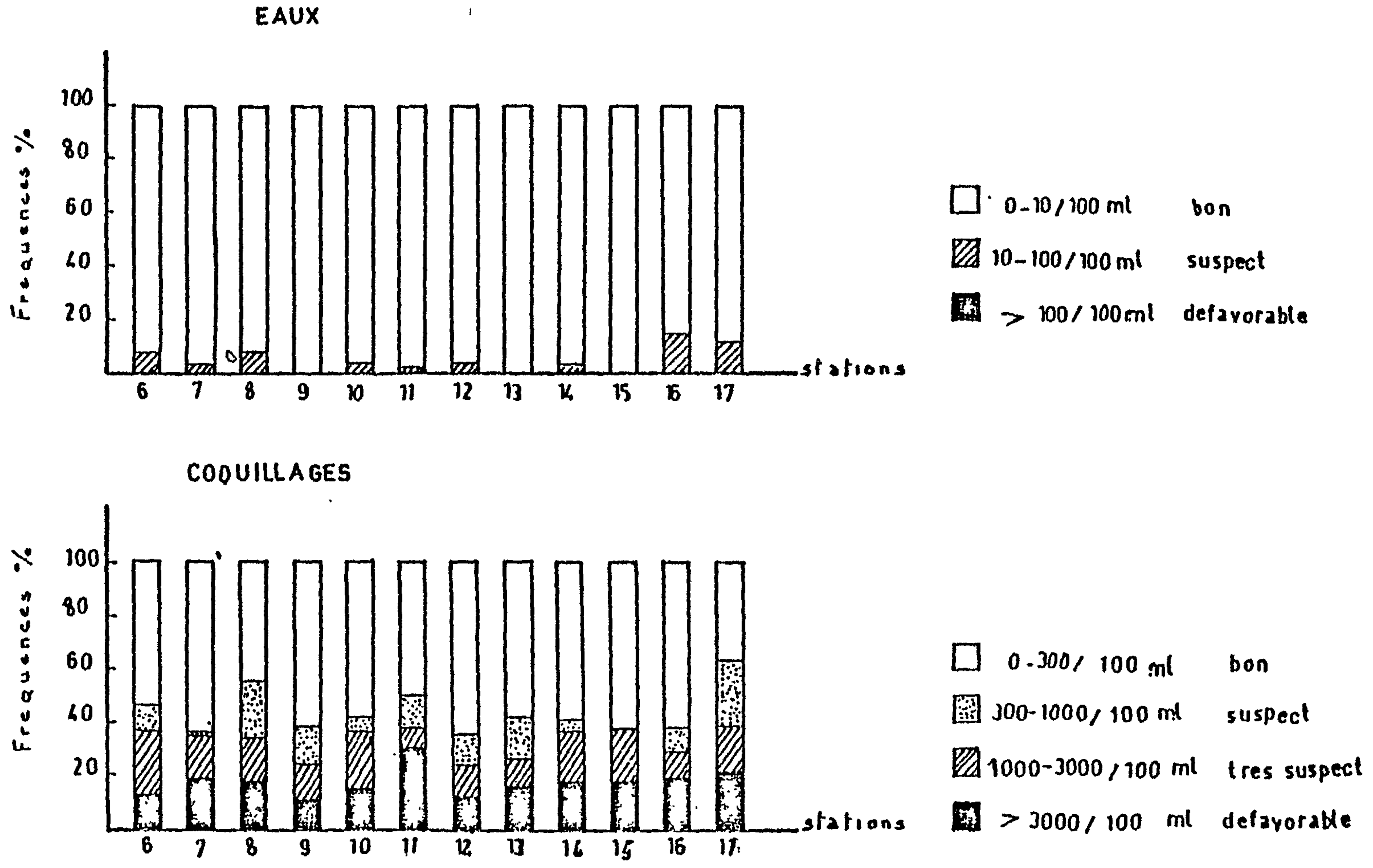


Fig.12. Etang de THAU. Coliformes totaux

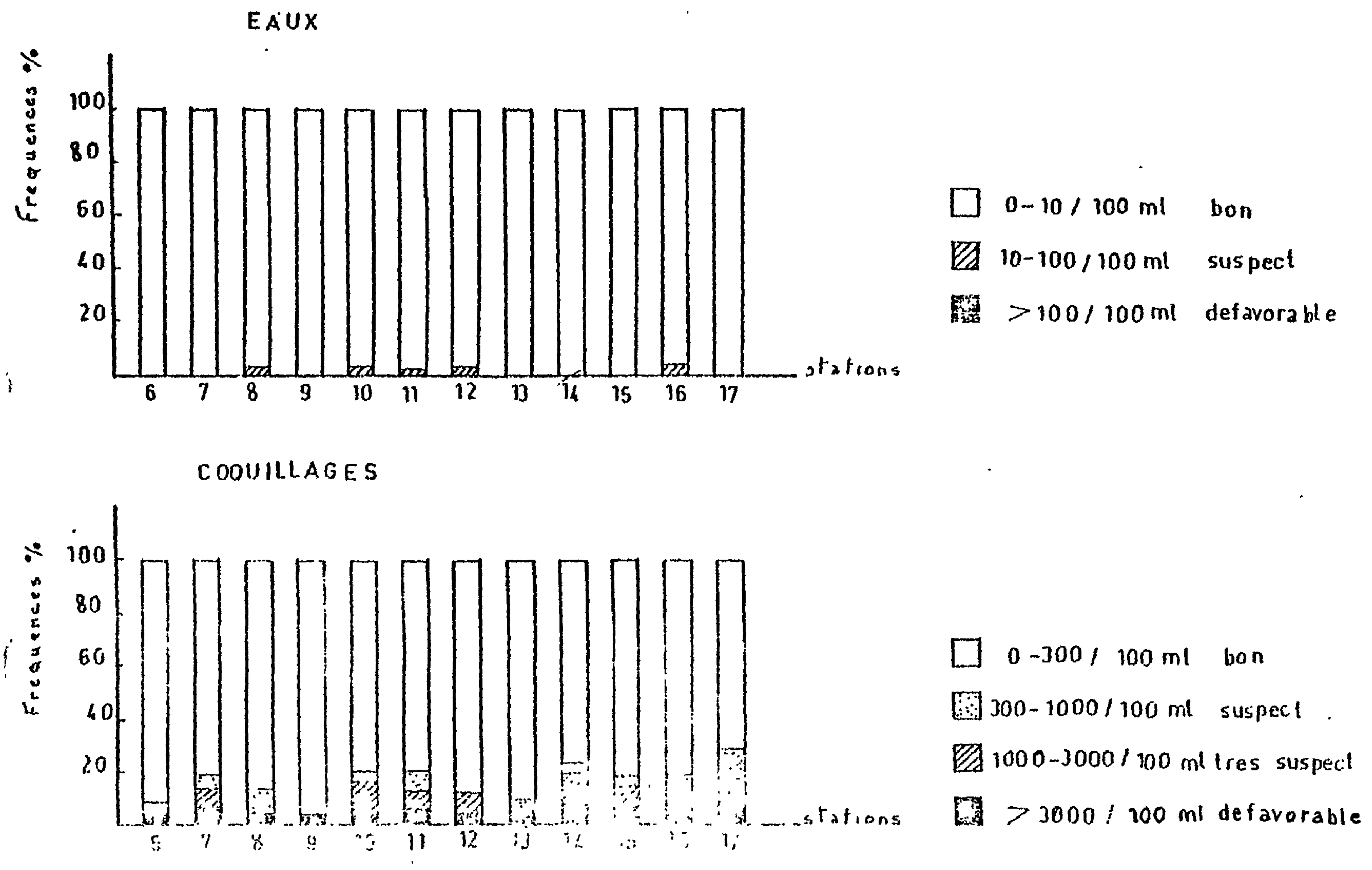


Fig. 13. Etang de THAU. Coliformes fécaux

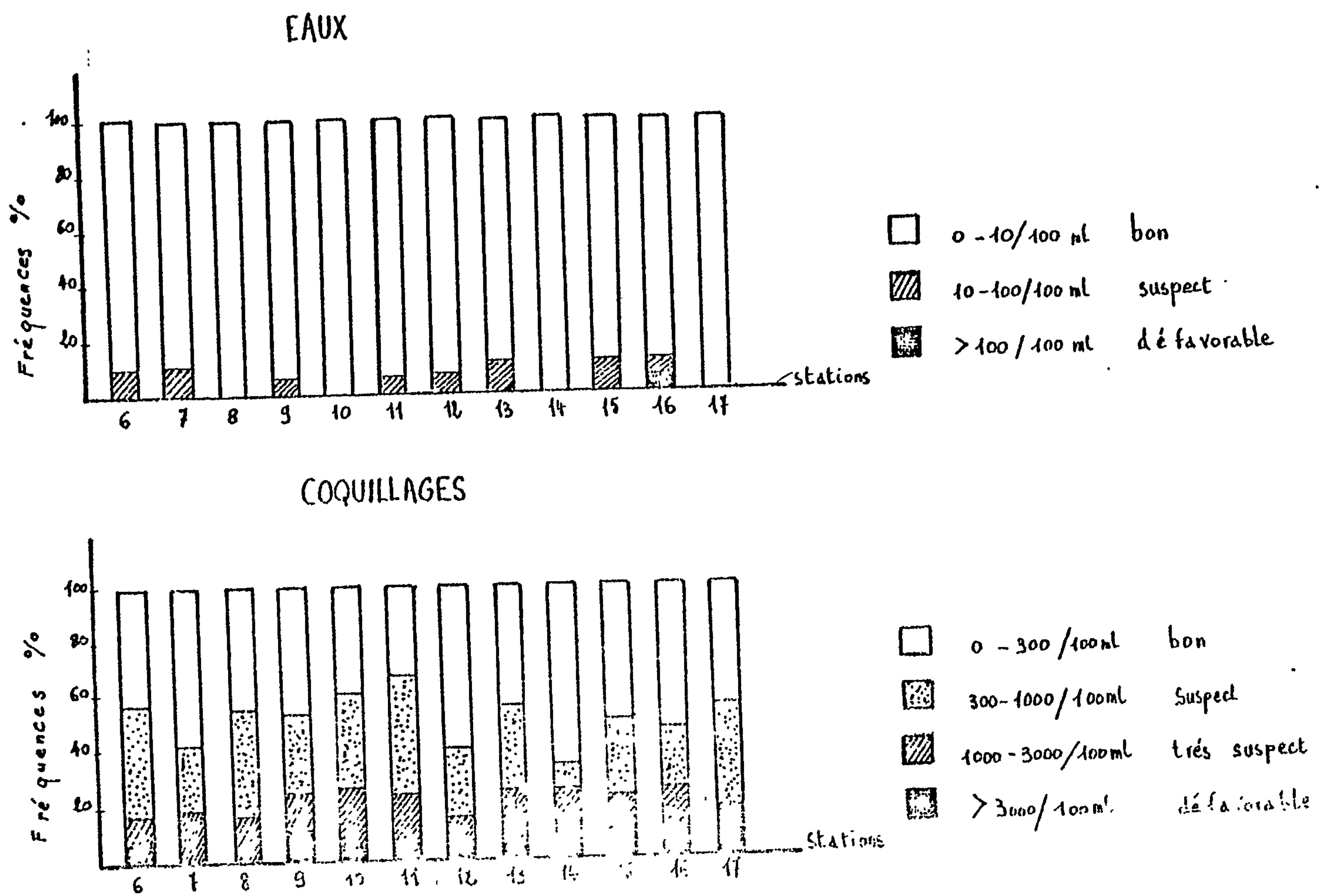


Fig. 14. Etang de THAU. Streptocoques

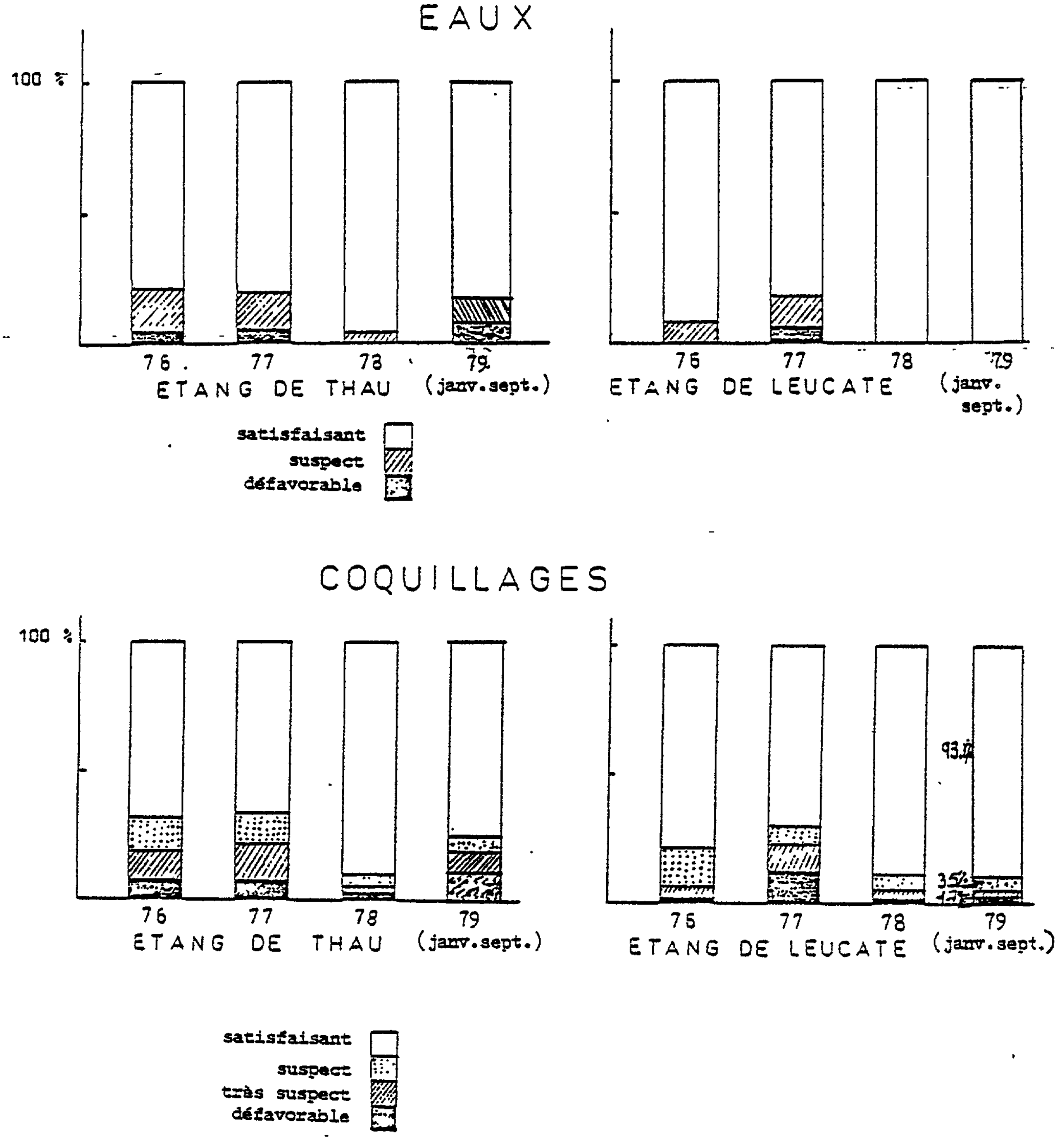


Fig. 15. Fréquences globales de contamination par E. coli en 1976, 1977, 1978 et 1979 (janvier-septembre)

Période janvier-septembre 1979

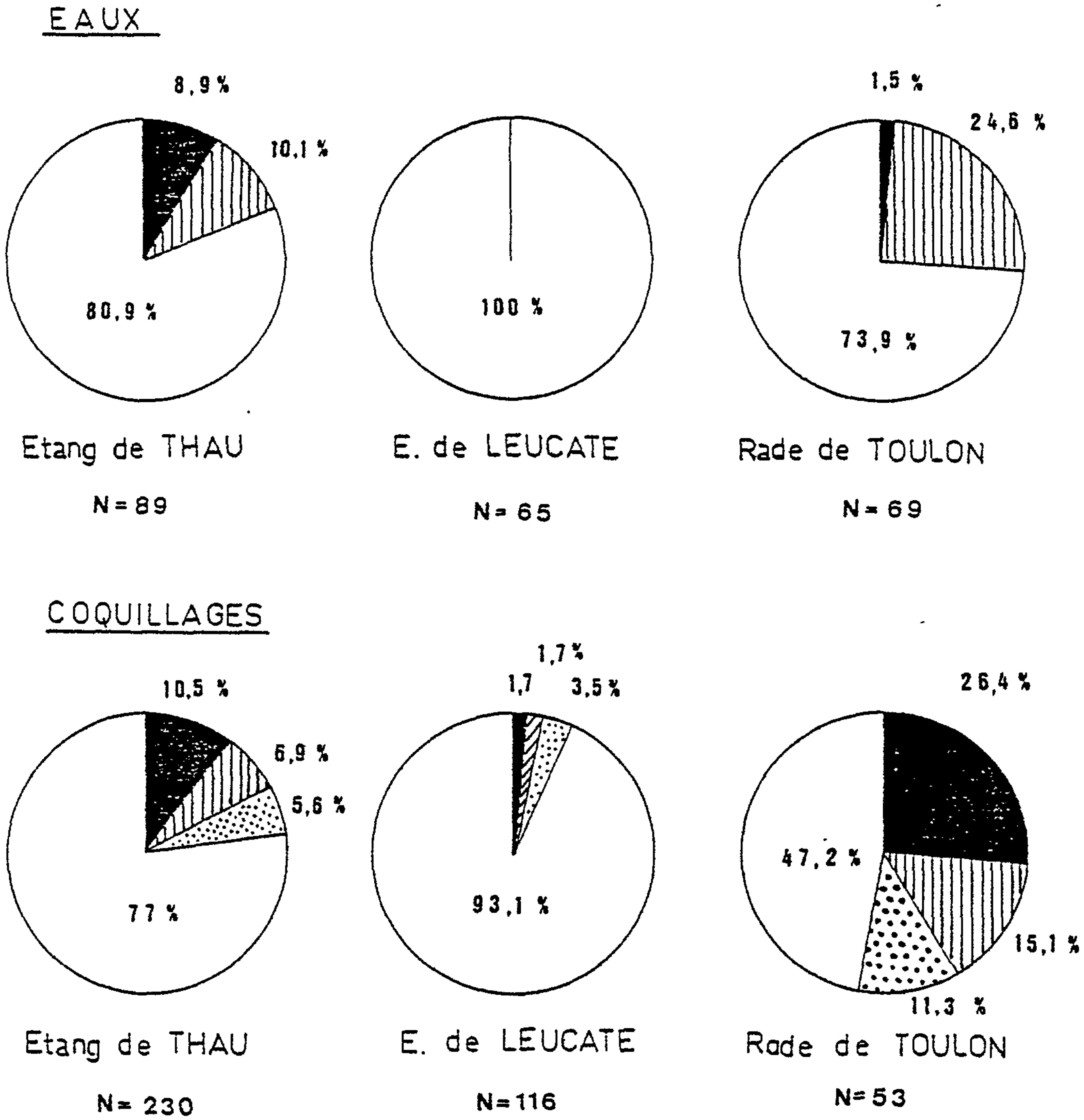


Fig. 16. Comparaisons globales de la contamination par *E. coli* pour les trois secteurs étudiés (janvier à septembre 1979)

COQUILLAGES / STATION - 1976

Stations	Normes	0-300 N	0-300 %	301-1000 N	301-1000 %	1001-3000 N	1001-3000 %	3000 N	3000 %	N total
ETANG DE THAU	T 6	31	83.8	4	10.8	2	5.4	0	0	37
	T 7	25	73.5	6	17.7	1	2.9	2	5.8	34
	T 8	22	59.5	5	13.5	4	10.8	6	16.2	37
	T 9	31	83.8	3	8.1	2	5.4	1	2.7	37
	T 10	23	62.2	2	5.4	9	24.3	3	8.1	37
	T 11	16	47.1	6	17.6	7	20.6	5	14.7	34
	T 12	23	67.7	6	17.6	1	2.9	4	11.8	34
	T 13	23	63.9	5	13.9	5	13.9	3	8.3	36
	T 14	23	71.9	3	9.4	3	9.4	3	9.4	32
	T 15	28	75.7	5	13.5	3	8.1	1	2.7	37
	T 16	21	55.3	5	13.2	8	21.0	4	10.5	38
	T 17	22	59.5	5	13.5	5	13.5	5	13.5	37
	Expédi-tion	47	73.5	11	17.2	5	7.8	1	1.5	64
total		335	67.8	66	13,4	55	11,1	38	7.7	494
ETANG DE LEUCATE	L 8	6	85,7	0		0		1	14,3	7
	L 9	3	50	2	33,3	1	16,7	0		6
	L 10	8	88,9	0		1	11,1	0		9
	L 11	6	66,7	3	33,3	0		0		9
	L 12	8	88,9	1	11,1	0		0		9
	L 13	7	87,5	1	12,5	0		0		8
total		38	792	7	14,5	2	4,2	1	2,1	48

Tableau I : Répartition par classes de contamination des coquillages en Escherichia coli pour les étangs de THAU et LEUCATE en 1976.

EAUX / STATION - 1976

Stations	Normes	10 N	10 %	10 - 100 N	10 - 100 %	100 N	100 %	Nombre total
ETANG DE THAU	T 6	34	94,4	2	5,6	0	0	36
	T 7	35	97,2	1	2,8	0	0	36
	T 8	29	82,9	6	17,1	0	0	35
	T 9	34	94,4	2	5,6	0	0	36
	T 10	27	77,1	8	22,8	0	0	35
	T 11	24	66,7	9	25	3	8,3	36
	T 12	25	73,5	8	23,6	1	2,9	34
	T 13	30	83,3	5	13,9	1	2,8	36
	T 14	27	79,5	6	17,6	1	2,9	34
	T 15	30	83,3	5	13,9	1	2,8	36
	T 16	25	69,4	8	22,2	3	8,4	36
	T 17	19	52,8	9	25	8	22,2	36
total		339	79,6	69	16,2	18	4,2	426
ETANG DE LEUCATE	L 8	7	87,5	1	12,5	0		8
	L 9	6	75	2	25	0		8
	L 10	8	88,9	1	11,1	0		9
	L 11	9	100	0		0		9
	L 12	9	100	0		0		9
	L 13	9	100	0		0		9
total		48	92,3	4	7,7	0	0	52

Tableau II: Répartition par classes de contamination des eaux en Escherichia coli pour les étangs de THAU et LEUCATE en 1976.

COQUILLAGES / STATION - 1977

Stations	Normes	0-300 N	0-300 %	301-1000 N	301-1000 %	1001-3000 N	1001-3000 %	3000 N	3000 %	N total
	T 6	21	77.8	2	7.4	3	11.1	1	3.7	27
	T 7	19	73.1	1	3.8	6	23.1	0	0	26
	T 8	18	56.3	3	9.4	7	21.9	4	12.5	32
	T 9	21	72.4	2	6.9	2	6.9	4	13.8	29
	T 10	23	74.2	3	9.7	2	6.4	3	9.7	31
	T 11	16	50	7	21.9	3	9.4	6	18.7	32
ETANG	T 12	24	72.7	3	9.1	4	12.1	2	6.1	33
DE THAU	T 13	22	68.7	3	9.4	3	9.4	4	12.5	32
	T 14	21	63.6	4	12.2	6	16.3	2	6.1	33
	T 15	24	72.7	4	12.2	3	9.1	2	6.1	33
	T 16	19	63.3	5	16.6	6	20	0	0	30
	T 17	21	63.6	5	15.1	6	16.3	1	3	33
	Expédition	33	61.1	7	13	11	20.4	3	5.7	54
total		282	66	50	11.7	62	14.5	33	7.7	427
	L 8	4	57.1	1	14.3	1	14.3	1	14.3	7
	L 9	3	50	1	16.7	2	33.3	0		6
ETANG	L 10	4	66.7	0		1	16.7	1	16.7	6
DE	L 11	5	71.4	1	14.3	0		1	14.3	7
LEUCATE	L 12	6	85.7	0		0		1	14.3	7
	L 13	6	85,7	0		0		1	14.3	7
total		28	70	3	7.5	4	10	5	12.5	40

Tableau III Répartition par classes de contamination des coquillages en Escherichia coli pour les étangs de Thau et Leucate en 1977.

EAUX / STATION - 1977

Stations	Normes	0 - 10 N	0 - 10 %	10 - 100 N	10 - 100 %	100 N	100 %	Nombre total
	T 6	21	91,3	2	8,7	0	0	23
	T 7	22	95,6	1	4,4	0	0	23
	T 8	16	64	8	32	1	4	25
	T 9	23	92	2	8	0	0	25
	T 10	21	84	2	8	2	8	25
ETANG	T 11	19	76	4	16	2	8	25
DE	T 12	22	88	3	12	0	0	25
THAU	T 13	20	80	4	16	1	4	25
	T 14	20	80	3	12	2	8	25
	T 15	21	84	4	16	0	0	25
	T 16	19	76	2	8	4	16	25
	T 17	16	64	7	28	2	8	25
total		240	81,1	42	14,2	14	4,7	296
	L 8	4	66,7	1	16,7	1	16,7	6
	L 9	5	83,3	0		1	16,7	6
ETANG	L 10	5	83,3	1	16,7	0		6
DE LEU-	L 11	5	83,3	1	16,7	0		6
CATE	L 12	4	80	1	20	0		5
	L 13	5	100	0		0		5
total		28	82,3	4	11,8	2	5,9	34

Tableau IV Répartition par classes de contamination des eaux en Escherichia coli pour les étangs de THAU et LEUCATE en 1977.

COQUILLAGES / STATION - 1978

Stations	Normes	0-300 N	0-300 %	301-1000 N	301-1000 %	1001-3000 N	1001-3000 %	3000 N	3000 %	N total
	T 6	18	90	0	0	1	5	1	5	20
	T 7	17	85	0	0	1	5.5	2	10	20
	T 8	19	86.4	2	9.1	0	0	1	4.5	22
	T 9	19	86.4	1	4.5	1	4.5	1	4.5	22
	T 10	20	87.0	0	0	0	0	3	13	23
	T 11	19	82.6	4	17.4	0	0	0	0	23
ETANG	T 12	18	90	0	0	1	5	1	5	20
DE THAU	T 13	18	81.8	1	4.5	1	4.5	2	9.1	22
	T 14	24	100	0	0	0	0	0	0	24
	T 15	22	95.6	0	0	0	0	1	4.4	23
	T 16	18	78.2	1	4.4	3	13	1	4.4	23
	T 17	19	86.4	0	0	3	13.5	0	0	22
	Expédition	126	94	6	4.5	1	0.7	1	0.7	134
total		357	89.7	15	3.8	12	3	14	3.5	398
	L 8	2								
	L 9	2								
	L 10	4								
ETANG	L 11	3								
DE	L 12	3								
LEUCATE	L 13	2								
	Expédition	76	86.3	6	6.8	4	4.5	2	2.3	88
total		92	88.6	6	5.8	4	3.8	2	1.9	104

Tableau V : Répartition par classes de contamination des coqui. en Escherichia coli pour les étangs de Thau et Leucate en 1978.

EAUX / STATION - 1978

Stations	Normes	0 - 10 N	0 - 10 %	10 - 100 N	10 - 100 %	100 N	100 %	Nombre total
	T 6	11	100					11
	T 7	10	90,9	1	9,1			11
	T 8	12	92,3	1	7,7			13
	T 9	12	100					12
	T 10	13	100					13
ETANG	T 11	12	92,3	1	7,7			13
DE	T 12	12	92,3	1	7,7			13
THAU	T 13	13	92,9	1	7,1			14
	T 14	14	100					14
	T 15	13	92,9	1	7,1			14
	T 16	14	100					14
	T 17	14	100					14
total		150	96,1	6	3,9	0	0	156
	L 8	3						
	L 9	3						
ETANG	L 10	4						
DE LEU-	L 11	4						
CATE	L 12	3						
	L 13	3						
	Expédition	17						
Total		37	100					

Tableau VI : Répartition par classes de contamination des eaux en Escherichia coli pour les étangs de THAU et LEUCATE 1978.

COLIFORMES TOTAUX - EAUX / STATION

Janvier - Septembre 1979

Stations	Classes	0 - 10 N	0 - 10 %	11 - 100 N	11 - 100 %	+ de 100 N	+ de 100 %	N total
ETANG DE THAU	T 6	5	83,3	1	16,7	0		6
	T 7	5	100					5
	T 8	4	66,7	2	33,3			6
	T 9	7	100					7
	T 10	8	72,7	3	27,3			11
	T 11	6	60,0	3	30,0	1	10,0	10
	T 12	9	100					9
	T 13	8	80,0			2	20,0	10
	T 14	3	50,0	2	33,3	1	16,7	6
	T 15	4	80,0			1	20,0	5
	T 16	4	57,1	1	14,3	2	28,6	7
	T 17	3	42,8	1	14,4	3	42,8	7
	total	66	74,2	13	14,6	10	11,2	89
ETANG DE LEUCATE	L 8	6	75,0			2	25,0	8
	L 9	5	62,5	3	37,5			8
	L 10	7	87,5	1	12,5			8
	L 11	8	100					8
	L 12	7	87,5	1	12,5			8
	L 13	6	75,0	2	25,0			8
	total	39	81,2	7	14,6	2	4,2	48

Tableau VII - Distribution par classe de contamination des eaux en Coliformes totaux pour les étangs de Thau et de Leucate.

COLIFORMES TOTAUX - COQUILLAGES / STATION

Janvier - Septembre 1979

Stations	Classes	0 - 300 N	0 - 300 %	301 - 1000 N	301 - 1000 %	1001 - 3000 N	1001 - 3000 %	+ de 3000 N	+ de 3000 %	N total
ETANG DE THAU	T 6	5	55,5	1	11,1	1	11,1	2	22,2	9
	T 7	4	44,4			2	22,2	3	33,3	9
	T 8	7	43,7	3	18,7	1	6,3	5	31,3	16
	T 9	8	44,4	3	16,7	2	11,1	5	27,8	18
	T 10	9	45,0	5	25	1	5	5	25,0	20
	T 11	5	25,0	6	30,0	3	15,0	6	30,0	20
	T 12	6	50,0			1	8,3	5	41,7	12
	T 13	7	53,8	1	7,7	1	7,7	4	30,8	13
	T 14	6	42,9	1	7,1	2	14,2	5	35,7	14
	T 15	2	15,4	5	38,5	2	15,4	4	30,8	13
	T 16	6	35,3	4	23,5	1	5,9	6	35,3	17
	T 17	4	26,7	2	13,3	4	26,7	5	33,3	15
	Expéd.	21	38,9	6	11,1	13	24,1	14	25,9	54
	total	90	39,1	37	16,1	34	14,8	69	30,0	230
ETANG DE LEUCATE	L 8	3	33,3	3	33,3			3	33,3	9
	L 9	3	33,3	3	33,3	2	22,2	1	11,1	9
	L 10	7	77,8	1	11,1	1	11,1			9
	L 11	5	55,6	3	33,3			1	11,1	9
	L 12	4	44,5	3	33,3	1	11,1	1	11,1	9
	L 13	4	44,4	4	44,4			1	11,1	9
	Expéd.	41	65,1	8	12,7	6	9,5	8	12,7	63
	total	67	57,3	25	21,4	10	8,5	15	12,8	117

Tableau VIII Distribution par classes de contamination des coquillages en Coliformes totaux pour les étangs de Thau et de Leucate.

COLIFORMES FECAUX - EAUX / STATION

Janvier - Septembre 1979

Stations	Normes	0 - 10 N	0 - 10 %	10 - 100 N	10 - 100 %	+ de 100 N	+ de 100 %	Nombre total
ETANG DE THAU	T 6	5	83,3	1	16,7	0		6
	T 7	5	100	0		0		5
	T 8	4	66,7	2	33,3	0		6
	T 9	7	100	0		0		7
	T 10	8	80,0	2	20,0	0		10
	T 11	7	70,0	3	30,0	0		10
	T 12	9	100	0		0		9
	T 13	8	80,0	0		2	20,0	10
	T 14	5	71,4	0		2	28,6	7
	T 15	4	80,0	0		1	20,0	5
	T 16	5	71,4	1	14,3	1	14,3	7
	T 17	4	57,1	0		3	42,9	7
total		72	80,9	9	10,1	8	8,9	89
ETANG DE LEUCATE	L 8	8	100					8
	L 9	8	100					8
	L 10	8	100					8
	L 11	8	100					8
	L 12	8	100					8
	L 13	8	100					8
	Bassins expédition	17	100					17
total		65	100					65

Tableau IX Répartition par classes de contamination des eaux en Escherichia coli pour los étangs de Thau et Leucate de janvier à septembre 1979.

COLIFORMES FECAUX - COQUILLAGES / STATION

Janvier - Septembre 1979

Stations	Normes	0 - 300 N	0 - 300 %	301 - 1000 N	301 - 1000 %	1001 - 3000 N	1001 - 3000 %	+ de 3000 N	+ de 3000 %	N total
ETANG DE THAU	T 6	6	66,7	0		2	22,2	1	11,1	9
	T 7	8	88,9	0		1	11,1	0		9
	T 8	13	81,2	1	6,3	0		2	12,5	16
	T 9	16	88,9	0		0		2	11,1	18
	T 10	15	75,0	1	5,0	1	5,0	3	15,0	20
	T 11	12	60,0	2	10,0	2	10,0	4	20,0	20
	T 12	10	83,3	1	8,3	0		1	8,3	12
	T 13	10	76,9	0		1	7,7	2	15,4	13
	T 14	11	78,6	0		3	21,4	0		14
	T 15	10	76,9	2	15,4	0		1	7,7	13
	T 16	10	58,8	3	17,6	1	5,9	3	17,6	17
	T 17	10	66,7	2	13,3	1	6,7	2	13,3	15
	Expédition	46	85,2	1	1,8	4	7,4	3	5,5	54
total		177	77,0	13	5,6	16	6,9	24	10,5	230
ETANG DE LEUCATE	L 8	7	77,8	1	11,1	1	11,1			9
	L 9	8	88,9			1	11,1			9
	L 10	9	100							9
	L 11	8	100							8
	L 12	8	88,9	1	11,1					9
	L 13	9	100							9
	Expédition	59	93,6	2	3,2	0		2	3,2	63
total		108	93,1	4	3,5	2	1,7	2	1,7	116

Tableau X - Répartition par classes de contamination des coquillages en Escherichia coli pour les étangs de Thau et Leucate de janvier à septembre 1979.

STREPTOCOQUES FECAUX - EAUX / STATION

Janvier - Septembre 1979

Stations	Classes	0 - 10 N	0 - 10 %	11 - 100 N	11 - 100 %	+ de 100 N	+ de 100 %	N total
ETANG DE THAU	T 6	3	50,0	3	50,0			6
	T 7	5	100,0					5
	T 8	3	50,0	3	50,0			6
	T 9	8	100					8
	T 10	6	66,7	3	33,3			9
	T 11	8	80,0	2	20,0			10
	T 12	7	87,5	1	12,5			8
	T 13	7	77,8	1	11,1	1	11,1	9
	T 14	3	50,0	2	33,3	1	16,7	6
	T 15	3	60,0	1	20,0	1	20,0	5
	T 16	3	42,9	3	42,9	1	14,3	7
	T 17	3	42,9	2	28,6	2	28,6	7
	total	59	68,6	21	24,4	6	69,7	86
ETANG DE LEUCATE	L 8	6	75,0	2	25,0			8
	L 9	7	87,5	1	12,5			8
	L 10	5	62,5	3	37,5			8
	L 11	8	100					8
	L 12	8	100					8
	L 13	5	62,5	3	37,5			8
	total	39	81,2	9	18,7			48

Tableau XI - Distribution par classe de contamination des eaux en Streptocoques fécaux pour les étangs de Thau et de Leucate, de Janvier à Septembre 1979.

STREPTOCOQUES FECAUX - COQUILLAGES / STATION

Janvier - Septembre 1979

Stations	Classes	0 - 300 N	0 - 300 %	301 - 1000 N	301 - 1000 %	1001 - 3000 N	1001 - 3000 %	+ de 3000 N	+ de 3000 %	N total
[illegible]TANG DE THAU	T 6	4	44,4	1	11,1	2	22,2	2	22,2	9
	T 7	6	66,7			2	22,2	1	11,1	9
	T 8	10	66,7	2	13,3	2	13,3	1	6,7	15
	T 9	12	70,6	1	5,9	3	17,6	1	5,9	17
	T 10	12	66,7	1	5,5	2	11,1	3	16,7	18
	T 11	11	55,0	4	20,0	4	20,0	1	5,0	20
	T 12	9	75,0	1	8,3	1	8,3	1	8,3	12
	T 13	10	76,9	1	7,7	1	7,7	1	7,7	13
	T 14	10	71,4	1	7,1	2	14,3	1	7,1	14
	T 15	10	76,9	1	7,7	1	7,7	1	7,7	13
	T 16	8	50,0	1	6,2	3	18,7	4	25,0	16
	T 17	7	50,0	2	14,3	2	14,3	3	21,4	14
	Exped.	30	66,7	6	13,3	7	15,6	2	4,4	45
	total	139	64,6	22	10,2	32	14,9	22	10,2	215
[illegible]ANG DE LEUCATE	L 8	7	77,8	2	22,2					9
	L 9	6	66,7	3	33,3					9
	L 10	8	88,9	1	11,1					9
	L 11	7	77,8	1	11,1			1	11,1	9
	L 12	7	77,8	1	11,1	1	11,1			9
	L 13	8	88,9			1	11,1			9
	Exped.	47	81,0	4	6,9	5	8,6	2	3,5	58
	total	90	80,4	12	10,7	7	6,2	3	2,7	112

Tableau XII Distribution par classes de contamination en Streptocoques fécaux pour les étangs de Thau et de Leucate, de Janvier à Septembre 1979.

Tableau XIII - Distribution par classe de contamination des eaux en coliformes totaux pour l'étang de Thau.

COLIFORMES TOTAUX - EAUX / STATION (novembre 1979 - mars 1981)

Stations	Classes	0 - 10 N	0 - 10 %	11 - 100 N	11 - 100 %	+ de 100 N	+ de 100 %	N total
ETANG DE THAU	T6	22	91,7	2	8,3			24
	T7	20	95,2	1	4,8			21
	T8	22	91,7	2	8,3			24
	T9	24	100	0				24
	T10	22	95,6	1	4,4			23
	T11	25	96,2	1	3,8			26
	T12	22	95,6	1	4,4			23
	T13	26	100	0				26
	T14	22	95,6	1	4,4			23
	T15	26	100	0				26
	T16	23	85,2	4	14,8			27
	T17	23	88,5	3	11,5			26
	total	277	94,5	16	5,5			293

Tableau XIV - Distribution par classes de contamination des coquillages en coliformes totaux pour l'étang de Thau.

COLIFORMES TOTAUX - COQUILLAGES / STATION (novembre 1979 - mars 1981)

Stations	Classes	0 - 300 N	0 - 300 %	301 - 1000 N	301 - 1000 %	1001 - 3000 N	1001 - 3000 %	+ de 3000 N	+ de 3000 %	N total
ETANG DE THAU	T6	15	57,7	2	7,7	6	23,1	3	11,5	26
	T7	17	65,4	1	3,8	3	11,5	5	19,3	26
	T8	13	44,8	8	27,6	3	10,3	5	17,2	29
	T9	18	62,1	4	13,8	4	13,8	3	10,3	29
	T10	15	57,7	2	7,7	5	19,2	4	15,4	26
	T11	15	50,0	4	13,3	2	6,7	9	30,0	30
	T12	18	69,1	3	10,3	3	10,3	2	10,3	26
	T13	18	58,1	5	16,1	3	9,7	5	16,1	31
	T14	16	59,3	2	7,4	4	14,8	5	18,5	27
	T15	18	64,4	0		5	17,8	5	17,8	28
	T16	20	64,5	2	6,5	3	9,7	6	19,3	31
	T17	11	37,9	7	24,1	5	17,2	6	20,7	29
	total	194	57,4	40	11,8	46	13,6	58	17,2	338

Tableau XV - répartition par classes de contamination des eaux en E.coli pour l'étang de Thau.

COLIFORMES FECAUX - EAUX / STATION (novembre 1979 - mars 1981)

Stations \ Classes		0 - 10		11 - 100		+ de 100		N total
		N	%	N	%	N	%	
	T6	24	100	0				24
	T7	21	100	0				21
	T8	23	95,8	1	4,2			24
	T9	24	100	0				24
	T10	22	95,7	1	4,3			23
	T11	25	96,2	1	3,8			26
ETANG DE THAU	T12	22	95,7	1	4,3			23
	T13	26	100	0				26
	T14	23	100	0				23
	T15	26	100	0				26
	T16	25	92,6	2	7,4			27
	T17	26	100	0				26
	Total	287	98,0	6	2,0			293

Tableau XVI Répartition par classes de contamination des coquillages en E.coli pour l'étang de Thau.

COLIFORMES FECAUX - COQUILLAGES / STATION (novembre 1979 - mars 1981)

Stations \ Classes	0 - 300		301 - 1000		1001 - 3000		+ de 3000		N total
	N	%	N	%	N	%	N	%	
T6	24	92,4	1	3,8	0	.	1	3,8	26
T7	21	80,8	1	3,8	2	7,7	2	7,7	26
T8	25	86,2	3	10,3	0		1	3,5	29
T9	28	96,6	0		0		1	3,4	29
T10	20	77,0	1	3,8	4	15,4	1	3,8	26
T11	24	80,0	2	6,7	2	6,7	2	6,7	30
T12	23	88,5	0		2	7,7	1	3,8	26
T13	28	90,3	1	3,2	0		2	6,5	31
T14	21	77,8	1	3,7	3	11,1	2	7,4	27
T15	23	82,1	1	3,6	2	7,1	2	7,1	28
T16	25	80,7	4	12,9	1	3,2	1	3,2	31
T17	21	72,4	3	10,3	3	10,3	2	7,0	29
Total	283	83,7	18	5,3	19	5,7	18	5,3	338

Tableau XVII - Distribution par classe de contamination des eaux en streptocoques fécaux pour l'étang de Thau.

STREPTOCOQUES FECAUX - EAUX / STATION (novembre 1979 - mars 1981)

Stations \ Classes		0 - 10		11 - 100		+ de 100		N total
		N	%	N	%	N	%	
ETANG DE THAU	T6	17	89,5	2	10,5			19
	T7	16	88,9	2	11,1			18
	T8	18	100	0				18
	T9	17	94,4	1	5,6			18
	T10	16	100	0				16
	T11	17	94,4	1	5,6			18
	T12	15	93,8	1	6,2			16
	T13	16	88,9	2	11,1			18
	T14	16	100	0				16
	T15	16	88,9	2	11,1			18
	T16	16	88,9	1	5,6	1	5,6	18
	T17	18	100	0				18
	Total	198	93,8	12	5,7	1	0,5	211

Tableau XVIII - Distribution par classes de contamination des coquillages en streptocoques fécaux pour l'étang de Thau.

STREPTOCOQUES FECAUX - COQUILLAGES / STATION (novembre 1979 - mars 1981)

Stations \ Classes		0 - 300		301 - 1000		1001 - 3000		+ de 3000		N total
		N	%	N	%	N	%	N	%	
ETANG DE THAU	T6	8	42,1	8	42,1	2	10,5	1	5,3	19
	T7	10	58,8	4	23,6	3	17,6	0		17
	T8	8	44,4	7	38,9	3	16,7	0		18
	T9	8	47,1	5	29,3	2	11,8	2	11,8	17
	T10	7	38,9	6	33,3	4	22,2	1	5,5	18
	T11	6	33,3	8	44,4	3	16,7	1	5,5	18
	T12	10	58,8	5	29,4	1	5,9	1	5,9	17
	T13	9	45,0	6	30,0	4	20,0	1	5,0	20
	T14	10	66,7	1	6,7	2	13,3	2	13,3	15
	T15	9	50,0	5	27,8	2	11,1	2	11,1	18
	T16	10	52,6	4	21,1	3	15,8	2	10,5	19
	T17	7	43,8	6	37,4	0		3	18,8	16
	total	102	48,1	65	30,7	29	13,7	16	7,5	212

COLIFORMES TOTAUX - RADE DE TOULON

octobre 1978 - octobre 1979

EAUX / STATION

Classes / Stations	0 - 10 N	0 - 10 %	11 - 100 N	11 - 100 %	+ de 100 N	+ de 100 %	N
RT 1	6	60,0	2	20,0	2	20,0	10
RT 2	6	60,0	3	30,0	1	10,0	10
RT 3	5	50,0	5	50,0			10
RT 4	5	50,0	3	30,0	2	20,0	10
RT 5	7	70,0	2	20,0	1	10,0	10
RT 6	7	70,0	2	20,0	1	10,0	10
RT 7	5	55,6	2	22,2	2	22,2	9
total	41	59,4	19	27,5	9	13,1	69

COQUILLAGES / STATION

Classes / Stations	0 - 300 N	0 - 300 %	301 - 1000 N	301 - 1000 %	1001 - 3000 N	1001 - 3000 %	+ de 3000 N	+ de 3000 %	N
RT 1	3	30,0			4	40,0	3	30,0	10
RT 2	2	22,2	2	22,2	2	22,2	3	33,3	9
RT 3	1	10,0			2	20,0	7	70,0	10
RT 4	2	20,0	2	20,0	1	10,0	5	50,0	10
RT 5					1	50,0	1	50,0	2
RT 6	3	30,0	2	20,0			5	50,0	10
RT 7	1	50,0			1	50,0			2
total	12	22,6	6	11,3	11	20,7	24	45,3	53

Tableau XIX - Distribution par classes de contamination en Coliformes totaux pour la rade de Toulon.

COLIFORMES FECAUX - RADE DE TOULON

octobre 1978 - octobre 1979

EAUX / STATION

Normes / Stations	0 - 10 N	0 - 10 %	11 - 100 N	11 - 100 %	+ de 100 N	+ de 100 %	N
RT 1	7	70	3	30			10
RT 2	7	70	3	30			10
RT 3	8	80	2	20			10
RT 4	7	70	3	30			10
RT 5	8	80	2	20			10
RT 6	8	80	1	10	1	10	10
RT 7	6	66,7	3	33,3			9
Total	51	73,9	17	24,6	1	1,5	69

COQUILLAGES / STATION

Normes / Stations	0 - 300 N	0 - 300 %	301 - 1000 N	301 - 1000 %	1001 - 3000 N	1001 - 3000 %	+ de 3000 N	+ de 3000 %	N total
RT 1	6	60,0			1	10,0	3	30,0	10
RT 2	6	66,7	1	11,1	1	11,1	1	11,1	9
RT 3	3	30,0	2	20,0	2	20,0	3	30,0	10
RT 4	4	40,0	1	10,0	2	20,0	3	30,0	10
RT 5	1	50					1	50,0	2
RT 6	3	30,0	2	20,0	2	20,0	3	30,0	10
RT 7	2	100							2
	25	47,2	6	11,3	8	15,1	14	26,4	53

Tableau XX - Distribution par classes de contamination en Coliformes fécaux dans la rade de Toulon.

STREPTOCOQUES FECAUX - RADE DE TOULON

octobre 1978 - octobre 1979

EAUX / STATION

Classes / Stations	0 - 10		11 - 100		+ de 100		N
	N	%	N	%	N	%	
RT 1	3	50,0	3	50,0			6
RT 2	2	33,3	4	66,7			6
RT 3	2	33,3	3	50,0	1	16,7	6
RT 4	2	33,3	4	66,7			6
RT 5	1	16,7	4	66,7	1	16,7	6
RT 6	3	50,0	3	50,0			6
RT 7	2	33,3	4	66,7			6
Total	15	35,7	25	59,5	2	4,8	42

COQUILLAGES / STATION

Classes / Stations	0 - 300		301 - 1000		1001 - 3000		+ de 3000		N
	N	%	N	%	N	%	N	%	
RT 1	1	10,0	5	50,0			4	40,0	10
RT 2	2	22,2	5	55,6			2	22,2	9
RT 3	3	30,0	1	10,0	2	20,0	4	40,0	10
RT 4	1	10,0	2	20,0			7	70,0	10
RT 5							2	100,0	2
RT 6	1	10,0	4	40,0			5	50,0	10
RT 7	1	50,0	1	50,0					2
Total	9	17,0	18	34,0	2	3,7	24	45,3	53

Tableau XXI - Répartition par classes de contamination en Streptocoques fécaux, dans la rade de Toulon.

Centre de Recherche : Centre d'Etudes et de Recherches de Biologie et d'Océanographie Médicale
C.E.R.B.O.M.
NICE
France

Chercheur Principal: A. FRUCHART

PREMIERE ETUDE

INTRODUCTION

Dans le cadre du projet MED POL VII (PNUE), le Centre d'Etudes et de Recherches de Biologie et d'Océanographie Médicale (C.E.R.B.O.M.) a effectué une étude bactériologique des eaux de baignade de la ville de Nice, dans la Baie des Anges.

Cette étude comprendait:

1. Des analyses bactériologiques des eaux de baignade :

   - Streptocoques fécaux
   - Coliformes fécaux
   - Coliformes totaux

2. Des analyses physico-chimiques des eaux de baignade :

   - Salinité
   - Température
   - Oxygène dissous

3. Des analyses hydrologiques et météorologiques :

   - Courantologie de la zone
   - Vent (force et direction)
   - Température de l'air
   - Nébulosité du ciel

4. L'observation de la plage afin de rechercher d'éventuels polluants liés aux macro-déchets et aux hydrocarbures.

ZONE(S) ETUDIEE(S)

Trente prélèvements ont été effectués simultanément dans la zone d'étude. Les stations sont reportées sur le schéma no.1 en annexe et sont numérotées de 1 à 30.

MATERIEL ET METHODES

L'étude de la courantométrie conditionne l'étude de la pollution car elle permet d'étudier le devenir des eaux rejetées par les fleuves côtiers et les collecteurs d'égout.

Etude des courants de la Baie des Anges:

Cette étude ayant été faite partiellement par Romanovsky, nous pouvons résumer les principales données de ce travail publié en 1951.

A ces données nous ajouterons certaines précisions obtenues par nos propres observateurs faites, soit au courantomètre à flotteur soit par l'étude des courbes thermiques, soit par la recherche de la salinité.

En résumé, il existe deux situations générales de circulation des eaux marines dans la Baie de Nice :

- d'une part, par beau temps, un tracé N.E.-S.O. qui s'infléchit pour suivre parallèlement le littoral de la Baie de Nice, les filets du large gardant une direction plus rectiligne. (Schéma 2)

- d'autre part, une deuxième situation est créée par les vents de secteur Ouest. Si les courants du large conservent à peu près une direction analogue mais plus ralentie, les courants de terre prennent un aspect tourbillonnaire formant près du rivage un contre-courant, c'est-à-dire en direction S.O.-N.E., partant de l'estuaire du Var, longeant la plage de Nice jusqu'à l'entrée de Villefranche où ils se dirigent vers le Sud formant ainsi une zone tourbillonnaire. Ce contre-courant aurait d'après les mesures faites, de 15 à 23 cm/sec. (Schéma 3)

Une double situation courantométrique se trouve créée : une, liée aux vents d'Est, l'autre aux vents d'Ouest.

1. Campagne du 12 juillet 1978 entre 9 et 10 heures :

a) Météorologie :

- Etat du ciel : clair à peu nuageux
- Vent : direction S.W. (force 1)
- Température de l'air : 22°C

b) Etat visuel de la plage :

- Propre dans l'ensemble
- Absence de goudrons sur les galets
- Absence de macro-déchets à la surface de l'eau et sur les galets.

2. Campagne du 10 août 1978 entre 9 et 10 heures :

a) Météorologie :

- Etat du ciel : clair à peu nuageux
- Vent : Direction S.W. (force 1)
- Température de l'air : 24°C

b) Etat visuel de la plage :

- Propre dans l'ensemble
- Absence d'hydrocarbures sur les galets
- Absence de macro-déchets à la surface de l'eau et sur les galets.

3. Campagne du 6 septembre 1978 entre 9 et 10h30:

a) Météorologie:

- Etat du ciel : clair
- Vent : Nul
- Température de l'air : 22.1°C

b) Etat visuel de la plage :

- Traces d'hydrocarbures sur les galets
- Traces d'hydrocarbures dans l'eau de baignade
- Présence de macro-déchets dans l'eau de baignade.

4. Campagne du 4 décembre 1978 entre 9 et 10 heures :

a) Météorologie :

- Etat du ciel à clair à peu nuageux
- Vent : nul
- Température de l'air : 12°C

b) Etat visuel de la plage :

- Propre dans l'ensemble
- Absence de macro-déchets dans l'eau de baignade et sur les galets
- Absence d'hydrocarbures dans l'eau de baignade et sur les galets.

RESULTATS ET LEUR INTERPRETATION

Les résultats des analyses bactériologiques sont les suivants :

1. Le taux des Streptocoques fécaux est élevé (Graphique 2).

Les concentrations les plus importantes sont observées au mois de décembre:

- période d'ensoleillement réduite
- apport de matériaux par les fleuves côtiers durant
- la saison des pluies, et déversoirs débouchant en mer.

2. Dans l'ensemble les Coliformes fécaux sont les moins répandus (Graphique 1).

Les taux les plus élevés se rencontrent au mois d'août (Graphique 2):

- période de forte densité de population estivale.

3. Les Coliformes totaux suivent la même évolution dans le temps que les Coliformes fécaux avec une forte concentration au mois d'août (Graphique 2).

DEUXIEME ETUDE

INTRODUCTION

Cette étude est plus étendue que la première et a pour but de surveiller trois zones ayant des caractéristiques différentes à savoir :

a) Villefranche-sur-Mer: Zone portuaire, activité de plaisance (Fig.1)

b) Beaulieu-sur-Mer : Zone balnéaire de type alvéolaire (plage artificielle) (Fig.2)

c) Nice : Zone balnéaire de type ouvert, Est de la Baie des Anges (Fig.3)

Paramètres :

Les paramètres qui ont été relevés comprenaient des paramètres météorologiques, des paramètres hydrologiques et physico-chimiques, des observations visuelles et des paramètres microbiologiques.

a) Paramètres météorologiques

Température de l'air: (°C)

Vent: force (échelle Beaufort)
direction
amplitude (en mètre)

Houle: direction

Nébulosité: (8e de ciel)

b) Paramètres hydrologiques et physico-chimiques

Température de l'eau: (°C)

PH

Salinité: (g/litre)

C : couleur exprimé en unité APHA (APHA Standard Methods)

T : Turbidité exprimé en unité FTU (Unité de Turbidité Formazine)

Observations visuelles :

Fréquentation de la plage (nombre de baigneurs)

Déchets observés : HC = Hydrocarbures
MO = Matières organiques

\+ faible
++ moyenne
+++ forte

Paramètres micro-biologiques :

1. Analyses plactoniques
Nombre de diatomées par ml
Nombre de péridiniens par ml
Nombre de nanoplancton par ml

2. Analyses bactériennes
Coliformes fécaux
Coliformes totaux
Streptocoques fécaux
Levures pathogènes (*Candida sp.*)
Pseudomonas aeruginosa

Les résultats sont donnés pour un volume d'eau de mer de 100 ml.

METHODOLOGIE

Bactériologie :

Méthode utilisée:

- Filtration sur membranes Millipore (0,45 ul) de différents volumes d'eau de mer (100 ml, 50 ml, 10 ml, 1 ml)

Mise en culture des membranes:

- pour coliforms totaux sur gélose mFC (DIFCO), 24h00, 37°C

- pour coliformes fécaux sur gélose mFC (DIFCO), 24h00, 44°C

- pour streptocoques fécaux sur gélose m Enterococcus (DIFCO) 48h00, 44°C

Planctonologie :

- Récoltes d'échantillons à l'aide d'un filet à plancton (maille 20 ul).

- Les analyses phytoplanctoniques se font à l'aide d'un microscope inversé. Les échantillons d'eau de mer sont formolés (5% de formol à pH 8,) et mis à décanter pendant 24h dans de cuves de 25 ml.

L'analyse se fait par observation directe.

Paramètres microbiologiques :

Voir ci-haut la liste des analyses bactériennes et planctoniques.

RESULTATS ET LEUR INTERPRETATION

1. Bactériologie (période Janvier - Juin 1980)

a) Zone de Villefranche sur mer (Graphique 3)

Les concentrations en coliformes totaux sont plus élevées en février et juin.

Les concentrations en Streptocoques fécaux sont plus élevées en avril.

b) Zone de Nice (Graphique 4)

Les concentrations en coliformes totaux sont plus élevées en février, mai et fin juin.

Les concentrations en streptocoques fécaux sont plus élevées en début mai et régressent en juin.

c) Zone de Beaulieu-sur-Mer (Graphique 5)

Les concentrations en coliformes totaux sont plus élevées en janvier, février et fin Mars.

Les concentrations en streptocoques fécaux sont plus élevées en avril et régressent en mai et juin.

De ces trois observations il apparaît une alternance de germes pour les trois zones considérées.

2. Bacteries-plancton (période Janvier - June 1980)

a) Zone de Villefranche-sur-Mer

A un taux moyen de coliformes totaux (68) correspond un rapport Diat/Périd. de 5,8.

b) Zone de Nice

A un taux moyen de coliformes totaux (43) correspond un rapport Diat./Périd. de 12,5.

c) Zone de Beaulieu-sur-mer

A un taux moyen de coliformes totaux (12) correspond un rapport Diat./Périd. de 22.

La contamination en germes fécaux de milieu marin entraine un accroissement en péridiniens de la flore planctonique.

Interprétation des données :

Période Janvier - Septembre 1980 (Graphique 6)

a) Zone de Nice

Les taux de germes fécaux sont peu élevés, le rapport Diat/Périd. est important : 4,75

b) Zone de Villefranche-sur-Mer

Les taux de germes fécaux sont élevés, le rapport Diat/Périd. est faible : 1,93

c) Zone de Beaulieu-sur-Mer

Les taux de germes fécaux sont peu élevés, le rapport Diat/Périd. est important : 6,52

Il apparaît en première analyse des résultats que les teneurs du milieu marin en Péridiniens (Phytoplancton) évoluent corrélativement avec les concentrations en germes fécaux. A de fortes concentrations en germes fécaux (1340 et 1890 germes/100 ml) correspond les taux de péridiniens les plus élevés (123 organismes par ml) et un taux de diatomées faible (70 organismes par ml). Inversement à de faibles concentrations en germes fécaux (de l'ordre de 20 germes/ ml) correspond de faibles concentrations en péridiniens (20 organismes/ml) et une teneur en diatomées plus forte (120 organismes par ml).

Dans le cas présent on observe un phénomème de pré-eutrophisation d'une zone marine fermée : Port de Villefranche. Il y a apparition temporaire d'une contamination bactérienne et une dérive de la flore planctonique vers les péridiniens.

CONCLUSIONS

Période Janvier - Septembre 1980

1. Saison hiver-printemps :

L'augmentation des taux en germes fécaux du milieu marin entraine un accroissement de certaines espèces phytoplanctoniques particulières : les Péridiniens.

Pour cette période considérée les concentrations en bactéries sont faibles.

2. Saison été

On observe le même phénomène que précédemment avec de plus fortes concentrations en germes fécaux et Péridiniens.

Les deux variables microbiologiques (bactérie-phytoplancton) évoluent de la même manière.

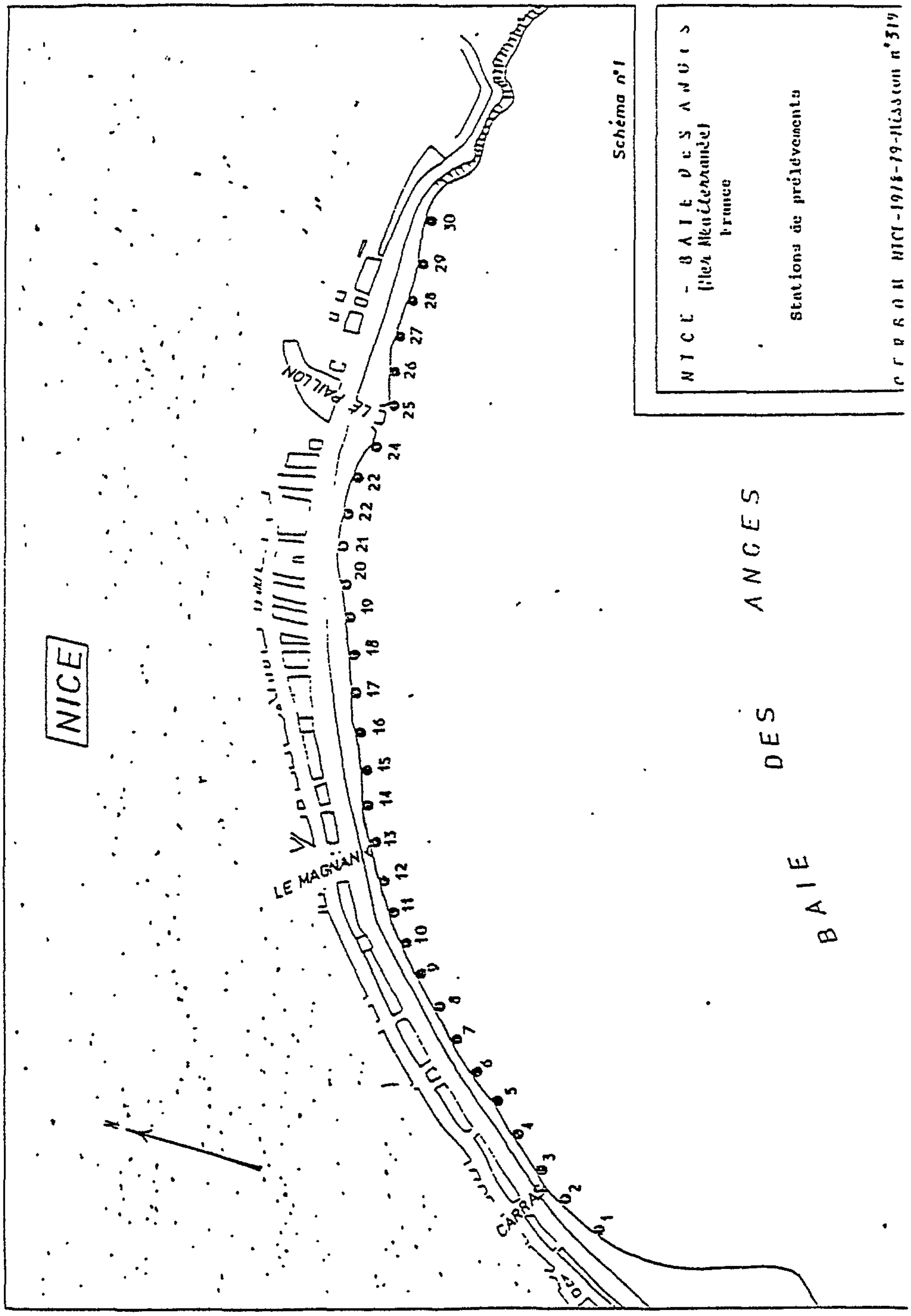
On observe dans le cas présent un phénomène de pré-eutrophysation d'une zone marine fermée.

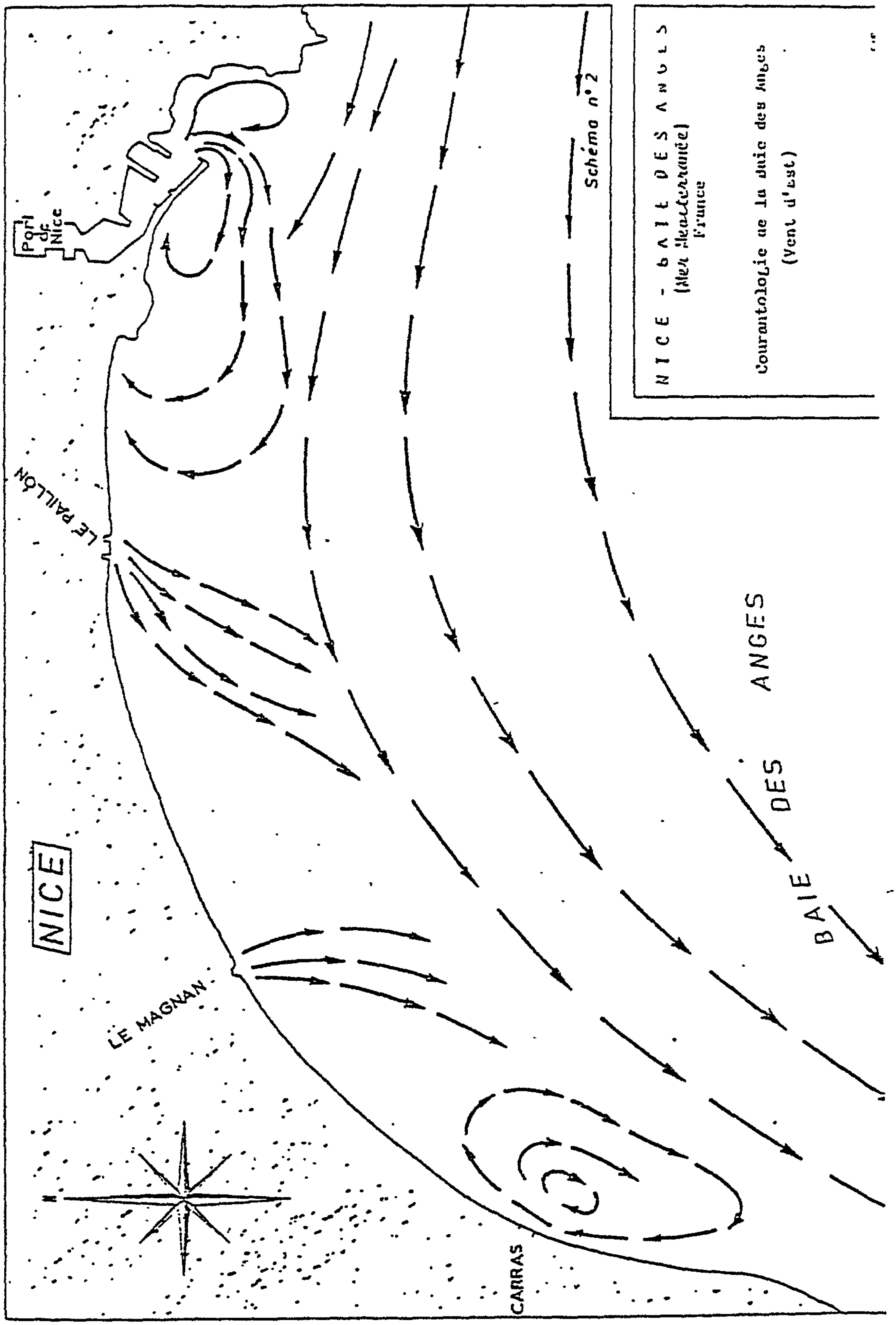
Il y a apparition temporaire d'une contamination bactérienne et une dérive de la flore planctonique.

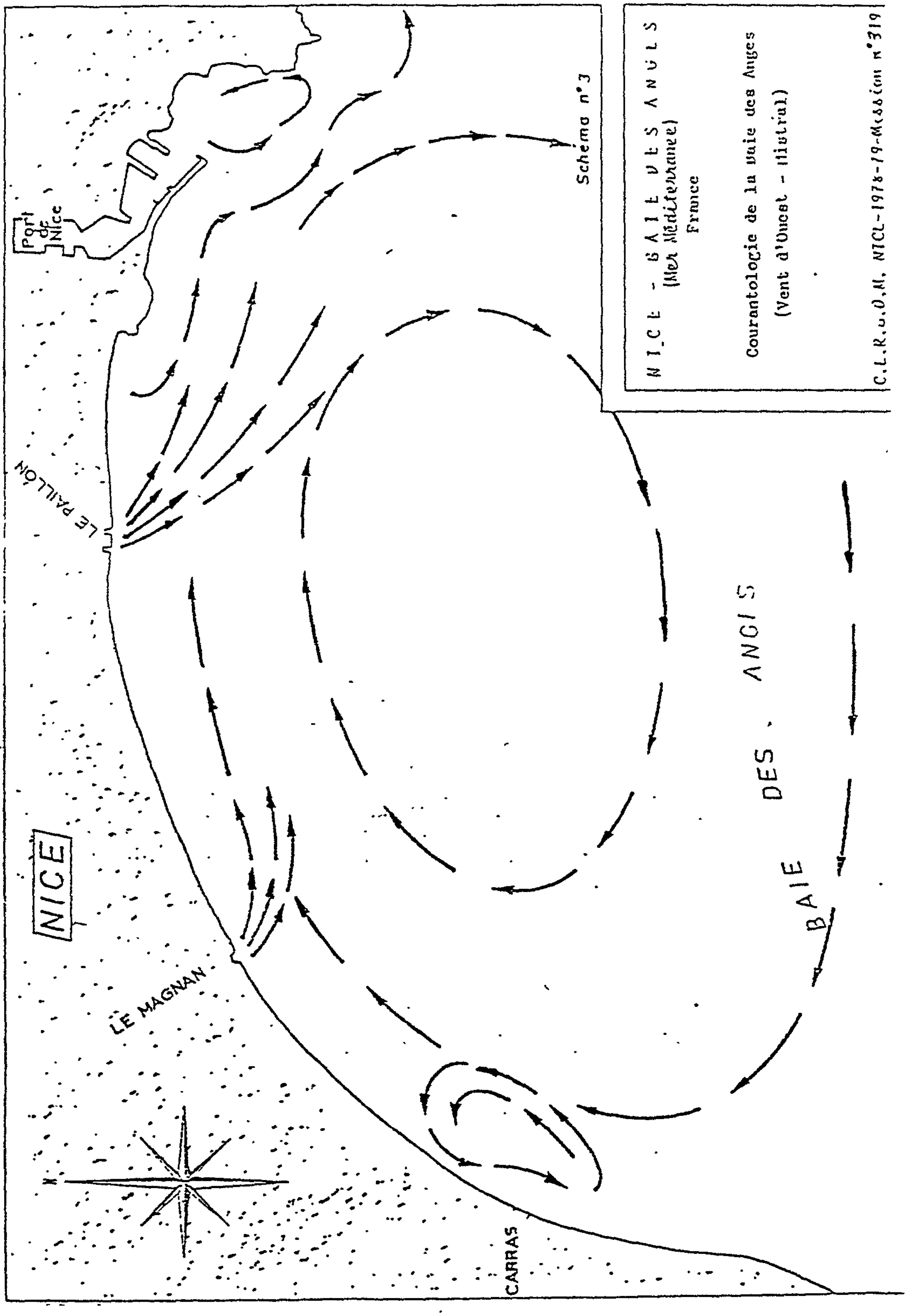
Période Juillet 1980 - Mars 1981 (Graphique 7)

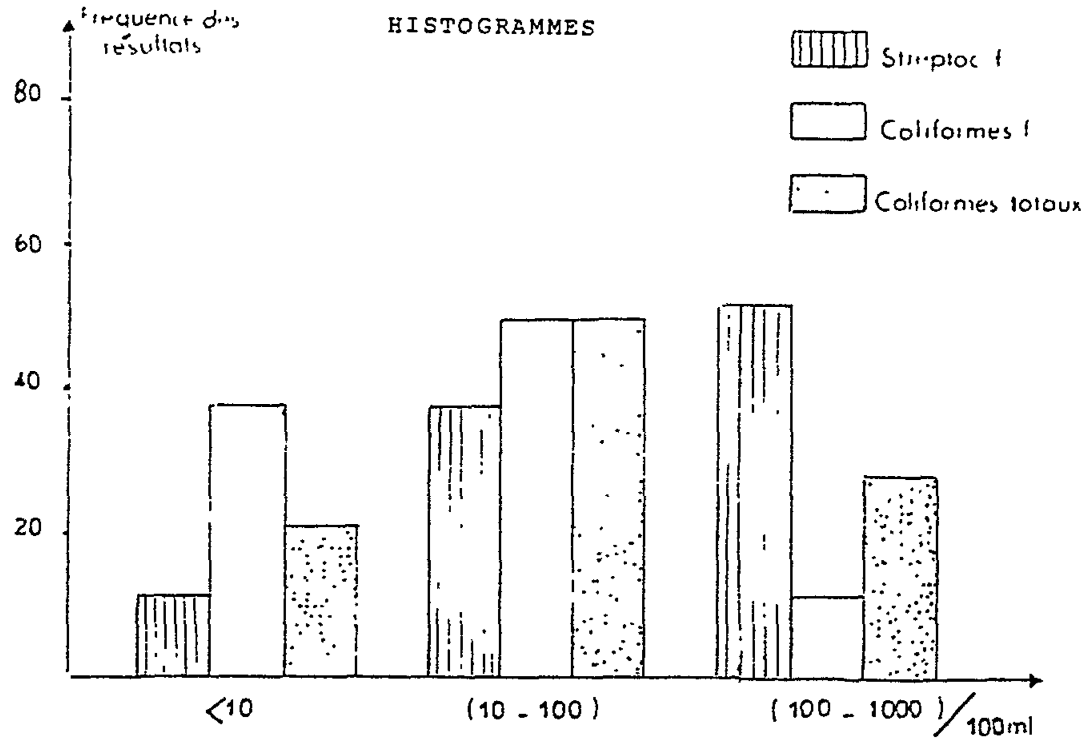
Il apparait en première analyse des résultats que les teneurs en germes sont plus élevées dans la zone de Villefranche-sur-Mer.

La zone de Beaulieu-sur-Mer peut être considérée comme propre pour un cycle annuel, ainsi que la zone de Nice dont les teneurs en germes n'excèdent pas pour la période d'été 100 germes par ml.

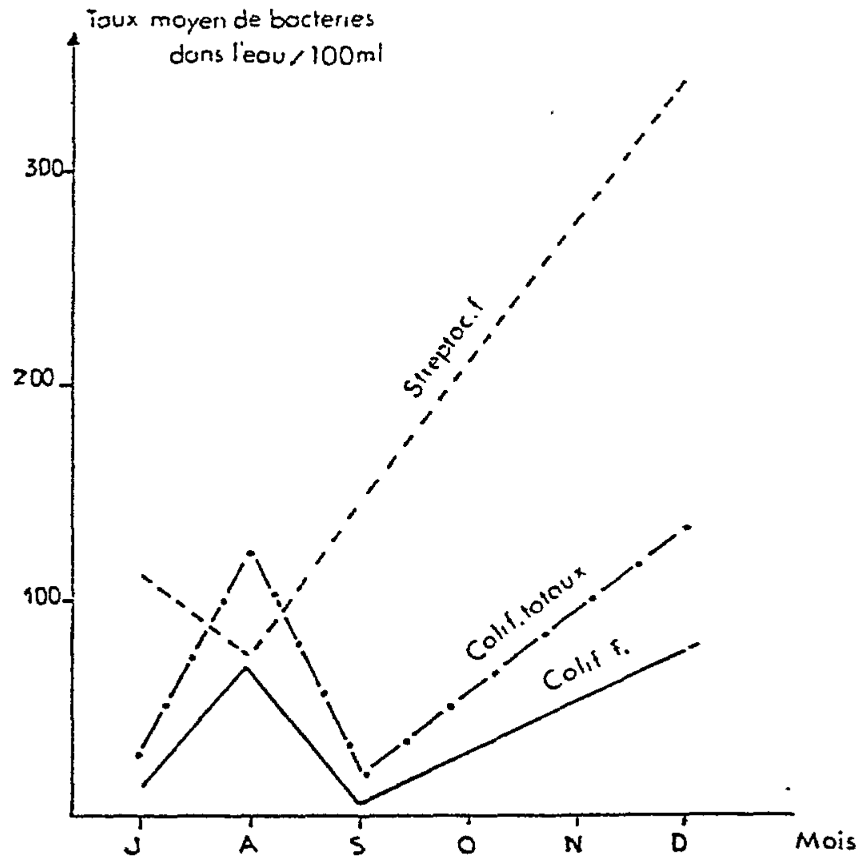

NICE
LE PAILLON
LE MAGNAN
BAIE DES ANGES
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
24
25
26
27
28
29
30
Schéma n°1
NICE - BAIE DES ANGES
(Mer Méditerranée)
France
Stations de prélèvements


NICE - BAIE DES ANGES
(Mer Méditerranée)
France
Courantologie de la Baie des Anges
(Vent d'Est)
Schéma n° 2
Port de Nice
LE PAILLON
NICE
LE MAGNAN
CARRAS
BAIE DES ANGES

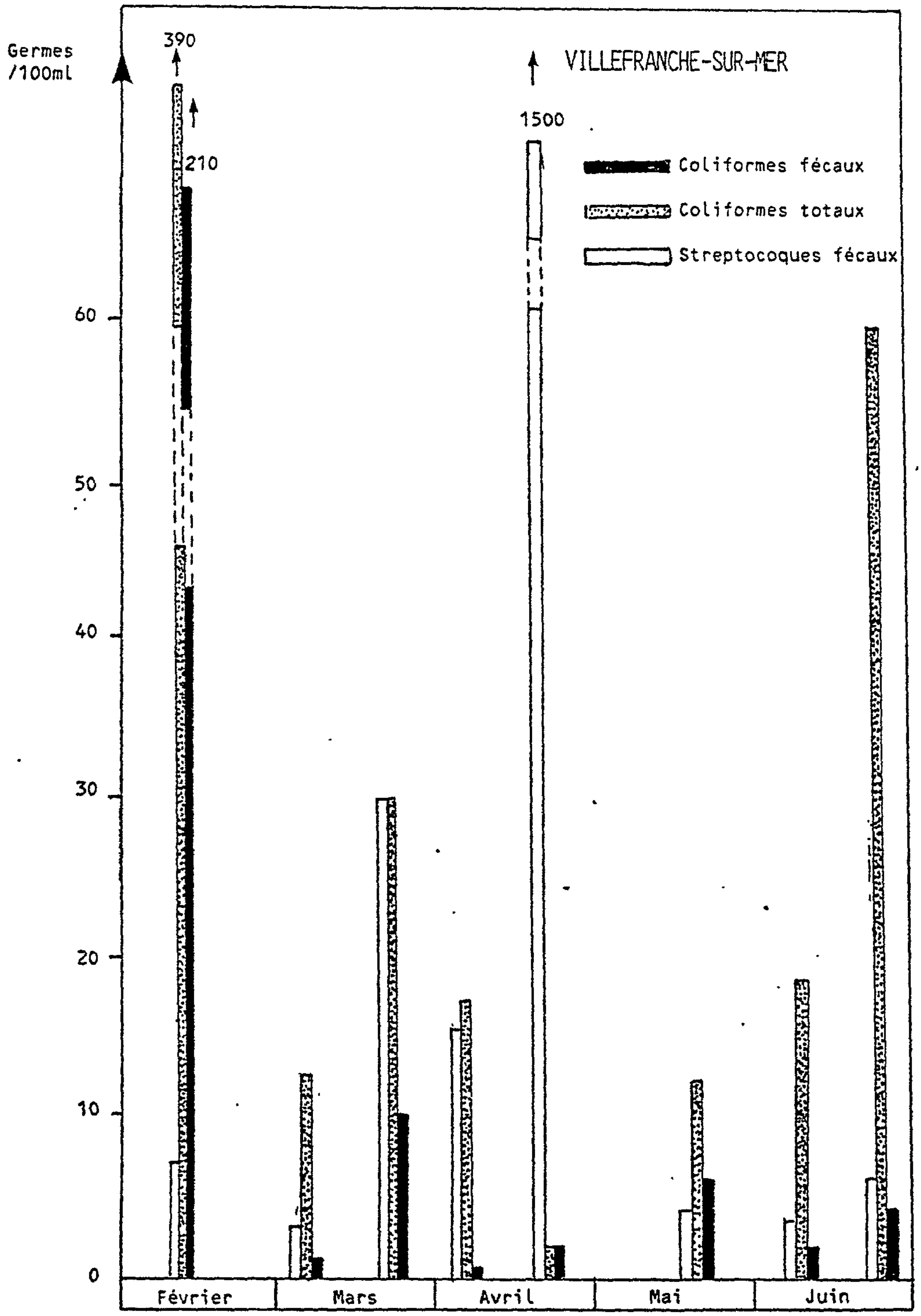

NICE - BAIE DES ANGES
(Mer Méditerranée)
France
Courantologie de la baie des Anges
(Vent d'Ouest - Mistral)
Schéma n°3
Port de Nice
LE PAILLON
NICE
LE MAGNAN
CARRAS
BAIE DES ANGES



Graphique n° 1 : Histogrammes des résultats pour la zone de la baie des Anges.

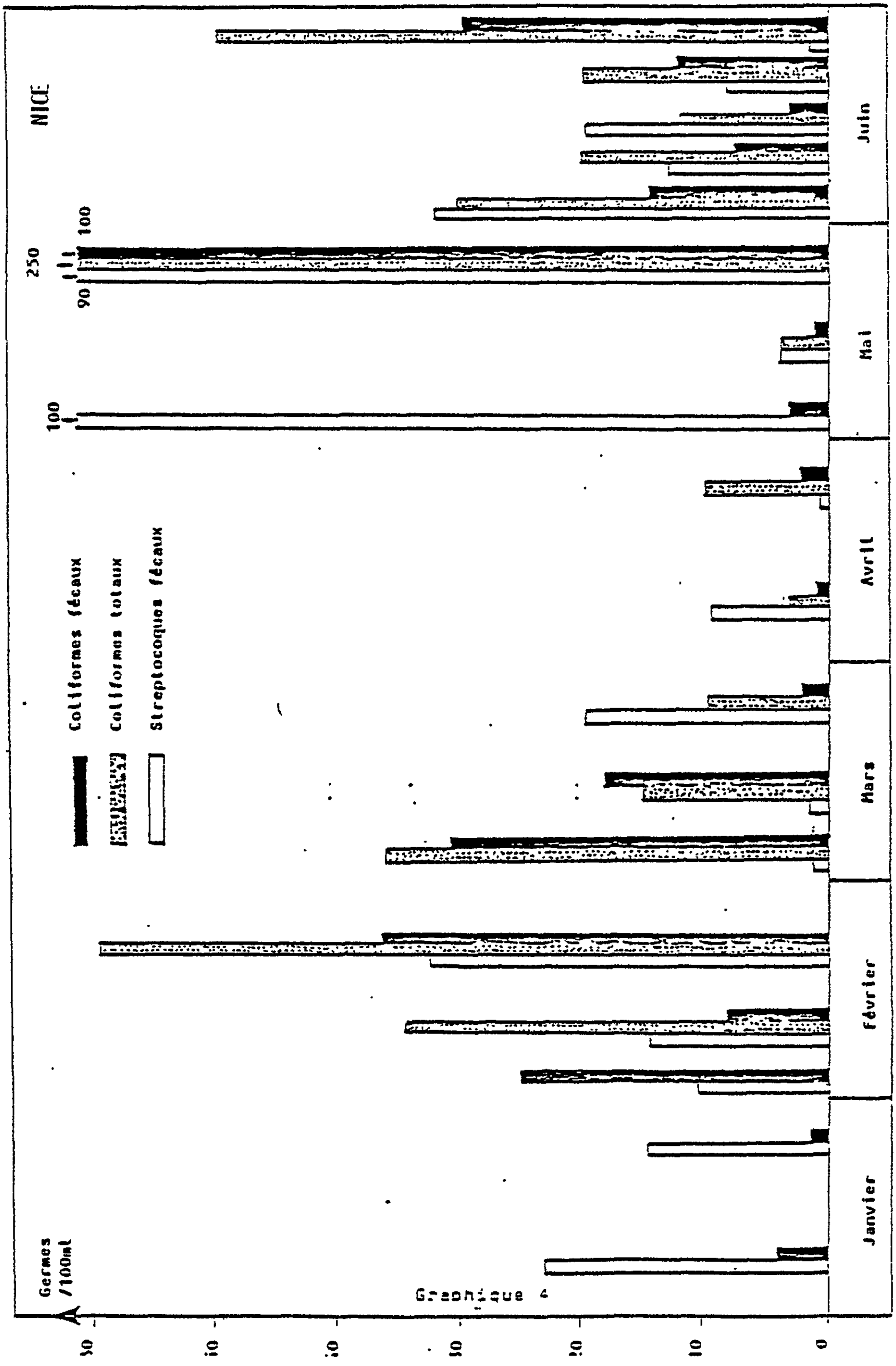


Graphique n° 2 : Taux moyens de bactéries en fonction du temps pour la baie des Anges.

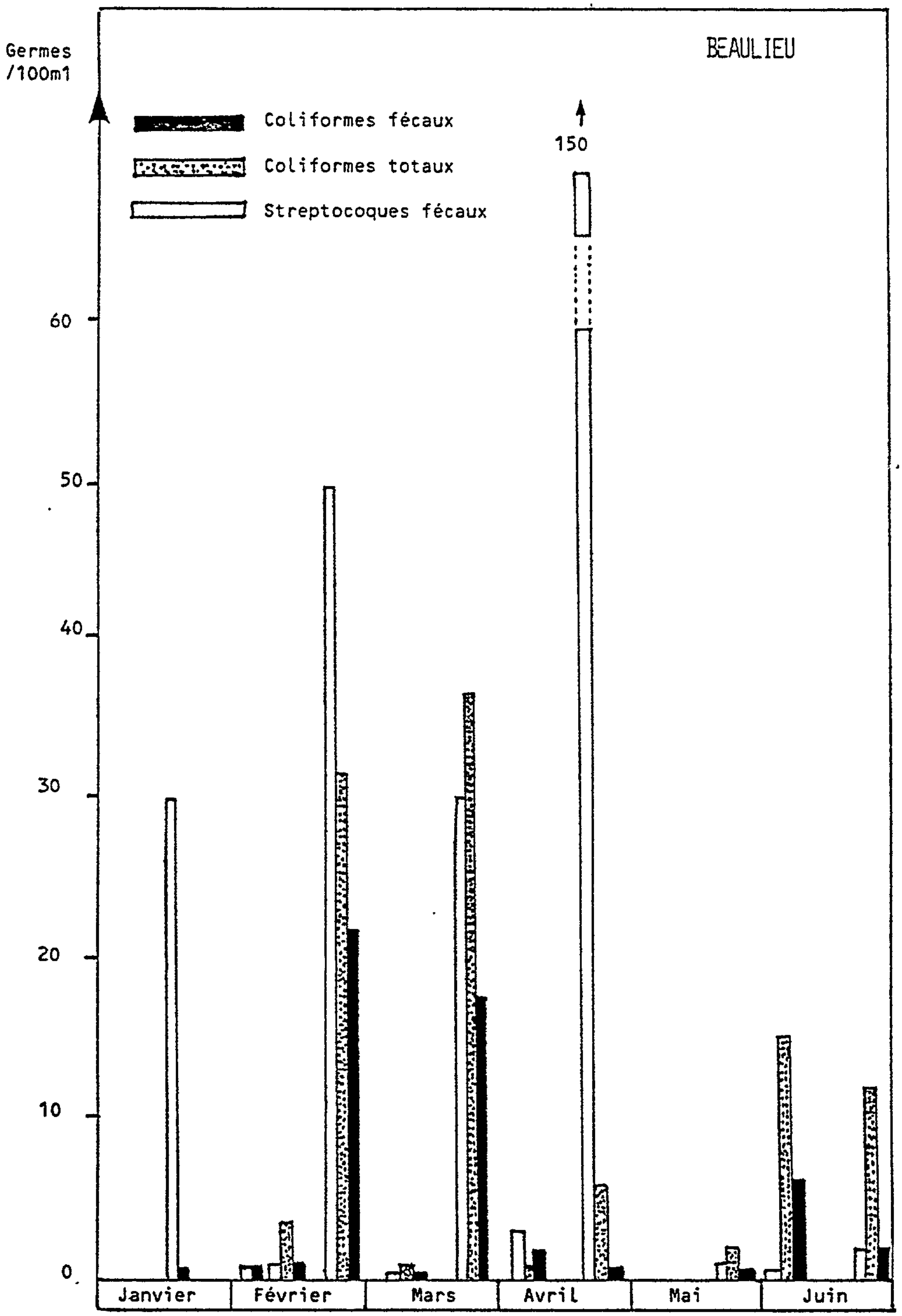


Graphique 3
REPARTITION DES COLIFORMES ET STREPTOCOQUES
DANS L'EAU DE MER EN FONCTION DU TEMPS

REPARTITION DES COLIFORMES ET STREPTOCOQUES DANS L'EAU DE MER EN FONCTION DU TEMPS

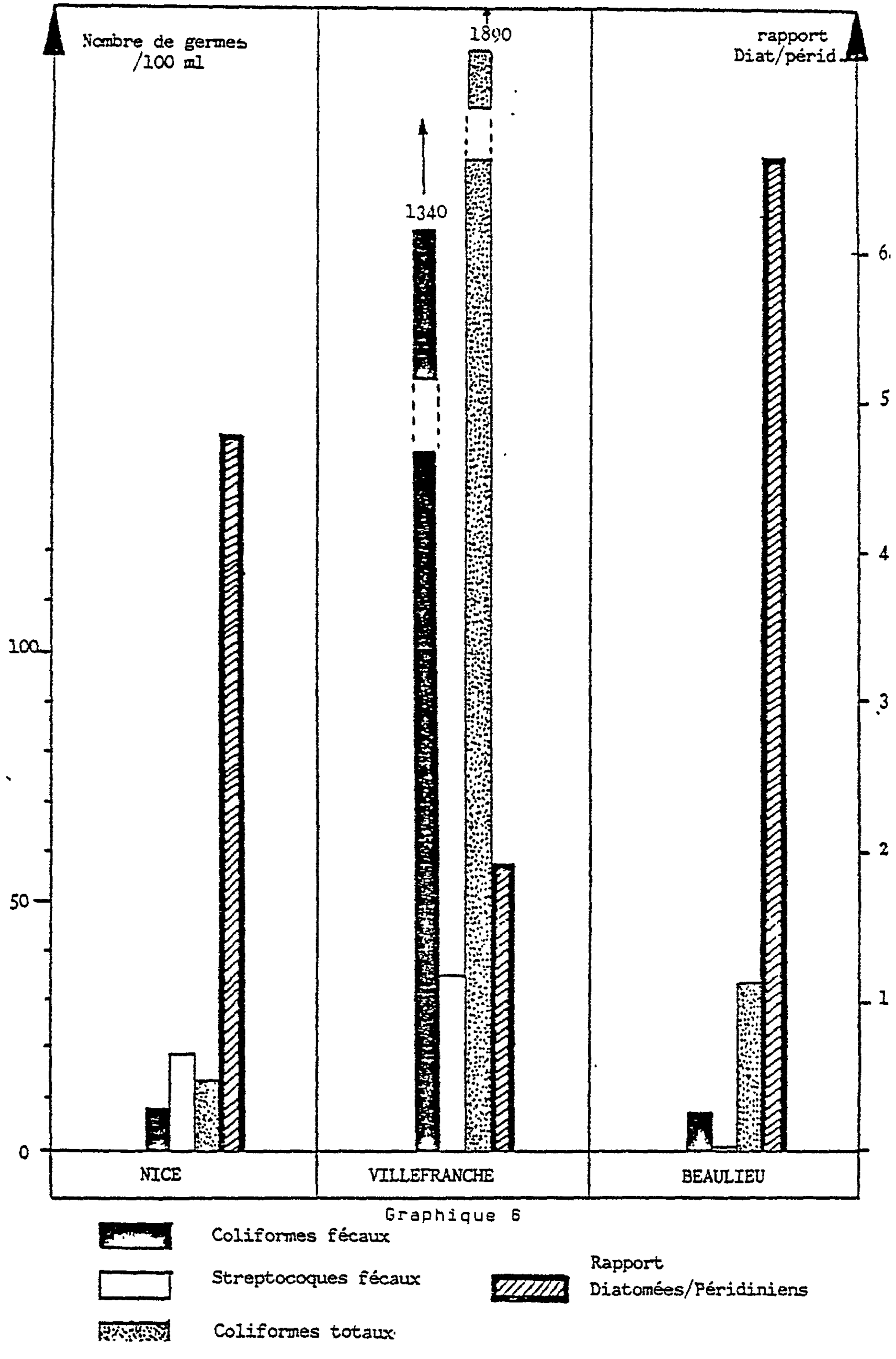


Graphique 4

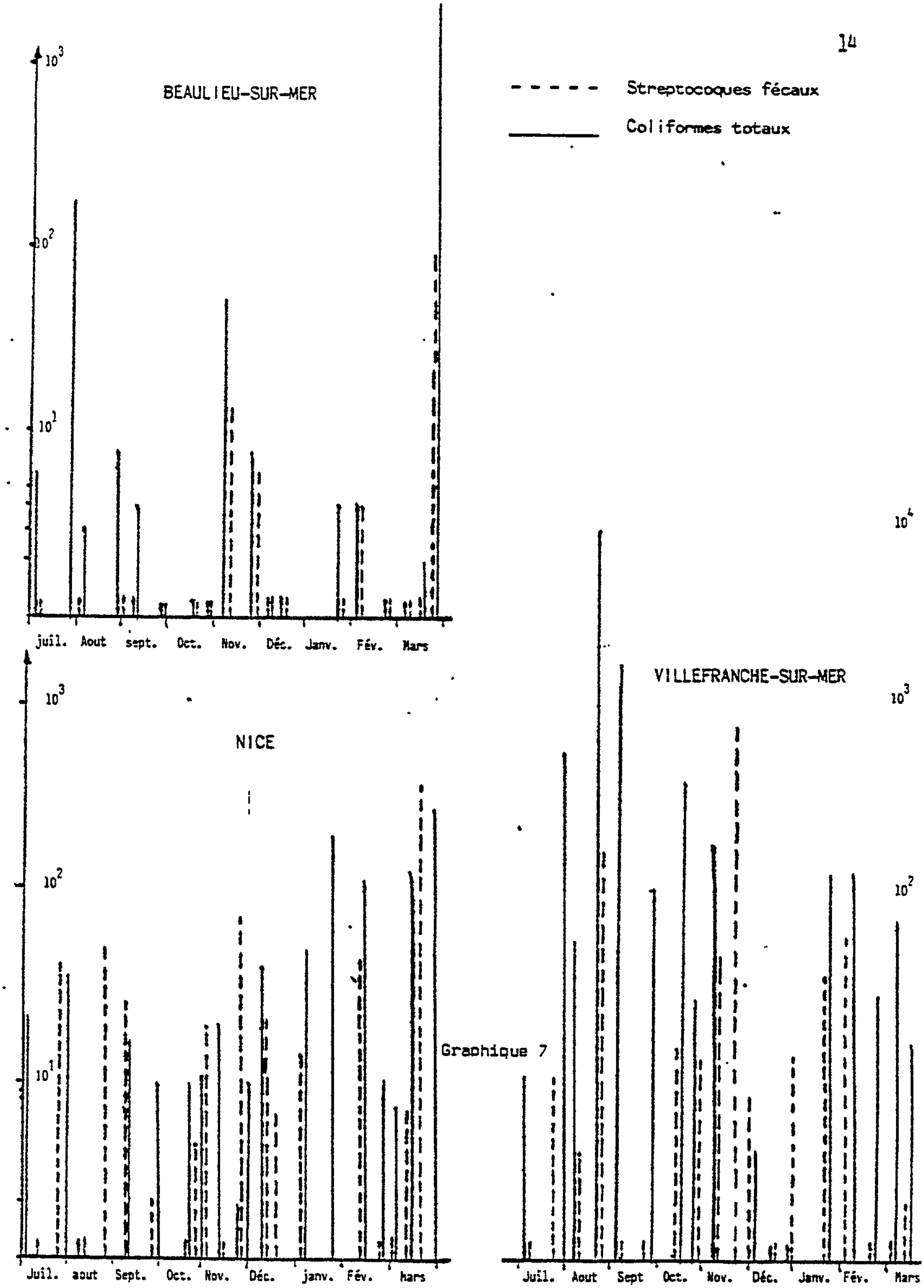


Graphique 5
REPARTITION DES COLIFORMES ET STREPTOCOQUES
DANS L'EAU DE MER EN FONCTION DU TEMPS

RAPPORT DIATOMEES/PERIDINIENS EN FONCTION DE LA CONCENTRATION DE CERTAINS GERMES FECAUX



Graphique 6


14
Streptocoques fécaux
Coliformes totaux
BEAULIEU-SUR-MER
10^3
10^2
10^1
juil. Aout sept. Oct. Nov. Déc. Janv. Fév. Mars
NICE
10^3
10^2
10^1
Juil. aout Sept. Oct. Nov. Déc. janv. Fév. mars
VILLEFRANCHE-SUR-MER
10^4
10^3
10^2
Juil. Aout Sept Oct. Nov. Déc. Janv. Fév. Mars

Graphique 7

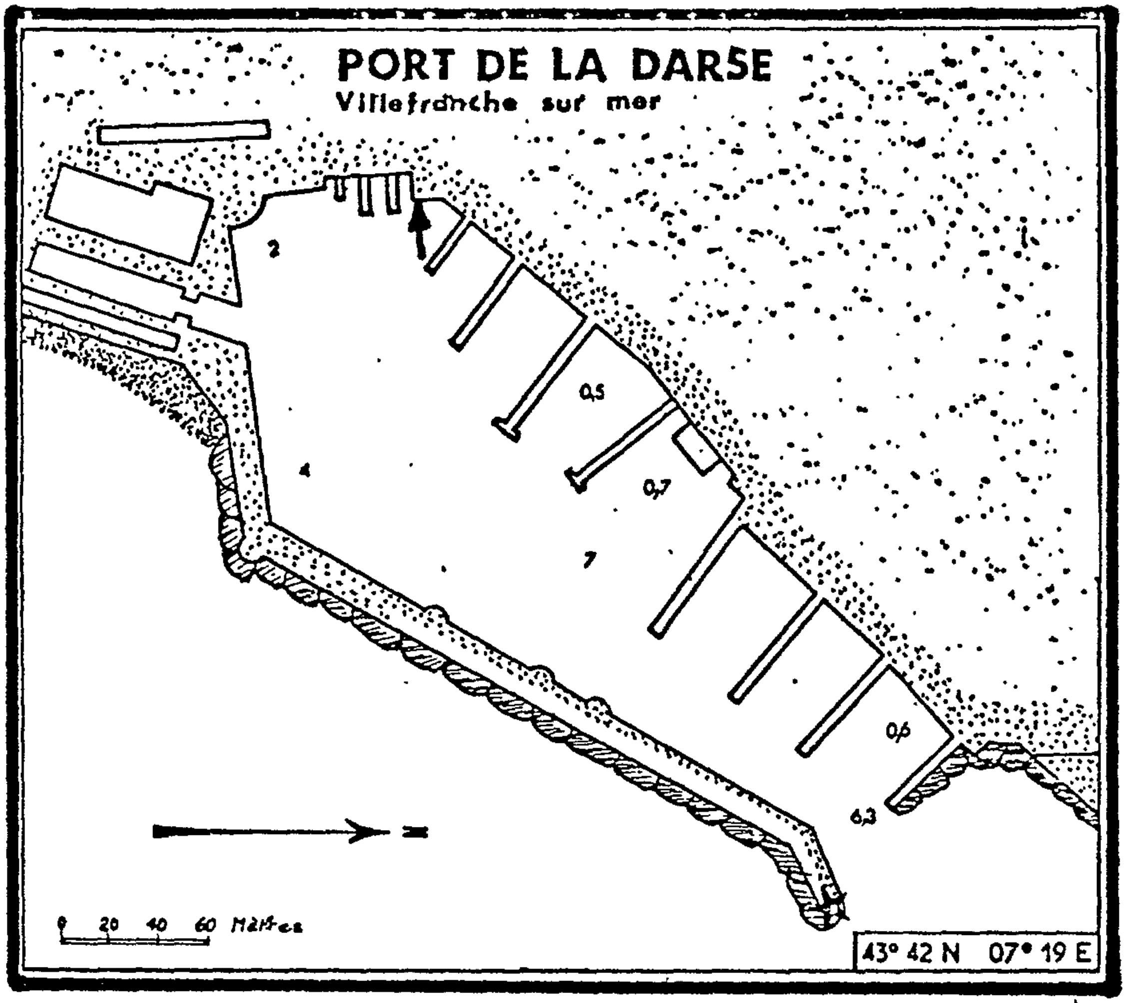

PORT DE LA DARSE
Villefranche sur mer
2
4
0,5
0,7
7
0,6
6,3
0 20 40 60 Mètres
43° 42 N 07° 19 E

Fig. 1

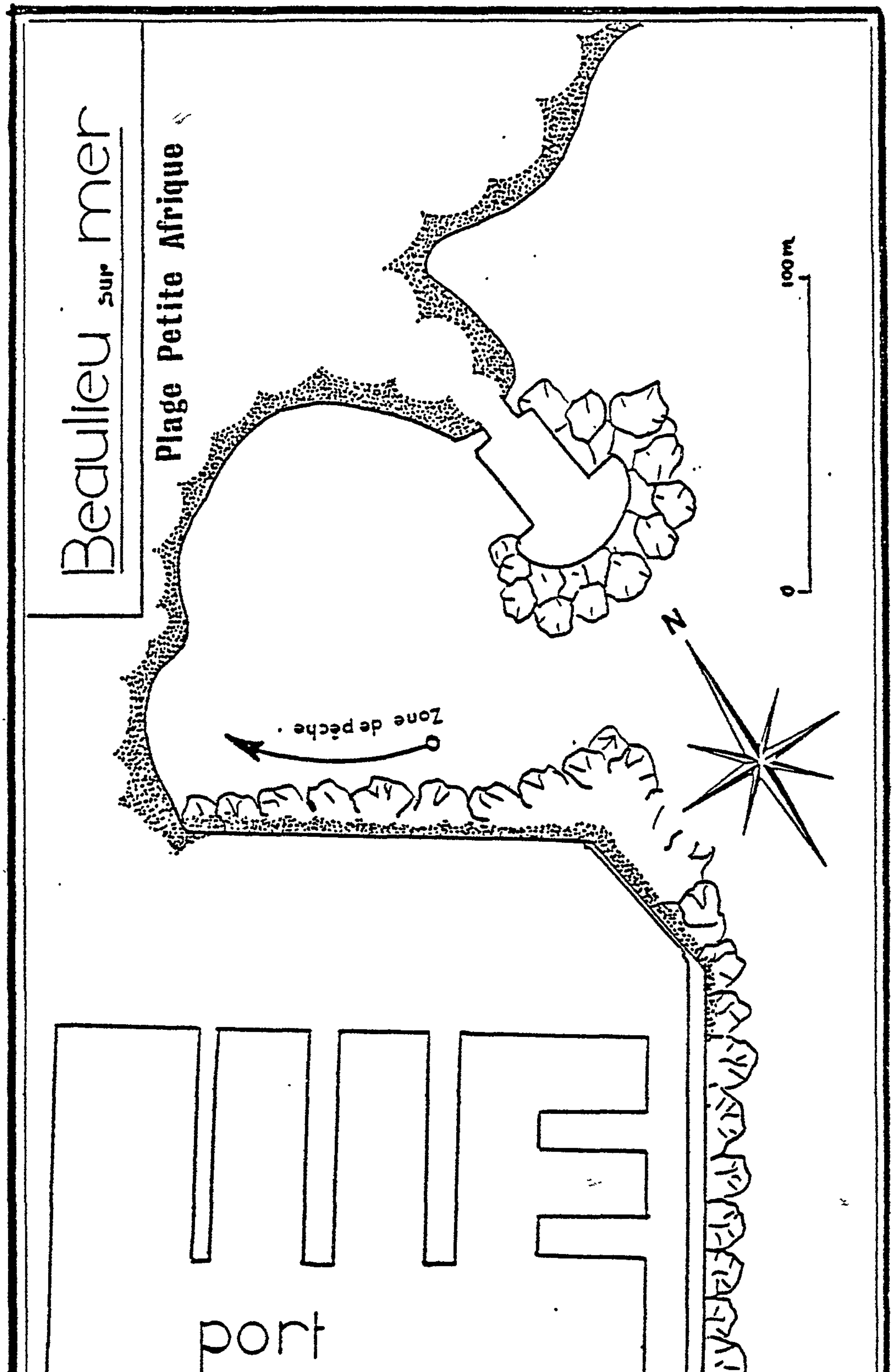
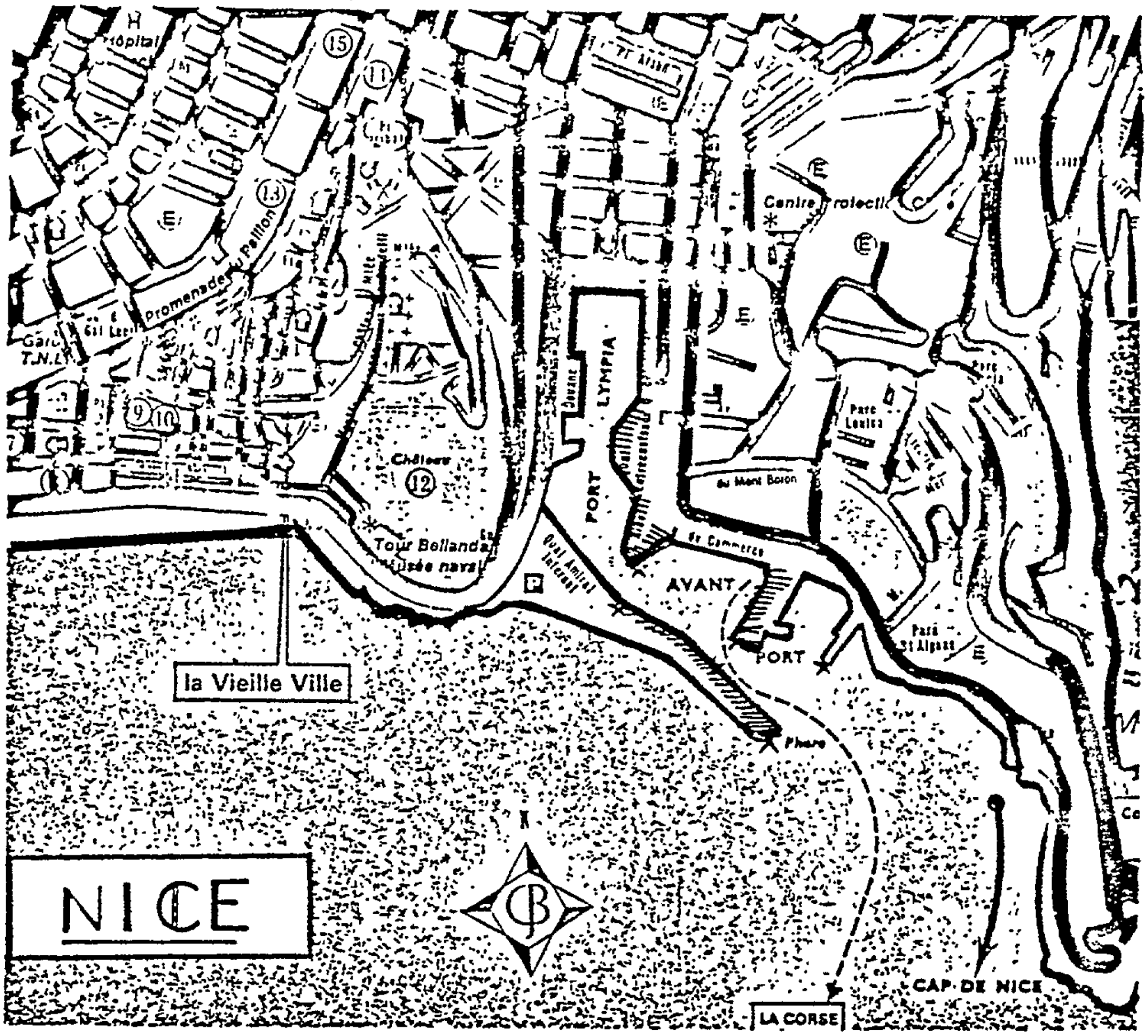

Beaulieu sur mer
Plage Petite Afrique
Zone de pêche
0
100 m
N
port

Fig. 2



ZONE DE PECHE

Lieu de prélèvement :

Fig. 3

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THESSALONIKI
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INTRODUCTION

The study on the identification and evaluation of the degree of pollution in the Gulf of Thessaloniki and in Thermaikos Gulf started in 1968. Until 1975, 526 sea-water samples as well as 172 samples of sea sediment, together with an equal number of coastal sand samples, were examined.

All the samples were examined for the following parameters:

1. Number of coliforms and E. coli (MPN).

2. Isolation and counting of enterococci and sulphite reducing clostridia.

3. Searching for salmonellae, shigella, V. parahaemoliticus.

4. Physical and chemical parameters, that is, air temperature, wind velocity, relative humidity, sea temperature, turbidity, pH, determination of chlorides, salinity, BOD_5, DO, and tracing and determination of Pb.

During that same period, 529 samples (1 sample x 5 = 2645) of shellfish were examined microbiologically and chemically. At the same time, the two rivers Axios and Aliakmon, flowing into the gulf of Thessaloniki, were examined to determine their pollution.

Since January 1975 the study has continued an was integrated later in the MED POL VII pilot project.

AREA(S) STUDIED

The map shows the zones of sea-water sampling (1, 2, 3, 4, 5, 6) and sediment and coastal sand sampling (4, 5, 6). The sign (■) shows the locations of shellfish culture and fishing. The results of physical, chemical and microbiological parameters are given in Tables I, II, III, IV, V, VI, VII).

During the period January to September 1979, the Laboratory continued the control of the recreational waters in the Thermaikos Gulf (Thermaikos Kolpos). One hundred and twenty six samples of sea-water, 68 of sediment and 66 of beach material were examined from the three sections I, II and III which had also been monitored previously.

In section I (see map), which covers a distance of about 8 km, samples from 27 points were taken. (For results see attached Table IX).

* Deceased

Emphasis was put on points 8 and 9, as there is a public beach with a camping site and it is controlled by the National Tourist Organization. Thus, 80, 36 and 35 samples from the sea, sediment and beach material respectively were examined.

Section II covers a distance of 3.8 km. In this region samples from points 30, 31 A, 31 B and 32, which correspond to a public beach, were taken in order to verify the unsuitability of the sea-water for bathing, as this region was defined as unsuitable for bathing last summer. Twenty-eight samples of sea-water, 25 samples from the sediment and 24 samples of beach material were examined (Table X). As this region is no longer used for bathing, other points have been selected (between sections I and III).

Section III covers about 2 km. 18 samples of sea-water, 7 samples from the sediment and 7 samples of beach material were examined (Table XI).

MATERIAL AND METHODS

Seven hundred and fourteen sea-water samples taken from the Gulf of Thessaloniki, as indicated on the map (1-6), were examined during the period of 1975-1978.

The samples were tested for the MPN of coliforms, E. coli, enterococci, sulphite reducing clostridia, as well as for the isolation of salmonellae and shigella.

One hundred and ninety-nine (199) sediment samples, 199 coastal sand samples and 108 shellfish samples (one sample consisted of 5 shellfish) were also examined. All these samples were taken from the Gulf of Thessaloniki at the same time as the sea-water sampling. They were tested for the above micro-organisms to which Vibrio parahaemolyticus was added. For shellfish itself, coagulase positive staphylococci were also included in the pathogens investigated.

For the MPN of coliforms the multiple tube method was used with the "Minerals modified Glutamate" as a medium, as well as the filtration method (Millipore) with M-endo agar as a medium. For the MPN of E. coli the Multiple tube method was used with the same medium used for the coliforms, and the filtration method with M-FC agar as a medium. It was found that the results obtained by the two methods used, i.e. the multiple tube method and the filtration method, did not differ significantly.

For the MPN of enterococcus the filtration method was used with M-enterococci agar as a medium. For the MPN of sulphite reducing clostridia the medium D.R.C.M. was used. For the isolation of salmonellae the selenite broth was used and for the isolation of shigella the G.N. broth was used. For the number of coagulase positive staphylococcus the medium "staphylococcus agar" was used and for the isolation of Vibrio parahaemolyticus the "Alcaline peptone Water".

For the period January - September 1979, 126 sea-water samples, 68 samples of sediment and 66 samples of beach material were collected and analysed

The measured parameters during this period were as follows:

Meteorological parameters:

- Air temperature, wind direction and wind velocity.

Chemical parameters:

- pH, salinity, BOD 5 and DO;

Microbiological parameters:

- Coliforms, E. coli, faecal streptococci, salmonellae, shigella, vibrio, fungi.

The used nutrients and the applied methodology were the same as those utilized during the previous period.

RESULTS AND THEIR INTERPRETATION

The results of the examination of the 714 sea-water samples for coliforms and E. coli during the period 1975 - Sep. 1978 are given in Table II, Figure 1.

From the table, it is quite clear that coliforms are more numerous in all but area 3 where coliforms and E. coli are present in roughly equal numbers.

Table III and Figure 2 show the number of enterococci and sulphite reducing clostridia found.

Enterococci and sulphite reducing clostridia are to be found in all areas although enterococci are present in greater numbers in areas 2, 4 while in area 3 enterococci and sulphite reducing clostridia are present in roughly equal numbers.

Tables IV and V and Figures 3 and 4 show the results obtained by examination of 199 samples of sea sediment and coastal sand. All samples were taken from areas 4, 5, and 6.

From the tables and figures it is evident that the number of coliforms is much greater in area 5, found in almost 100 per cent of the samples.

Certainly, E. coli are to be found in all three areas, especially in areas 4 and 5. In area 6 they are present in smaller numbers, being found only in 5 per cent of the samples.

As far as enterococci and sulphite reducing clostridia are concerned, the results are given in Tables VI, VII, and in Figures 5 and 6.

Table VIII shows the results of microbiological and chemical analysis of the 108 samples of shellfish from the Gulf of Thessaloniki (five shellfish constitute 1 sample).

In detail, the results are as follows: Out of the 108 samples, coliforms were found in 86 and great numbers of E. coli were found in 74.

Pathogenic staphylococci were isolated in 35 samples. Sulphite reducing clostridia in 57, enterococci were found in 62 samples.

In 5 samples during the runs, serotype E. coli (O_{55}/B_5, O_{26}/B_6, O_{125}/B_5) were found, in one sample S. typhi, in 10 samples Shigella sonnei, and in 8 samples Proteus.

At the same time, the above mentioned samples were tested chemically for the determination of Pb and Hg: The results were for Pb 1.25-4.25 mg/l and for Hg 0.02 mg/l.

To find out the extent to which the gulf is polluted, 20 samples of sea-water and sediment were collected in 1978 in four runs: A, B, C, D (see map of Thermaikos Gulf).

The distance of the runs from the coast were as follows:

A-1250 m, B-2500 m, C-5500m, and D-11000 m.

From the water samples obtained during the runs, the following were isolated:

Four Vibrio parahaemolyticus, 10 serotypes of salmonellae: S. Senftenberg (4); S. Agona (3); S. Blockley (1); S. Fresno (1) and S. Wien (1).

Finally by the method of swabs the following micro-organisms were isolated during the runs:

Seven serotypes of salmonellae: S. Agona (4), S. Senftenberg (2), S. paratyphi B (1).

In Tables IX, X, and XI the results for total coliforms in the sea-water samples from the sections I, II and III (period January - September 1979) are subdivided on the basis of the present Greek regulation for quality grading which is as follows:

Coliforms per 100 ml	Grade
0 - 50	Safe for bathing
51 - 500	Acceptable for bathing, with some reservations
501 - 1000	Doubtful, not recommended
$>$ 1000	Unsafe for bathing.

The Greek regulations do not include faecal coliform standards.

Similarly in the above tables appear the results of E. coli subdivided according to the following scale: 0/100 ml; 1-100/100 ml 100/100 ml, which is adopted by many countries. Thus in Table IX for section I it appears that 97.5% of the samples have less than 500 total coliforms per 100 ml and 100% of the samples have less than 100 E. coli per 100 ml.

These values for sediment are respectively 88,8% and 94.4% and for beach material 80% and 94,2%. They show a similar picture but with slightly higher pollution.

In section II all the samples correspond to a public beach. The section is close to the city of Thessaloniki. 77.8% of the sea-water samples have less than 500 total coliforms per 100 ml and 32.2% have 1000 total coliforms. As far as E. coli is concerned the respective figures are: 82.1% of samples having less that 100 E. coli and 17.9% having more than 100 E. coli per 100 ml.

In section III the number of samples is rather small; however the figure for sea-water in 100% of samples have less than 500 total coliforms per 100 ml and the quality can be considered satisfactory.

CONCLUSIONS

From the results obtained, it is evident that the Gulf of Thessaloniki is polluted continuously at a great distance from the coast, from the wastes of the city of Thessaloniki. However, the coastal waters of sampling areas 5 and 6 seem to be of a good quality. Still, regular monitoring is indicated as results vary widely.

The results also show that in order to draw the right conclusions two samplings should be carried out from the same point and at the same time; one of sea-water and the other of sediment. Sea-water often appears less polluted than sediment. The pollution seems to be higher when north or north-westerly winds are blowing.

The pollution of the Gulf will be halted only when an appropriate solution for the disposal of sewage and wastes coming from the city of Thessaloniki is applied. It appears that a treatment plant for the sewage will be constructed in about five years.

PUBLICATIONS

Neuere Untersuchungen auf die Schalentiere-bedingten (Austern) Infectionen - 1968.

Research on the pollution of the sea-water of the Gulf of Thessaloniki - 1971.

Analysis of the sea-water polluting fatty substances by Gas-Chromatography - 1971.

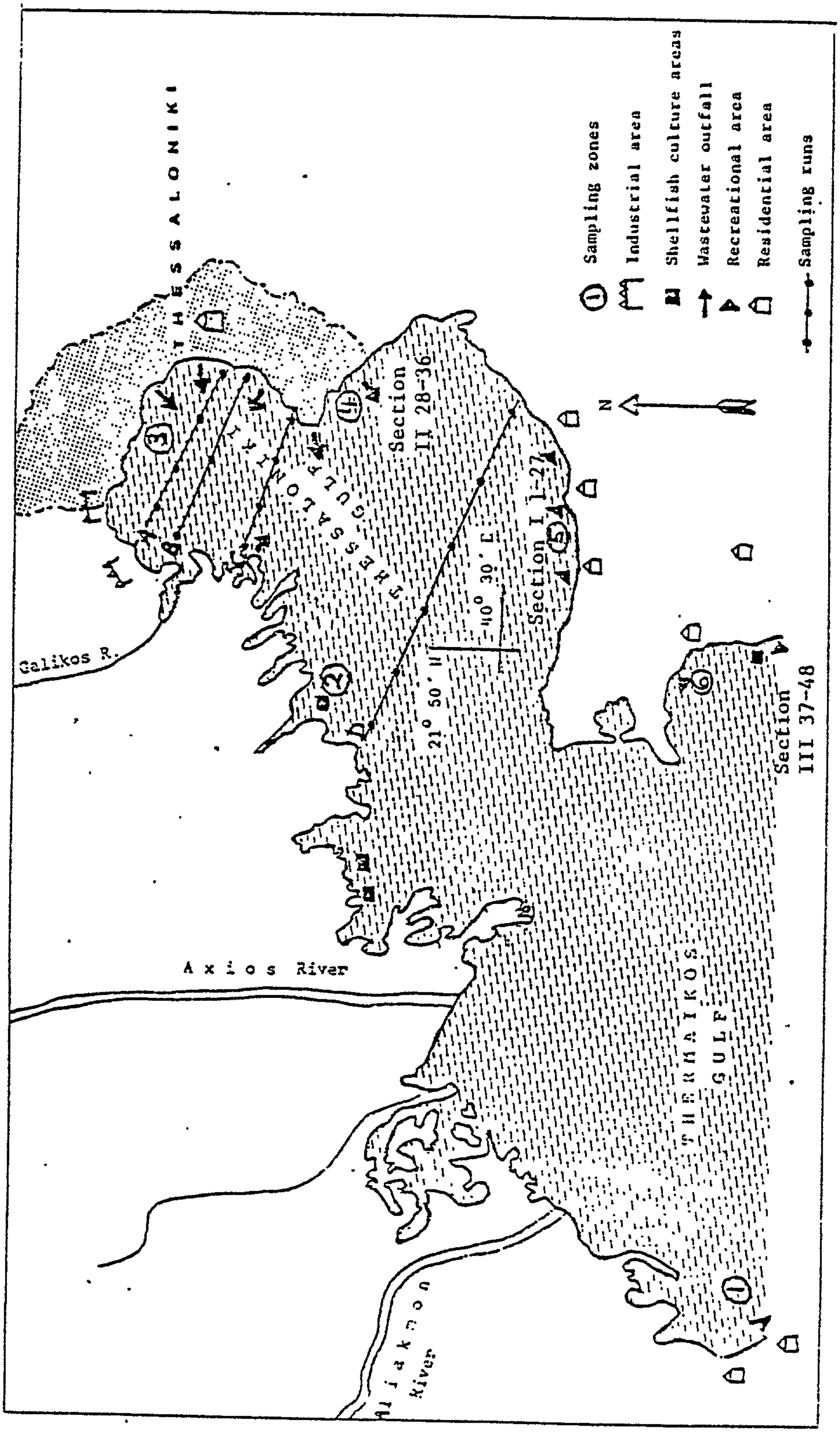
Purifications of sewage from micro-organisms through the action of Entomostraca of the genus Daphnia of the order Cladocera - 1971.

Mediterranean Pilot study on Environmental degradation and pollution from Coastal development. Pollution in the Thermaic Gulf - 1973.

Les résultats des examens de l'eau de mer du golfe de Thessalonique du 26.5.77 jusqu'à Mars 1978. (1978).

Observations sur la pollution (Chimique et microbienne) du Golfe de Thessalonique pendant les dernières dix années (1968-1978) - 1978.

La pollution des rivières de la Grèce du Nord. - 1978.



Map of the area

Table I: Results of chemical analysis of 714 samples of sea-water from the Gulf of Thessaloniki from 1 January 1975 to 30 September 1978

	Meteorological conditions					Chemical analysis					
Sections	Air temp. °C	Wind velocity m/min.	Relative humidity %	Sea temp. °C	Turbidity (Secchi)	pH	Cl °/oo	Salinity °/oo	BOD_5 mg/l	DO mg/l	Pb mg/l
1	13-25	80-180	65-80	16-22	1-2.5	8.01-8.40	19.51-19.85	34.65-36.71	0.7-2.8	7.9-8.6	0.00-0.05
2	12-23	55-90	73-85	18-20	1-3	8.6-8.9	19.16-20.29	35.21-35.88	0.7-7.8	9.0-12.6	0.01-0.04
3	17-24	90-110	75-88	19-23	0.30-0.80	8.03-8.9	19.21-19.71	35.11-36.60	1.9-19.5	6.8-14.9	0.03-0.05
4	11.5-25	40-230	50-88	18-24	0.50-1.25	8.02-8.42	19.18-20.21	34.74-36.60	0.8-11.5	6.5-13.9	0.02-0.11
5	11-24	85-190	75-77	17-20	0.80-1.25	8.11-8.55	19.51-20.29	35.28-36.65	1.9-10.1	7.1-8.6	0.01-0.04
6	17-23	90-103	73-77	20-24	0.50-1.25	7.64-8.95	19.74-19.85	35.53-35.86	1.6-2.7	8.1-8.7	0.008-0.04

Table II

Sample areas for sea-water and the results of microbiological examination for coliforms and E. coli from 1 January 1975 to 30 September 1978

SEA WATER

		Coliforms per 100 ml		E. coli per 100 ml	
Sections	Samples	1-2000	0	1-2000	0
1	12	7 (58.3%)	5 (41.7%)	3 (25.0%)	9 (75.0%)
2	130	51 (39.2%)	79 (60.8%)	30 (23.1%)	100 (76.9%)
3	109	69 (62.3%)	40 (37.7%)	66 (60.5%)	43 (39.5%)
4	224	144 (61.2%)	80 (38.8%)	95 (42.4%)	129 (57.6%)
5	149	96 (64.4%)	53 (35.6%)	59 (39.3%)	90 (60.5%)
6	90	44 (48.8%)	46 (51.2%)	31 (34.4%)	59 (65.6%)
Total	714	411 (57.5%)	303 (42.5%)	284 (39.7%)	430 (60.3%)

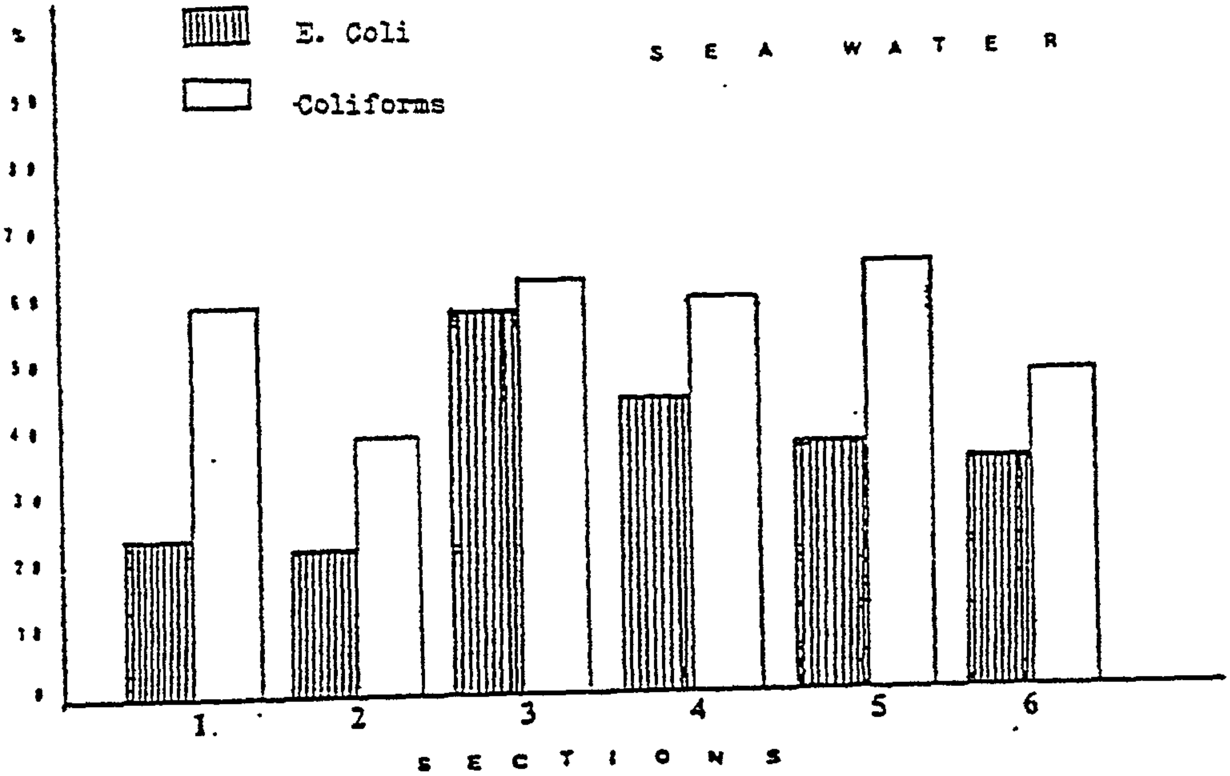


Fig. 1.

Table III

Sample areas for sea-water and the results of microbiological examinations for enterococci and sulfite-reducing Clostridia from 1 January 1975 to 30 September 1978

SEA WATER

		Enterococci per 100 ml		Sulfite-reducing *Clostridia* per 100 ml	
Sections	Samples	1-1000	0	1-1000	0
1	21	6 (28.5%)	15 (71.5%)	5 (23.8%)	16 (76.2%)
2	152	123 (80.9%)	29 (19.1%)	61 (40.1%)	91 (59.9%)
3	68	48 (70.5%)	20 (29.5%)	48 (70.5%)	20 (29.5%)
4	241	141 (58.5%)	100 (41.5%)	48 (19.9%)	193 (80.1%)
5	179	54 (30.1%)	125 (69.9%)	63 (35.1%)	116 (64.9%)
6	53	36 (67.9%)	17 (32.1%)	8 (15.1%)	445 (84.9%)
Total	714	408 (57.1%)	306 (42.9%)	233 (32.6%)	481 (67.4%)

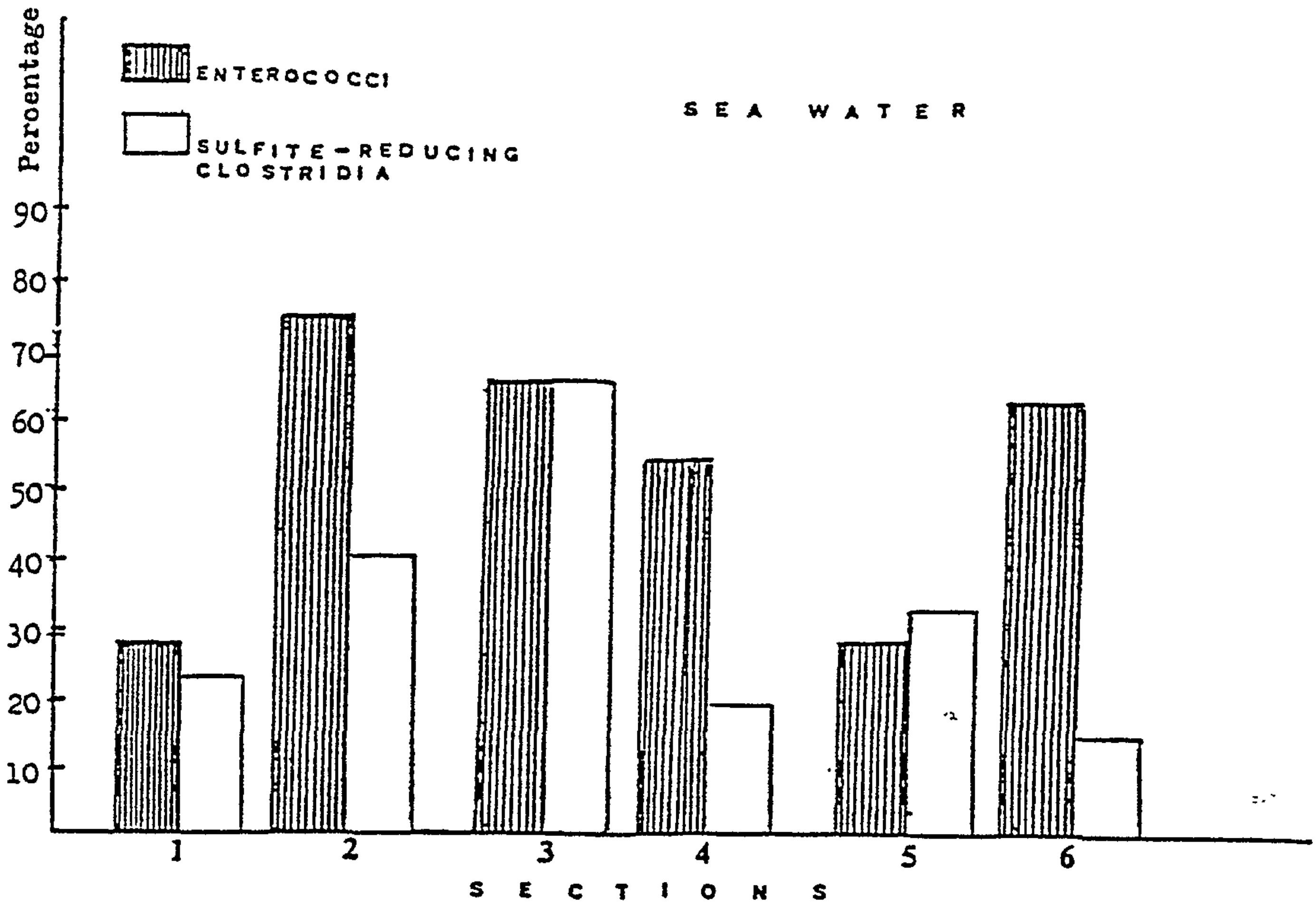


Fig. 2.

Table IV

Sample areas for sediment and the results of microbiological examination for coliforms and E. coli from 1 January 1975 to 30 September 1978

SEDIMENT

		Coliforms				E. coli			
Sections	Samples	Pos.	%	Neg.	%	Pos.	%	Neg.	%
4	132	70	53.1	62	46,9	24	18.2	108	81.8
5	38	38	100.0	0	0.0	21	55.2	17	44.8
6	29	8	27.5	21	72.5	2	6.8	27	93.2
Total	199	116		83		47		152	

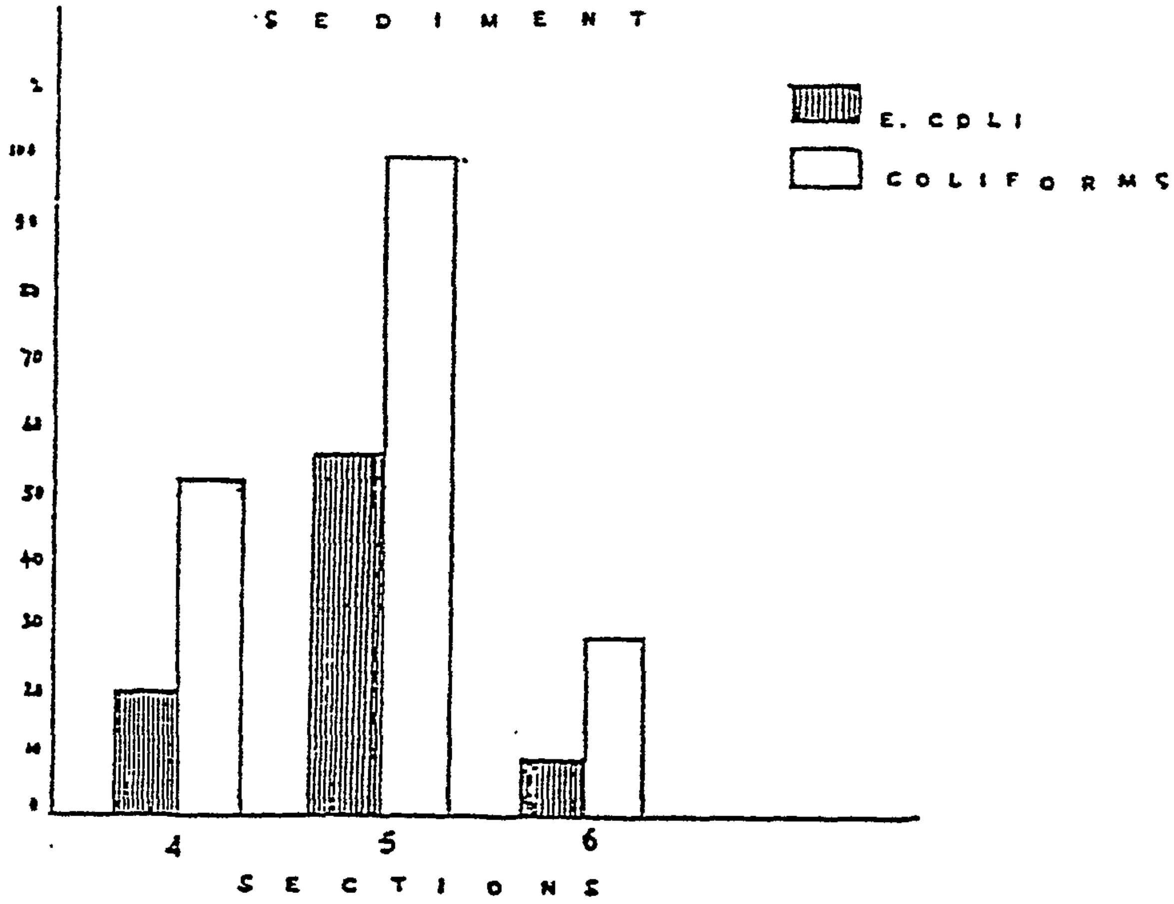


Fig. 3.

Table V

Sample areas for coastal sand and the results of microbiological examination for coliforms and E. coli from 1 January 1975 to 30 September 1978

COASTAL SAND

		Coliforms				*E. coli*			
Sections	Samples	Pos.	%	Neg.	%	Pos.	%	Neg.	%
4	132	78	59.1	54	40.9	18	13.6	114	86.4
5	38	37	97.4	1	2.6	20	52.6	18	47.4
6	29	11	37.9	18	62.1	1	3.4	28	96.6
Total	199	126		73		39		160	

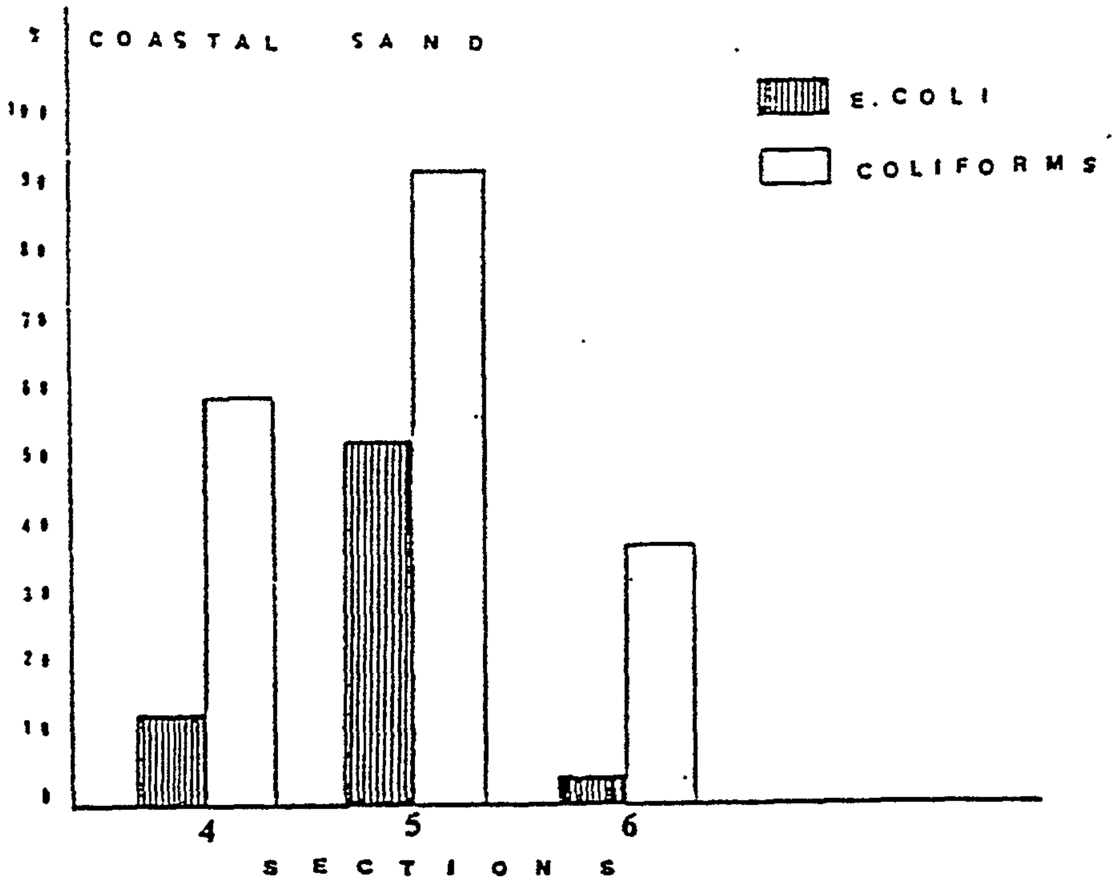


Fig. 4.

Table VI

Sample areas for sediment and the results of microbiological examination for enterococci and sulfite-reducing Clostridia from 1 January 1975 to 30 September 1978

SEDIMENT

		Enterococci				Clostridia			
Sections	Samples	Pos.	%	Neg.	%	Pos.	%	Neg.	%
4	113	78	69.1	35	30.9	69	61.1	44	38.9
5	59	24	40.6	35	59.4	25	42.4	34	57.6
6	27	25	92.5	2	7.5	15	55.5	12	44.5
Total	199	127		72		109		90	

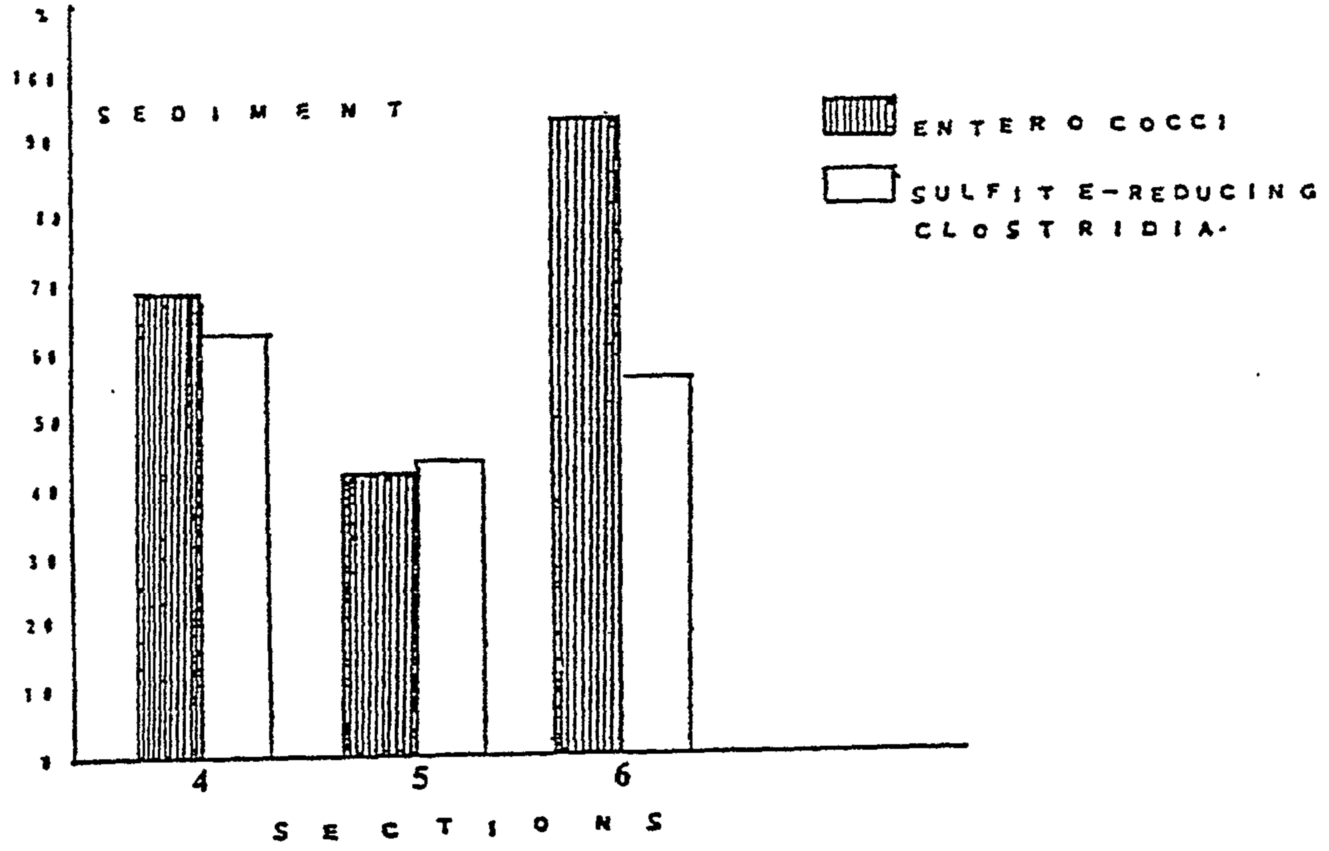


Fig. 5.

Table VII

Sample areas for coastal sand and the results of microbiological examination for enterococci and sulfite-reducing Clostridia from 1 January 1975 to 30 September 1978

COASTAL SAND

		Enterococci				Clostridia			
Sections	Samples	Pos.	%	Neg.	%	Pos.	%	Neg.	%
4	113	53	46.9	60	53.1	57	50.4	56	49.6
5	59	44	74.5	15	25.5	28	47.4	31	52.6
6	27	21	77.7	6	22.3	I4	51.8	13	48.2
Total	199	118		81		99		100	

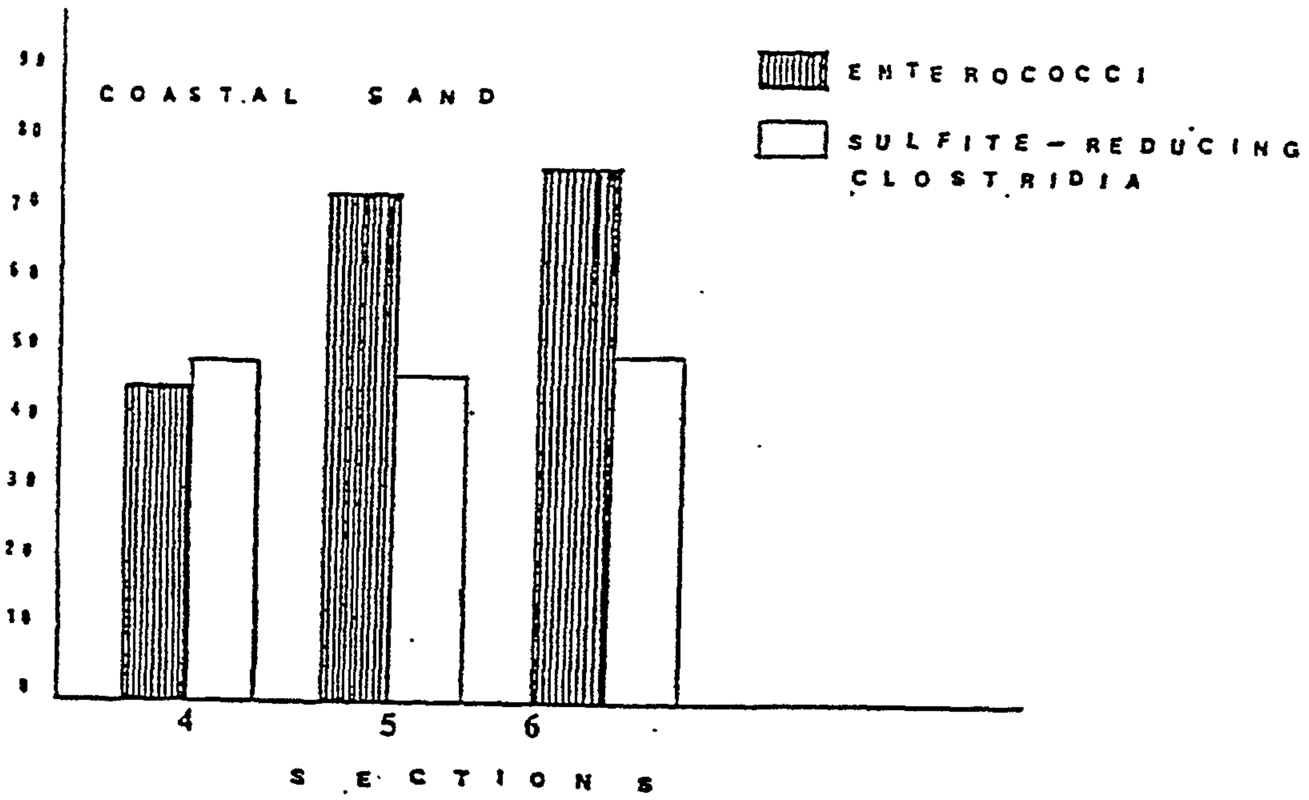


Fig. 6.

Table VIII

Results of microbiological and chemical examination of 540 (108x5) samples of shellfish from the Gulf of Thessaloniki from 1 January 1975 to 30 September 1978

ISOLATED MICROORGANISMS	SAMPLES
Coliforms	86
E. coli	74
Staphylococci coagulase positive	35
Sulfite-reducing *Clostridia*	57
Enterococci	62
Serotype of *E. coli* O_{55}/B_5	1
Serotype of *E. coli* O_{26}/B_6	1
Serotype of *E. coli* O_{125}/B_{15}	3
Salmonella typhi	1
Shigella sonnei	10
Proteus	8
Pb mg/l	1.25-4.25
Hg mg/l	0.02

TABLE IX Section I

	Number of Samples	Coliforms per 100 ml				E.Coli per 100 ml		
		0-50	51-500	501-1000	>1000	0	1-100	>100
Sea Water	80	60 75%	18 22,5%		2 2,5%	41 51,3%	39 48,7%	
Sediment	36	20 55,5%	12 33,3%	4 11,2%		25 69,4%	9 25%	2 5,6%
Beach Material	35	19 54,3%	9 25,7%	1 2,8%	6 17,2%	27 77,1%	6 17,1%	2 5,8%

TABLE X. Section II

	Number of Samples	Coliforms per 100 ml				E.Coli per 100 ml		
		0-50	51-500	501-1000	>1000	0	1-100	>100
Sea Water	28	7 25%	12 42,8%		9 32,2%	13 46,4%	10 35,7%	5 17,9%
Sediment	25	8 32 %	11 44%	1 4%	5 20%	16 64%	2 8%	7 28%
Beach Material	24	12 50%	6 25%	1 4,2%	5 20,8%	16 66,7%	3 12,5%	5 20,8%

TABLE XI Section III

	Number of Samples	Coliforms per 100 ml				E.Coli per 100 ml		
		0-50	51-500	501-1000	>1000	0	1-100	>100
Sea Water	18	15 83,4%	3 16,6%			11 61,2%	7 38,8%	
Sediment	7	1 14,3%	5 71,4%		1 14,3%	5 71,4	1 14,3%	1 14,3%
Beach Material	7	3 42,8%	3 42,8%		1 14,3%	6 85,7%	1 14,3%	

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Principal Investigator: A.J. MANTIS

INTRODUCTION

The laboratory has had no previous activities directly relevant to MED POL VII except for V. parahaemolyticus. This micro-organism has been investigated since 1970, and 3 papers have already been published concerning the existence and enumeration of the above Vibrio in seafood and sea-water in the north Aegean sea.

AREA(S) STUDIED

The laboratory performs microbiological monitoring of shellfish (Mytilus galloprovincialis and Ostrea edulis) on the north-west shore of Thessaloniki gulf (40°30'N - 22°50'E). The area covered (see attached map), corresponds to an anomalous coast line, formed by the soil brought in by three main rivers. It is characterized by shallow waters which have proved an excellent environment for cultivation of shellfish. This coast is not suitable for swimming and is mainly accessible by boat. As indicated in the map, the main polluting sources of the gulf are the city main sewage outlet and an industrial outlet. Since 1960 the pollution of the gulf has been progressive and today it is at a stage which threatens the suitability of large areas of the above coast for shellfish cultivation.

For the purpose of monitoring the area, four sampling points have been selected, covering the main shellfish cultivation beds. Sampling point No. 1 is the nearest to the polluting sources and it falls within the area in which the culture or harvesting of shellfish is prohibited by the public health authorities. It will be regarded as a control.

MATERIALS AND METHODS

Parameters measured:

(a) Water of the cultivation beds:

Total coliforms, faecal coliforms, faecal streptococci, Salmonellae, salinity, temperature, DO and BOD_5.

(b) Shellfish:

Total coliforms, faecal coliforms, faecal streptococci, total heterotrophic bacteria, Vibrio parahaemolyticus and Salmonellae.

Enumeration of total coliforms and faecal coliforms in water was performed by both MPN and MF methods using MacConkey broth and mFC broth or mFC-agar respectively, according to "Guidelines for Health related monitoring of coastal Water Quality". For enumeration of the above indicator organisms in shellfish, only the MPN method was used. MacConkey broth and peptone waters were used as culture media, according to the reference method proposed by this project. However, a minor modification was introduced in the preparation of dilutions from a shellfish sample. Thus 30 g of shellfish flesh were homogenized in a Waring blender with 270 ml of 0.1 per cent peptone water and thus a 1/10 dilution was prepared while the first five tubes containing 10 ml of double strength MacConkey broth were inoculated with 10 ml each of the 1/10 dilution. This procedure, widely accepted in food microbiology, permits quantification of coliforms in values greater than 20/100 g or the negative results can be expressed as less than 20/100 g.

For faecal streptococci, M-enterococcus agar with the MF method was used for the water and the same medium with the PP method for shellfish.

Vibrio parahaemolyticus was quantified in shellfish only, with the MPN method using Glucose-Salt-Teepol broth as enrichment broth and TCBS agar as plating medium.

Salmonellae recovery was attempted from both water and shellfish. The methods applied and the media used were those proposed for this project.

RESULTS AND THEIR INTERPRETATION

Total heterotrophic bacteria:

The results concerning total heterotrophic bacteria in shellfish are summarized in Table I. Samples of shellfish from sampling point No. 1 had a total plate count ranging between 3.1 x 10^3 and 43 x 10^3/g. Samples from sampling points Nos. 2, 3 and 4 had similar mean values (3.8084 $\pm$ 0.8084, 3.6664 $\pm$ 0.3232 and 3.6336 $\pm$ 0.3608 respectively). The results concerning sampling point No. 1 differ significantly from our previous reported values which were always higher than 10^4 g. (Table II). This observation cannot be explained at the moment.

The results for the period September 1979 - September 1980 are summarized in Table III. Log mean values ranged between 3,8319 to 3,9203 (antilog 6,800 to 8,300/g). The results do not differ significantly from the results of the previous year.

Total coliforms and faecal coliforms:

From the frequency distribution of the values of total coliform and *E. coli* in shellfish and water which resulted during the first period of the pilot project (up to December 1978) it could be seen that except from sampling point No. 1 for which high values were expected sampling point No. 2 gave values above the suggested limits in a considerable percentage of samples, while sampling points No. 3 and No. 4 gave values which fell within the suggested limits of acceptance (fig. 2 and 3).

The results for the period January - September 1979 are summarized in Table I for shellfish and Tables IV and V for the water. The mean log values of total coliforms are calculated for both MPN and MF methods.

From the relevant tables it is evident that sampling point No. 1 (polluted area) continues to have values of total coliforms and faecal coliforms above suggested limits for shellfish and for the water. Moreover, sampling point No. 2 gives, especially for shellfish, mean values which, considering the confidence limits, cannot be interpreted as satisfactory. Sampling points No. 3 and 4, continue to give values within the limits accepted by Greek law as well as by the proposed interim criteria of this project.

The results for the period September 1979 - September 1980 concerning total coliforms and faecal coliforms are given in Tables VI and VII for the water and in Table VIII for the shellfish. From the relevant tables, it appears that the mean values of coliforms for all sampling points are less than 10/100 ml. It is noticable that values of sampling point No. 1 (polluted area) are reduced significantly for this last period (September 1979 - September 1980).

Faecal streptococci:

Results concerning faecal streptococci are summarized in Table IX. From this table it can be seen that values for shellfish cultivated in unpolluted water (sampling points 3 and 4) were less than 10/g in the majority of the cases (80 per cent and more of the samples) while the water from the above sampling points gave values less than 100/100 ml in more than 87 per cent of the samples.

The results of the second period of the pilot project are given in Table X for the water and in Table XI for the shellfish.

From the above tables it can be seen that the log mean values for the water ranged between 2 and 11/100 ml for all sampling points with confidence limits ranging betwen 0 and 10/100 ml, except for sampling point No. 1 whose mean value had confidence limits between 4 and 35/100ml ($P < 0.05$).

As far as shellfish are concerned, faecal streptococci were frequently encountered in shellfish from sampling points No. 1 and 2 (62.5% and 47.75% positive) in numbers ranging between 10^3 - 10^4/100g (or 10-100/g), while samples from sampling points 3 and 4 had a positivity of 22.2% and 11.1% respectively.

For the period September 1979 - September 1980 the number of faecal streptococci in water are given in Table XII. They range between 1 and 9/100 ml (95% confidence limits) with a log mean range between 0,2097 to 0,5935 (antilog 2 to 4/100 ml). In shellfish faecal streptococci (Table XIII) were measured in 60% of the samples for sampling point No. 1 and in 40% to 46% in the remaining sampling points. The numbers ranged from 10 to 200/g.

Vibrio parahaemolyticus:

During the first period of the pilot project (up to the end of 1978) quantification of Vibrio parahaemolyticus in shellfish with the MPN method revealed that a percentage of the samples ranging between 34 per cent and 60 per cent were positive (Figure 1). The MPN value of the positive samples was always smaller than 10^3/100 g. Positivity of the samples increased during the warmer months of the year and decreased markedly during the cold months. This confirms the well established view that V. parahaemolyticus is a natural inhabitant of sea-water and does not correlate with pollution.

During this project more than 600 strains of V. parahaemolyticus were tested for Kanagawa phenomenon and proved to be Kanagawa negative. Randomly selected strains were serologically tested and the majority of them fell into the serotypes O_4K_{12}, O_4K_3, $O_5K_{10}K_{24}$. About 25 percent of the strains were not typeable with available antisera.

As far as food poisoning is concerned, there are no data suggesting possible cases of gastroenteritis among humans in Greece caused by the consumption of shellfish.

Table XIV displays the results concerning Vibrio parahaemolyticus in shellfish during the period January - September 1979. The positivity of samples ranged between 18% and 75% for the relevant sampling points and the numbers of points and the numbers of vibrios ranged between 30 and 10^3/100 g (0.3-10/g).

Table XV gives the results on Vibrio parahaemolyticus for the period September 1979 - September 1980. Positive samples were found in 36% to 46% of the cases and the number counted with the MPN method ranged between 30 and 10^3/g.

Salmonella

No salmonella serotypes have been so far isolated from the water or shellfish tested. Although our laboratory has a long experience in salmonella isolation from different sources, we consider the negative results from sampling point No. 1 as contradictory and if in the future sampling the situation continues to be so, consideration will be given to the effect that is produced on salmonella and probably on other micro-organisms by the industrial (chemical) wastes which are discharged near the above sampling point.

However during the last period of monitoring (January - September 1979) four (4) strains of Salmonella were isolated. One was typed as Salmonella agona (4:fgs) and was isolated from shellfish of sampling point No. 1, and the other three were typed as Salmonella heidelberg (4,5:r:1,2) and were isolated from the water (two strains from sampling point No. 2 and one strain from sampling point No. 1).

During the period September 1979 - September 1980 no salmonella was isolated either from the water samples or from shellfish.

Evaluation of the results according to interim microbiological criteria for shellfish:

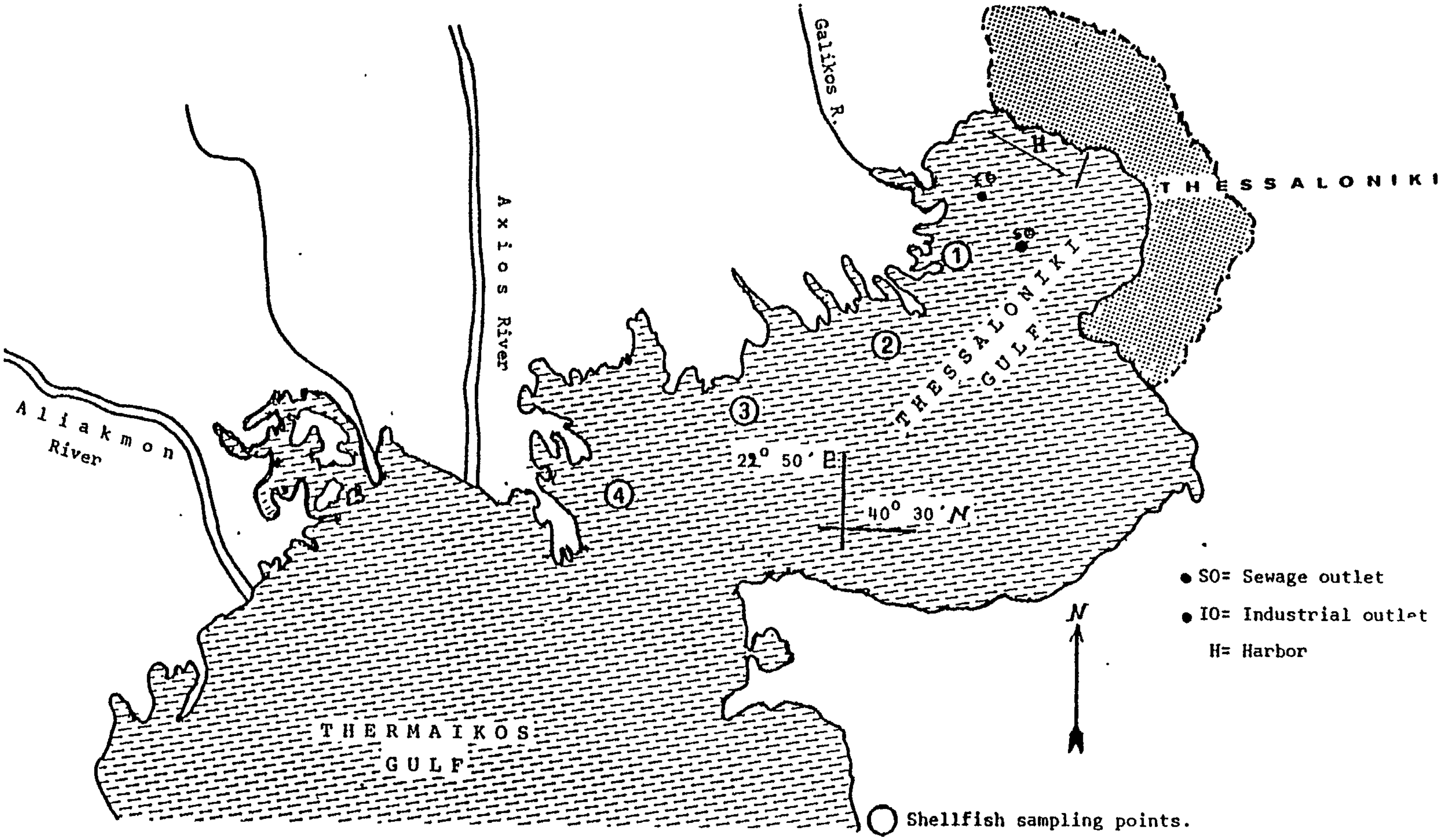
On the basis of faecal coliforms, the percentage of the samples of shellfish or water which fall within or outside the proposed microbiological limits are presented in Table XVI for the period before January 1979 and in Table XVII for the period January - September 1979.

From Table XVI it is evident that sampling point No. 2 does not fulfil completely the proposed criteria either for shellfish or for the water, while sampling points No. 3 and 4 satisfy the criteria. In evaluating the results obtained so far, it is evident that the pollution of the north-west coast of Thermaikos gulf is increasing year by year, and this in addition to other problems, also creates a problem of shellfish hygiene. This problem is already anticipated by a shellfish cleaning station (ozone treatment) and very soon all shellfish from the above area will be subjected to treatment before they are released to the market.

From Table XVII it appears that apart from point 1 (already polluted) sampling point No. 2 does not satisfy the criteria either.

The mean values of total coliforms and faecal coliforms for these sampling points are higher compared to the previous sampling period. This observation strengthens the assumption already made following the first period of monitoring (up to Dec. 1978) that the pollution of Thessaloniki Bay is increasing.

From the results obtained during the period September 1979 to September 1980 and on the basis of faecal coliforms, sampling points No. 1 and No. 2 have the majority of shellfish samples outside the proposed limits, while No. 3 and No. 4 are considered still acceptable.



INSTITUTE: Laboratory of Food Hygiene.
Veterinary Faculty.
University of Thessaloniki - Greece.

Scale : 1:165.000

Map of the area studied

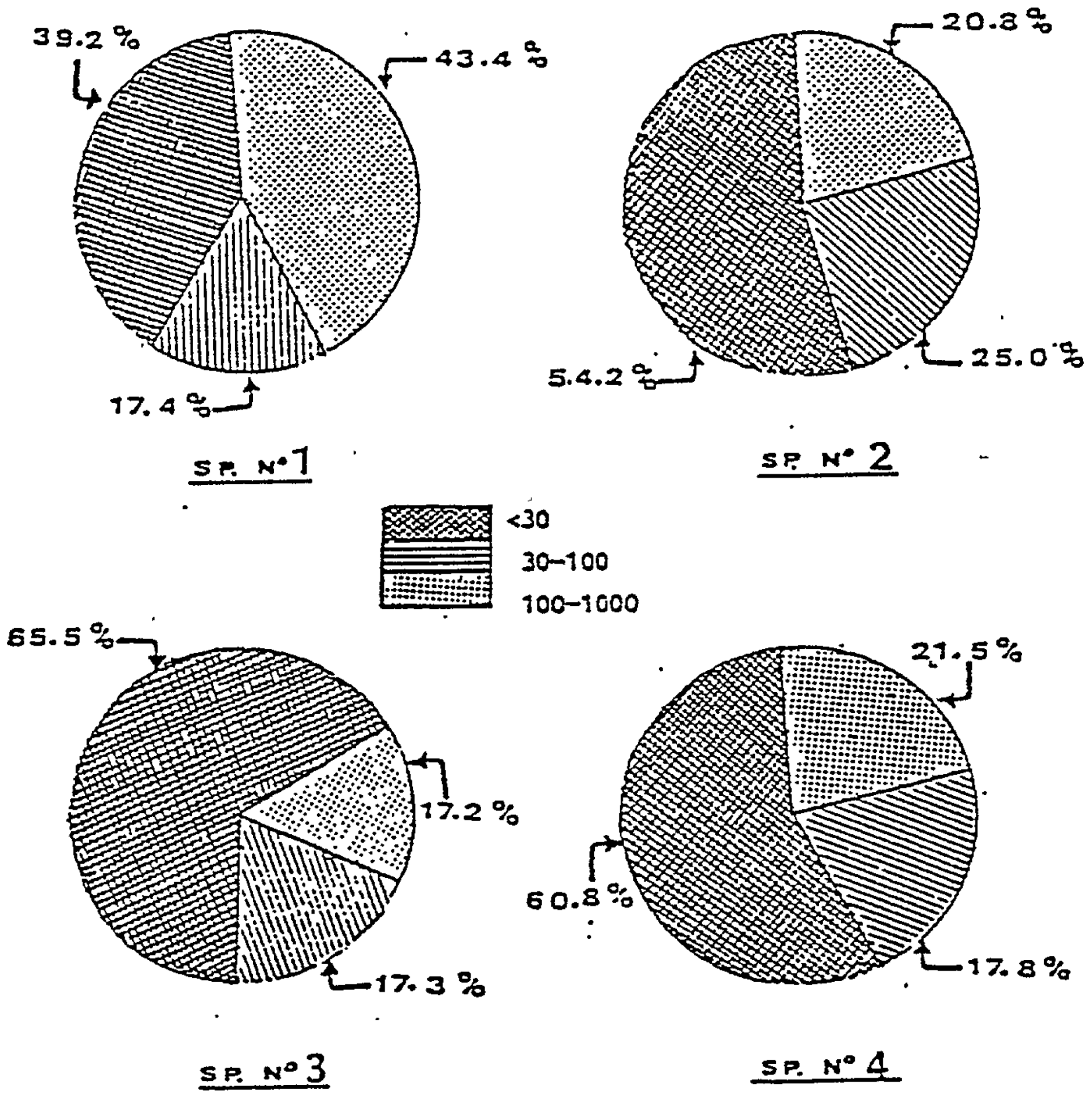


Fig. 1. Vibrio Parahaemolyticus in shellfish (per 100 g)

Sampling period : February 1977—December 1978

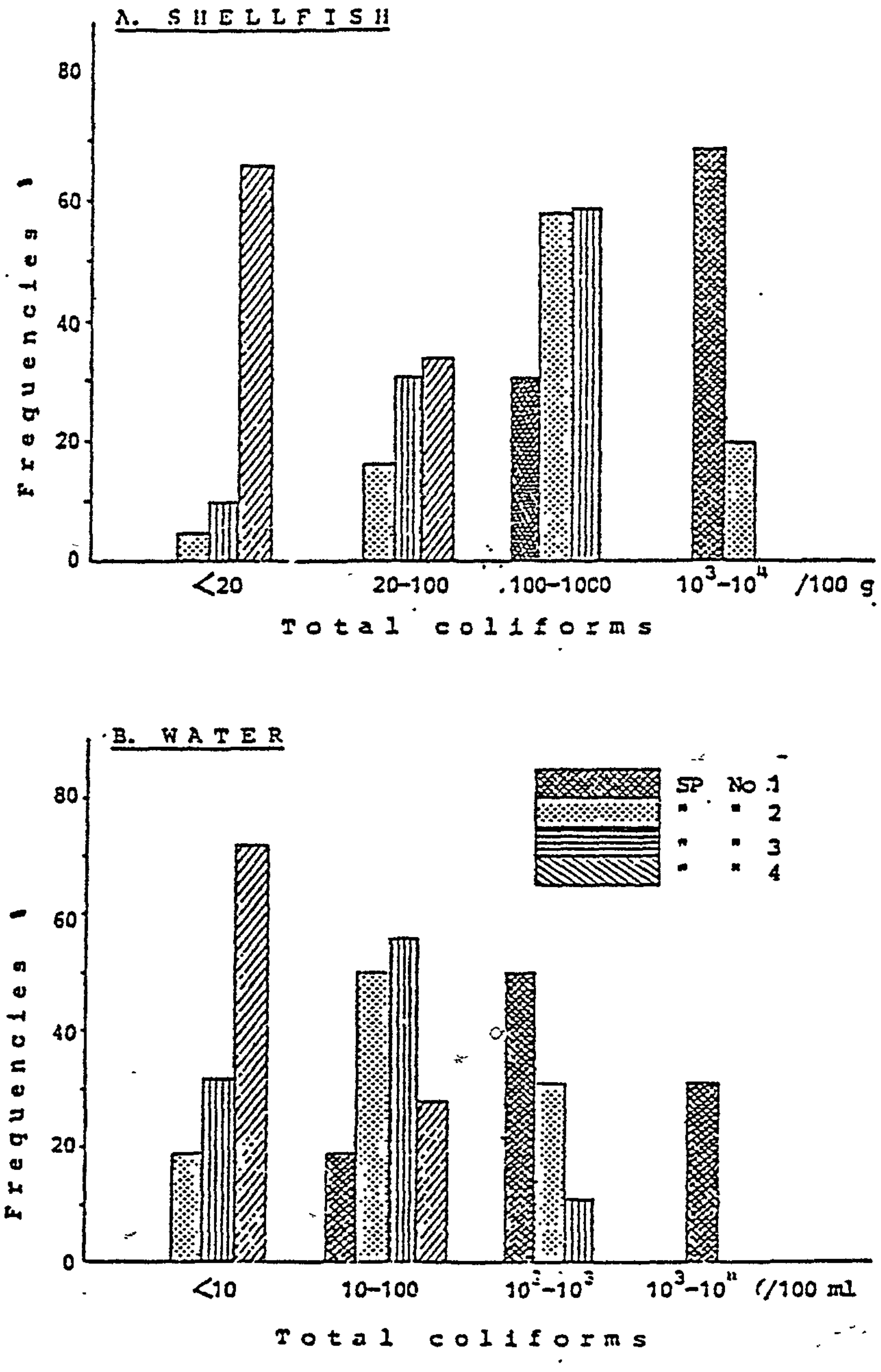


Fig. 2. Total coliforms in (A) shellfish (per 100 g.) and (B) seawater (per 100 ml)

Sampling period : February 1977 - December 1978

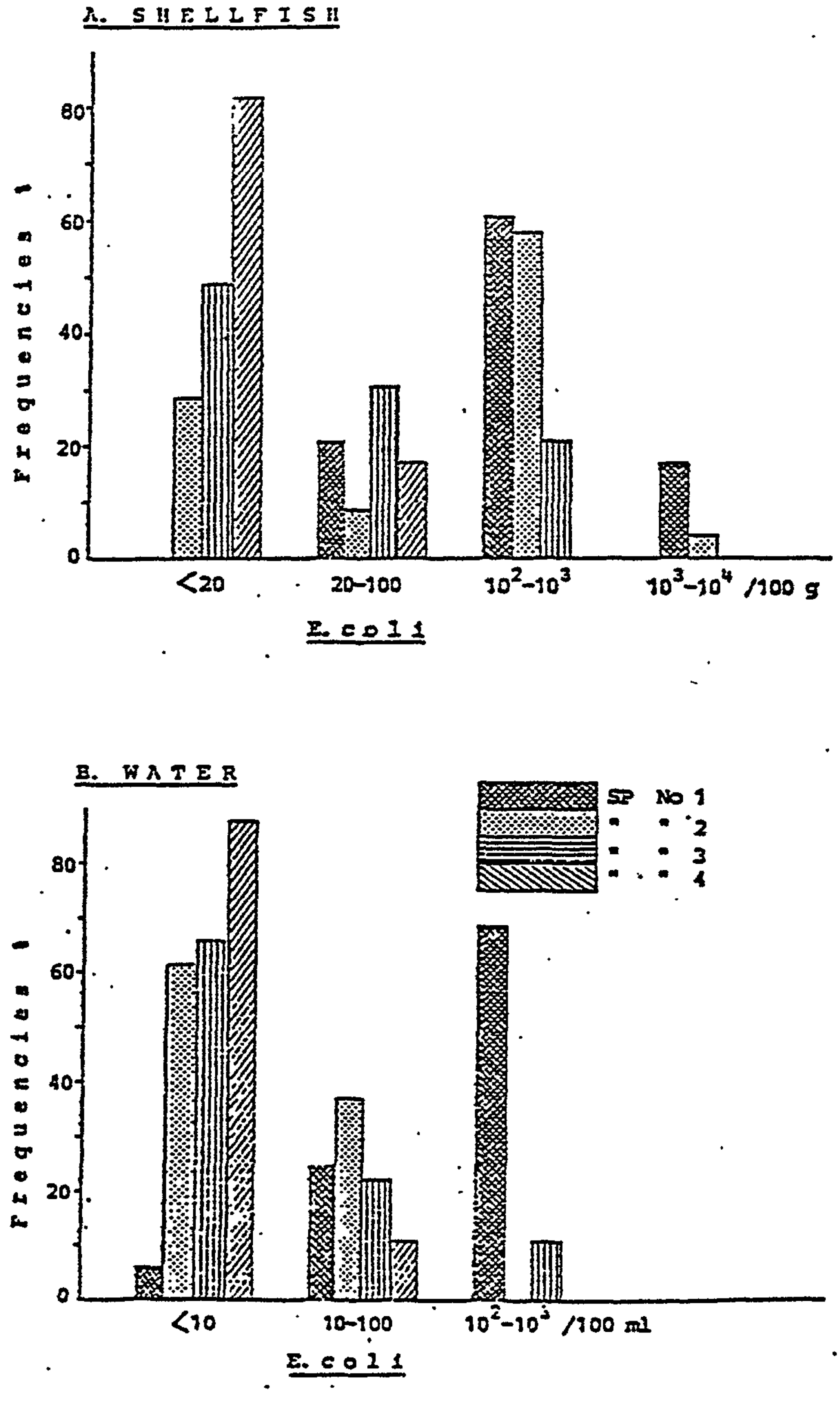


Fig. 3. E. coli in (A) shellfish (per 100 g.) and (B) seawater (per 100 ml)

Table I. Total Coliforms, Faecal Coliforms and Total Heterotrophic bacteria in shellfish

(Period covered: January - September 1979)

Sampling point	No. of samples	Total Coliforms/100 g				Faecal Coliforms/100 g				Total Heterotrophic Bacteria/g			
		Mean (log)	Deviation (log)	Confidence limits (log)	Mean & Deviation (antilog)	Mean (log)	Deviation (log)	Confidence limits (log)	Mean & Deviation (antilog)	Mean (log)	Deviation (log)	Confidence limits (log)	Mean & Deviation (antilog)
1	16	3.1383	0.5183	$2.8621<\bar{x}<3.4145$	1400±4	2.7127	0.6187	$2.3830<\bar{x}<3.0424$	520±4	3.9379	0.2989	$3.7787<\bar{x}<4.0970$	8700±2
2	16	2.7707	0.4265	$2.5435<\bar{x}<2.9979$	600±3	2.3381	0.5936	$2.0219<\bar{x}<2.6543$	220±4	3.8084	0.2107	$3.6961<\bar{x}<3.9207$	6500±2
3	18	2.5879	0.3327	$2.4227<\bar{x}<2.7531$	400±2	2.0062	0.4445	$1.7853<\bar{x}<2.2271$	101±3	3.6664	0.3232	$3.5061<\bar{x}<3.8269$	4600±2
4	18	2.1649	0.2102	$2.2605<\bar{x}<2.4967$	230±2	1.3471	0.6922	$1.0136<\bar{x}<1.6904$	22±5	3.6336	0.3608	$0.4545<\bar{x}<0.8127$	4300±3

Table II. Total Heterotrophic bacteria (frequencies %)

SHELLFISH

Per gram	Sampling point			
	1	2	3	4
10^2 - 10^3	—	4.2 %	—	14.3 %
10^3 - 10^4	—	75.0 %	82.1 %	85.7 %
10^4-5×10^4	52.2 %	20.8 %	17.9 %	—
5×10^4 - 10^5	47.8 %	—	—	—

Table III. Total Heterotrophic bacteria in shellfish per gram of flesh

(Period covered: Sept. 1979 - Sept. 1980)

Sampling point	n	Mean (log)	Deviation (log)	Confidence limits	Mean ± Deviation (antilog)
1	15	3.8895	0.1882	$3.7856<\bar{x}<3.9934$	7800 2
2	15	3.9203	0.1809	$3.8204<\bar{x}<4.0202$	8300 2
3	15	3.8661	0.2491	$3.7285<\bar{x}<4.0037$	7300 2
4	15	3.8319	0.2412	$3.6987<\bar{x}<3.9651$	6800 2

Table IV. Total Coliforms per 100 ml of water of shellfish culture area

(Period covered: January - September 1979)

Sampling point	n	Mean (log)		Deviation (log)		Antilog ML		Antilog SL	
		MPN	MF	MPN	MF	MPN	MF	MPN	MF
1	16	2.1921	1.9405	0.6027	0.7478	155	87	4	6
2	16	1.1619	0.9448	0.7068	0.9566	15	9	5	9
3	18	0.4780	0.6240	0.6895	0.6314	3	4	5	4
4	18	0.4345	0.4728	0.5521	0.5677	3	3	4	4

Table V. Faecal Coliforms per 100 ml of water of the shellfish culture area

(Period covered: January - September 1979)

Sampling point	n	Mean (log)		Deviation (log)		Confidence limits		Mean (antilog)	
		MPN	MF	MPN	MF	MPN	MF	MPN	MF
1	16	1.6024	1.3620	0.8634	0.9566	$1.1747<\bar{X}<2.071$	$0.8510<\bar{X}<1.873$	40±7	23±9
2	16	0.7030	0.5868	0.7074	0.6692	$0.3260<\bar{X}<1.2140$	$0.2660<\bar{X}<0.9060$	5±5	4±5
3	18	0.3343	0.1959	0.5549	0.4711	$0.0587<\bar{X}<0.6099$	$0.0934<\bar{X}<0.3244$	2±4	2±3
4	18	0.1576	0.1155	0.4349	0.4209	—	$-0.0379<\bar{X}<0.4227$	1±3	1±3

Table VI. Total Coliforms per 100 ml of water of shellfish culture area
(Period covered: Sept. 1979 - Sept. 1980)

Sampling point	n	Mean (log)		Deviation (log)		Mean ± Deviation (Antilog)	
		MPN	MF	MPN	MF	MPN	MF
1	15	1.0158	0.9179	0.8709	0.8939	10 ± 7	8 ± 8
2	15	0.7352	0.5146	0.8126	0.6915	6 ± 7	3 ± 5
3	15	0.8590	0.6787	0.8399	0.7795	7 ± 7	5 ± 6
4	15	0.4072	0.6109	0.5922	0.5559	3 ± 4	4 ± 4

Table VII. Faecal Coliforms per 100 ml of water of shellfish growing area
(Period covered: Sept. 1979 - Sept. 1980)

Sampling point	n	Mean (log)		Deviation (log)		95% Confidence limits (log)		Mean ± Deviation (antilog)	
		MPN	MF	MPN	MF	MPN	MF	MPN	MF
1	15	0.7651	0.5161	0.7513	0.6499	$0.35 < \bar{x} < 1.1802$	$0.1570 < \bar{x} < 0.8752$	6 ± 6	3 ± 5
2	15	0.2348	0.3070	0.3227	0.5646	$0.0539 < \bar{x} < 0.4157$	$- < \bar{x} < 0.6189$	2 ± 3	2 ± 4
3	15	0.5985	0.4722	0.7152	0.5947	$0.2034 < \bar{x} < 0.9936$	$0.1436 < \bar{x} < 0.8003$	4 ± 5	3 ± 4
4	15	0.4722	0.3181	0.2016	0.4637	$0.3603 < \bar{x} < 0.5836$	$0.0619 < \bar{x} < 0.5743$	3 ± 2	2 ± 3

Table VIII. Total Coliforms and Faecal Coliforms in shellfish
(Period covered: Sept. 1979 - Sept. 1980)

Sampling point	n	Total coliforms/100 g of flesh				Faecal coliforms/100 g of flesh			
		Mean (log)	Deviation (log)	95% Confidence limits (log)	Mean ± Deviation (antilog)	Mean (log)	Deviation (log)	95% Confidence limits (log)	Mean ± Deviation (antilog)
1	15	3.0844	0.4514	$2.8276 < \bar{x} < 3.3412$	1215 ± 3	2.6693	0.5997	$2.3483 < \bar{x} < 2.9903$	467 ± 4
2	15	2.8390	0.5312	$2.5394 < \bar{x} < 3.1386$	690 ± 4	2.4297	0.6103	$2.0873 < \bar{x} < 2.7721$	269 ± 4
3	15	2.7747	0.4568	$2.4179 < \bar{x} < 3.0315$	595 ± 3	2.2345	0.5002	$1.9563 < \bar{x} < 2.5127$	172 ± 3
4	15	2.5254	0.4717	$0.2686 < \bar{x} < 2.7822$	335 ± 3	1.4038	0.9541	$0.8902 < \bar{x} < 1.9174$	25 ± 9

Table IX. Enterococci (Frequencies %)

A. SHELLFISH (MPN)				
per gram	Sampling point			
	1	2	3	4
<10	21.7 %	66.7 %	82.8 %	100.0 %
10-100	78.3 %	33.3 %	17.2 %	—
B. WATER (MF)				
per 100 ml				
0	6.25 %	25.0 %	27.8 %	50.0 %
1-10	—	31.3 %	33.3 %	33.3 %
10-100	18.75 %	31.2 %	33.3 %	16.7 %
100-1000	75.00 %	12.5 %	5.6 %	—

Table X. Faecal streptococci per 100 ml of water of shellfish culture area

Sampling point	n	Mean (log)	Deviation (log)	Confidence limits	Mean & Deviation (antilog)
1	16	1.0551	0.9210	$0.5643<\bar{X}<1.5459$	11±8
2	16	0.6398	0.6625	$0.2869<\bar{X}<0.9927$	4±5
3	18	0.3588	0.4613	$0.1299<\bar{X}<0.5877$	2±3
4	18	0.3723	0.4456	$0.1512<\bar{X}<0.5934$	2±3

Table XI. Shellfish:Enterococci (Frequencies %)

per 100 g	Sampling point			
	1	2	3	4
$<10^3$	37.5	56.25	77.8	88.9
10^3-10^4	62.5	43.75	22.2	11.1

Table XII. Faecal streptococci per 100 ml of water of shellfish culture area

(Period covered: Sept. 1979 - Sept. 1980)

Sampling point	n	Mean (log)	Deviation (log)	Confidence limits	Mean ± Deviation (antilog)
1	15	0.5210	0.6633	$0.1572<\bar{x}<0.8848$	3 ± 5
2	15	0.4785	0.6588	$0.1147<\bar{x}<0.8423$	4 ± 5
3	15	0.5935	0.5756	$0.2725<\bar{x}<0.9145$	4 ± 4
4	15	0.2097	0.3689	$0.0043<\bar{x}<0.4151$	2 ± 2

Table XIII. Enterococci in shellfish

(Frequencies %)

per 100 g	Sampling point			
	1	2	3	4
$<10^3$	40.0	46.6	60.0	60.0
10^3-10^4	60.0	46.6	40.0	40.0
10^4-2x10^4	—	6.8	—	—

Table XIV. Shellfish: *Vibrio parahaemolyticus* (frequencies %)

(Period covered: January - September 1979)

per 100 g	Sampling point			
	1	2	3	4
<30	81.25	25.0	50.0	77.8
30-100	6.25	62.5	33.3	11.1
100-100	12.50	12.5	16.7	11.1

Table XV. *Vibrio parahaemolyticus* in shellfish (frequencies %)

(Period covered: Sept. 1979 - Sept. 1980)

per 100 g	Sampling point			
	1	2	3	4
<30	53.3	60.0	53.3	53.3
30-100	33.3	20.0	33.3	26.7
100-1000	13.4	20.0	13.4	20.0

Percentage of samples within the proposed limits
on the basis of E. coli values.

Table XVI

SAMPLING POINT	SHELLFISH			WATER		
Point	0.2/g *	3-10/g **	10/g	10/100 ml	10-100/100ml ***	100/100ml
1	30.4%	52.2%	-	18.7%	75	6.3%
2	79.2%	20.8%	-	62.5%	37.5%	-
3	92.9%	7.1%	-	87.7%	13.3%	-
4	100%	-	-	94.4%	5.6%	-

* Accepted
** Temporary prohibition of sale
*** Accepted if not more than 20%

Table XVII

SAMPLING POINT	SHELLFISH			WATER		
Point	0-2 /g	3-10/g	>10	<10/100 ml	10-100/100ml	>100/100ml
1	31.25%	18.75	50.0%	18.75	37.50	43.75
2	43.75	43.75	12.5%	81.25	12.50	6.25
3	77.78	22.22	0.0%	88.80	5.60	5.60
4	94.40	5.60	0.0%	94.40	5.60	0.00

Research Centre: Environmental Pollution Control Project
Ministry of Social Services
ATHENS
Greece

Principal Investigator: J.A. PAPADAKIS/M. THALASSINOU-TZATZANI/
A. SOTIRACOPOULOU

INTRODUCTION

The Ministry of Social Services participates in project MED VII through its three laboratories attached to the following national services:

(a) Environmental Pollution Control Project

(b) Athens School of Hygiene, and

(c) Central Public Health Laboratory

Because the above laboratories are monitoring the coastal water quality in the same geographical area, the monitoring work has been allocated according to their data collection and analysis capabilities and co-ordinated by the above project.

A survey during the period 1962-77 of a number of bathing beaches near Athens, using the mean value MPN of coliforms for sea-water and carried out for the most part during the bathing season (15 May to 15 October), revealed the influence of land-based sources of pollution on the quality of the sea-water.

As a result of the above study and the yearly routine examination of beaches, the Ministry of Social Services has forbidden bathing at some beaches of the Athens area and taken appropriate measures to improve the quality of others.

Since the establishment of the Environmental Pollution Control Project, a broad sampling network has been developed and progressively extended, reaching 72 sampling stations.

The Central Public Health Laboratory has been involved in the microbiological examination of recreational coastal water as well as shellfish culture areas since 1965.

The present summary covers the work of the collaborating laboratories up to March 1981.

AREA(S) STUDIED

Four bathing beaches along the Attica peninsula were chosen as sites for MED POL VII recreational multiple sampling monitoring and one as a site for shellfish area monitoring: Alimos, Varkiza, Ag. Marina, Lagonissi (the latter chosen as reference beach), and Loutropyrgos as a shellfish-growing area. The exact location of the above beaches is shown on Figure 1 attached.

Based on the analysis of the data collected up to September 1978 the number of sampling points at certain bathing beaches was reduced. On the other hand two more beaches (Perama and Votsalikia) were included in the monitoring.

MATERIALS AND METHODS

The "Guidelines for Health Related Monitoring of Coastal Water Quality" (WHO, 1977) were used as the basic document for the implementation of the work undertaken. More specifically the following methods and materials were used for each of the parameters monitored:

Sea-water samples:

Total coliforms: (a) Multiple tube method with glutamate modified for sea-water (Papadakis, 1975); (b) Membrane filtration method with M-endo agar according to the Guidelines as well as with Teepol broth. The m-FC agar proposed at the Rome meeting (May 1977) was found unsatisfactory. Dilutions were made with phosphate buffer.

E. coli: (a) Multiple tube method (as above) with differentiation at 44°C (gas from lactose, indole positive); (b) Membrane filtration method according to the Guidelines.

Faecal streptococci: Membrane filtration method according to the Guidelines.

Pathogens: (a) Salmonellae - filtration through membranes incubated in buffer phosphate for 20-40 hours at 37°C and subculture in modified Rappaport's medium and Muller-Kauffman's tetrathionate broth at 43°C. Enrichment media were plated on brillant green lactose-sucrose agar; (b) Vibrio-filtration through membranes incubated in alkaline peptone water for 6-8 hours and subculture on TCBS agar.

Sediment samples:

In accordance with the Guidelines, sediments were shaken for 30 minutes in phosphate buffer and dilutions were made, of which 1 ml was examined with the pour plate technique.

(a) Total coliforms: Teepol agar;

(b) Faecal coliforms: M-FC agar, and

(c) Faecal streptococci: K-F agar.

Beach material samples:

(a) Total coliforms;

(b) Faecal coliforms, and

(c) Faecal streptococci.

The beach materials were examined according to the Guidelines, using the multiple tube technique. The amount of beach material samples processed was 100 g.

(d) Pathogens: Beach material pathogens were examined using similar methodology to that used in shellfish-growing areas (see below).

(e) Fungi: The spread plate technique was employed using rose bengal agar as it is described in the "Method for Microbiological Analysis of Waters, Wastewaters and Sediments" (Inland Waters Directorate, Canada Centre for Inland Waters, Burlington, Ontario, Canada).

Shellfish area samples:

(a) Total coliforms;

(b) Faecal coliforms;

(c) Faecal streptococci were all examined on the shellfish flesh, sea-water and sediments of the area, using the multiple tube technique with sodium azide broth as presumptive medium and ethyl azide broth as the confirmatory medium. The amount of shellfish flesh, including the sediment sample processed for the analysis, was 100 g;

(d) Pathogens: the following pathogens were examined on shellfish flesh, sea-water and sediments: salmonellae, shigella, Vibrio cholerae and non-agglutinable vibrios, and Vibrio parahaemolyticus. All these tests were performed in accordance with the suggested guidelines. For the Vibrio parahaemolyticus, teepol salt broth was used as enrichment medium instead of the G. Pselichidic salt meat broth. For the salmonellae test, the pre-enrichment procedure was applied.

Beach sanitary surveillance:

The four recreational areas monitored were also surveyed from the sanitary point of view during each sampling. Both the beach and sea-water area were examined and classified according to the Garber code.

Salinity:

Salinity was measured by the hydrometric method, based on the specific weight, and by the argentometric method as described by the US AWWA Standards.

Turbidity:

The *Secchi disc* method was not applied because of the shallowness and cleanliness of the waters 10 m from the coastline. Turbidity was therefore measured by the nephelometric method using a turbidimeter as well as by comparison with original SiO_2 suspensions.

Dissolved oxygen:

This was measured by the Winkler method in situ while only the final titration was carried out at the laboratory.

Temperature:

This was measured in situ by simple thermometers.

Meteorological data:

Specific meteorological data from two meteorological stations were collected in view of possible correlation between wind and coastal pollution.

Dynamic conditions:

Data on tides were requested from the Army Hydrographic Services. However in view of their very small value this was discontinued after September 1978. Waves were usually evaluated. Current data presented some difficulties and no information was available for surface currents.

Hydrographic conditions:

The required hydrographic data were collected locally at the sampling points.

RESULTS AND THEIR INTERPRETATION

Sea-water:

Generally, low densities for coliforms and even lower for faecal coliform organisms were found, except for the two sampling points at which, during October 1977, rather high values of both indicator organisms were noted. (see Figure 3).

During the period September 1978 to September 1979 (Fig. 2) the few higher values of total coliforms, which were still within the acceptable EEC limits for bathing waters, were accompanied by very low faecal coliforms values, indicating accidental local pollution of non-faecal origin.

The two new bathing areas which were added to the monitoring programme show generally low acceptable densities of indicator organisms although they are in the vicinity of the main Athens sewage outfall and Piraeus port.

A few high values of total coliforms (above those set by the Greek regulations, but always within the acceptable EEC limit values) were noted at Votsalakia beach only for 2 sampling dates in October 1979 and April 1980. As these values were not associated with high values of faecal coliforms, which could justify a faecal origin, they were mainly attributed to the surface drainage of the densily populated areas of the vicinity of the beach, occuring after heavy rains during the sampling period.

Faecal streptococci were not found consistently lower or higher than faecal coliforms and no justification seems to exist for a further statistical analysis of the gathered results in order to investigate possible relation between the above two parameters. It appears that for polluted sea-water there is some correlation but not for clean waters as the case was in this project.

The low coliform and especially the very low faecal coliform densities indicated that the monitoring areas are free from sewage pollution and their waters are of excellent quality for bathing and recreational activities.

Pathogens, salmonellae, shigella and V. cholerae were not found except at one sampling point from which salmonellae were isolated only once during October 1977 when the area was accidentally polluted by sewage. Non-agglutinable vibrios were occasionally found at all sampling points except for the two points of the reference area.

During the period October 1979 - March 1981, the sea-water quality was meeting the established interim quality criteria and the E. coli densities were less than 100/100 ml in 98% of the samples. (Figure 12).

Sediments (Figures 4, 5 and 13):

The densities of coliform per gram, found in sediments of all sampling points, are rather low, with the highest values observed during the summer months.

Faecal coliform organisms were generally absent with a few exceptions, but faecal streptococci were observed at levels approaching the coliform densities.

There was a seasonal fluctuation for both coliforms and faecal streptococci, the highest densities being found during the summer months. The fluctuation was not only on different days but also between different sampling points.

In October 1979 some fluctuation with higher values was observed in all sampling points along the coast. This followed the relatively higher values of the respective indicator values found for the sea-water and the effects attributed to high rains in that period.

Beach materials (Figs. 6, 7, 14):

Sand was the only beach material examined from the microbiological point of view. Our data indicate that occasionally there is some bacterial contamination with coliforms and faecal streptococci. Fungi were consistently present at all the sampling points.

Few dispersed high values should be attributed to accidental pollution on the point of the beach where the sampling took place.

Shellfish-growing area (Figures 8, 9, 10, 11, 15, 16 and 17):

The water quality of the shellfish-growing area was found to be within the proposed WHO/UNEP standards (Rome 1978) for all samples, while the shellfish flesh quality exceeded them only once, for the period 1977-78.

During the period September 1978 - September 1979 the water quality in 93% of the samples had an *E. coli* density of less than 10/100 ml. However the remaining 7% had more than 100/100 ml that is above the interim MED VII proposed standard. It consisted of two samples with values of 230 and 430 *E. coli*/100 ml.

During the above period (September 78 - September 79) the values of *E. coli* in shellfish flesh (Fig. 9) were $<$ 2 per g. in all the analysed samples. Thus they met the standards proposed by MED VII. However as far as enterococci are concerned the respective values in shellfish flesh were not so low as those of *E. coli*. Densities of less than 2 enterococci per gram were found in 79% of the samples in the remaining samples (21%) values as high as 110 and 240 per gram were found.

Beach sanitary surveillance:

Suveillance of the sanitary conditions of beaches has shown that at some stations there is a permanent accumulation of rubbish originating from sea-water, beach and domestic refuse, while in others there is only occasional accumulation of some of the above-mentioned litter.

Extensive growth of algae occurs during spring and summer offshore near polluted areas. A considerable population of jelly fish has also occurred recently.

Wind conditions:

During MED VII samplings, the winds were quite variable in direction, particularly at point C (Ellinikon airport), while wind speeds were rather low (0.1-0.4 m/sec) on most of the sampling days. The maximum wind speed during the respective months ranged between 7 and 13 m/sec.

A correlation of winds and pollution of the beaches has been observed.

Wave conditions:

Wave conditions during MED VII sampling days were mostly of rate 1 and 2, i.e. calm and nearly calm with only one exception in January 1978 (rough).

Tidal conditions:

The tidal range during MED VII samplings was quite limited. The flood tide ranged from 0.02 to 0.08 while the ebb tide ranged from 0 to 0.21 in relation to respective monthly mean sea-level. No considerable effect, as far as pollution is concerned, is expected from tidal ranges of this order of magnitude.

Currents:

The available data for currents do not provide sufficient information on the water movement along the coasts, because they are limited to only one point (D) and also refer to comparatively deep waters (25 m), and they do not give any information on the surface water movements, which are most important for coastal water quality, in relation to pollution transfer.

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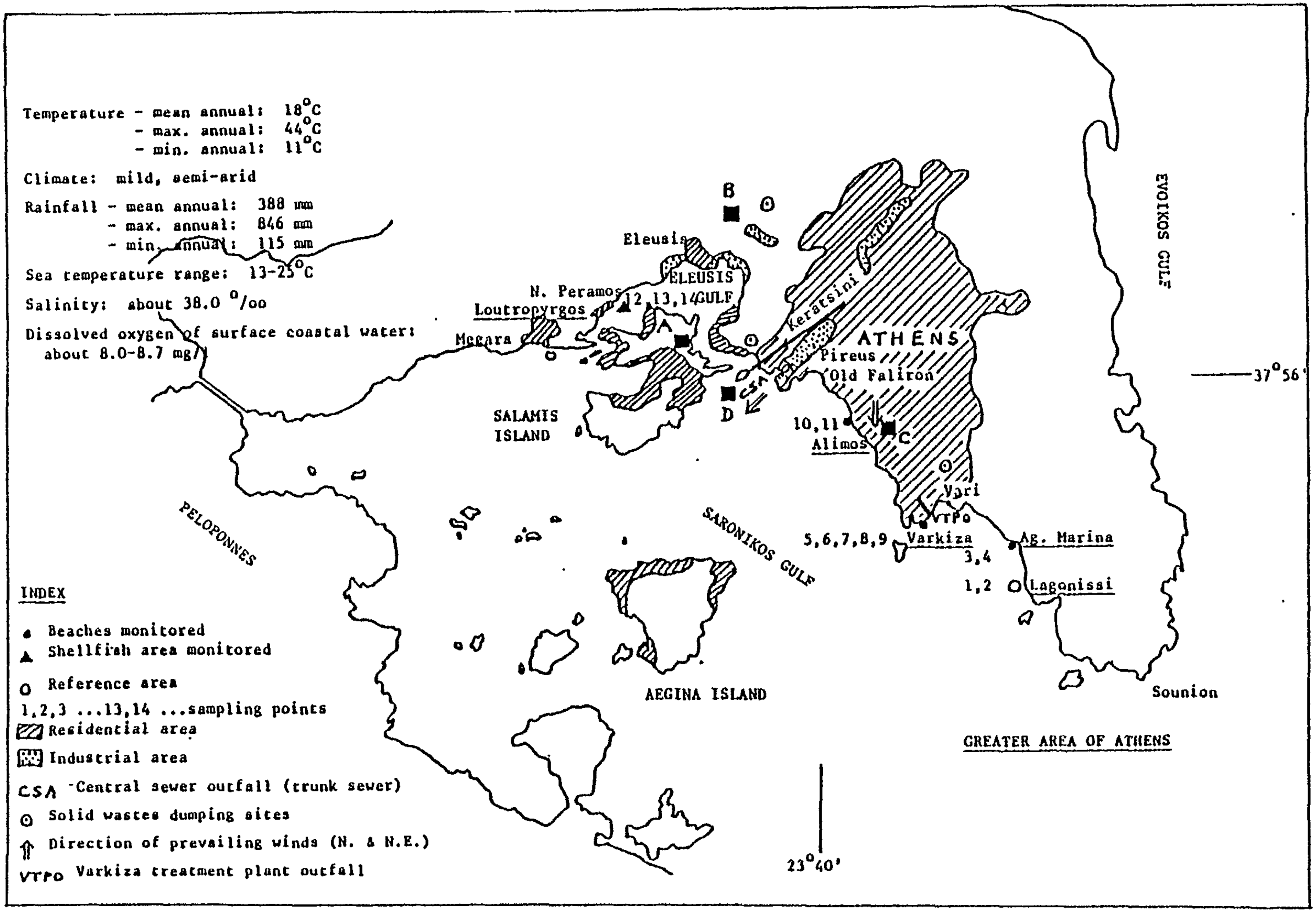

Fig. 1. Area studied

WHO/UNEP COORDINATED PILOT PROJECT ON COASTAL WATER QUALITY CONTROL IN THE MEDITERRANEAN

Athens area - Greece

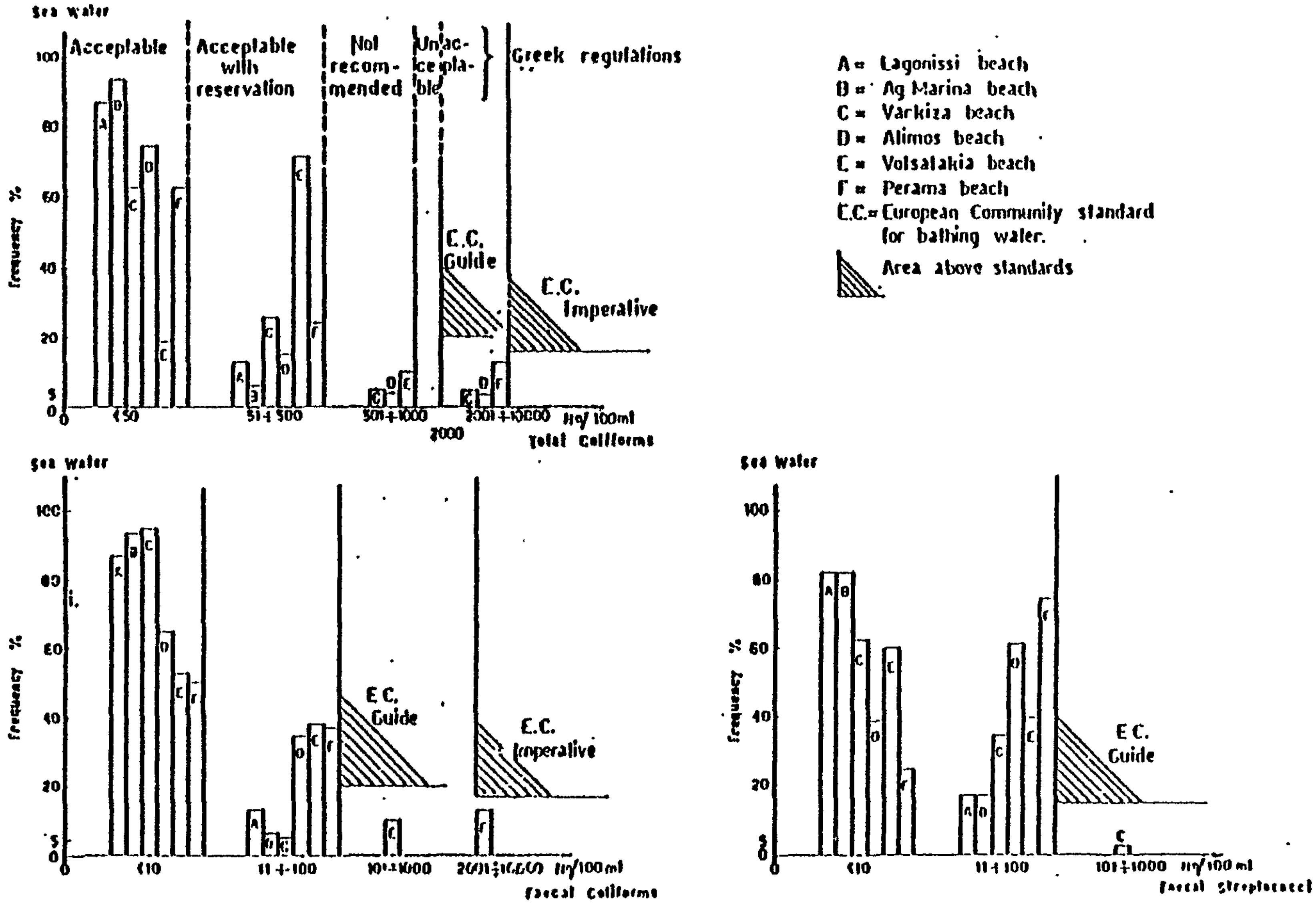

Fig. 2. Sea water quality data (Period Sept. 1978-Sept. 1979)

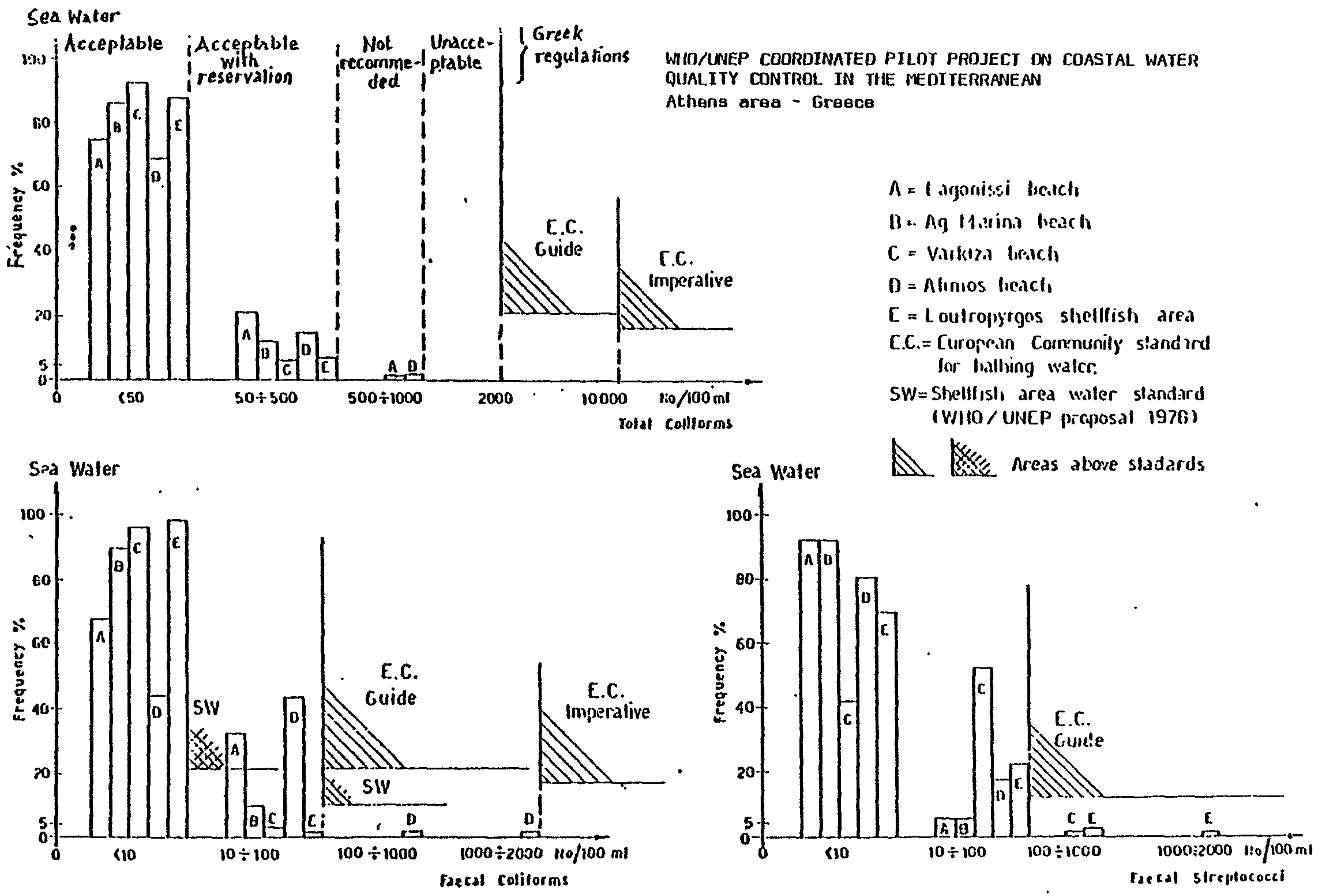

Fig. 3. Sea water quality data (Period May 1977-Sept. 1978)

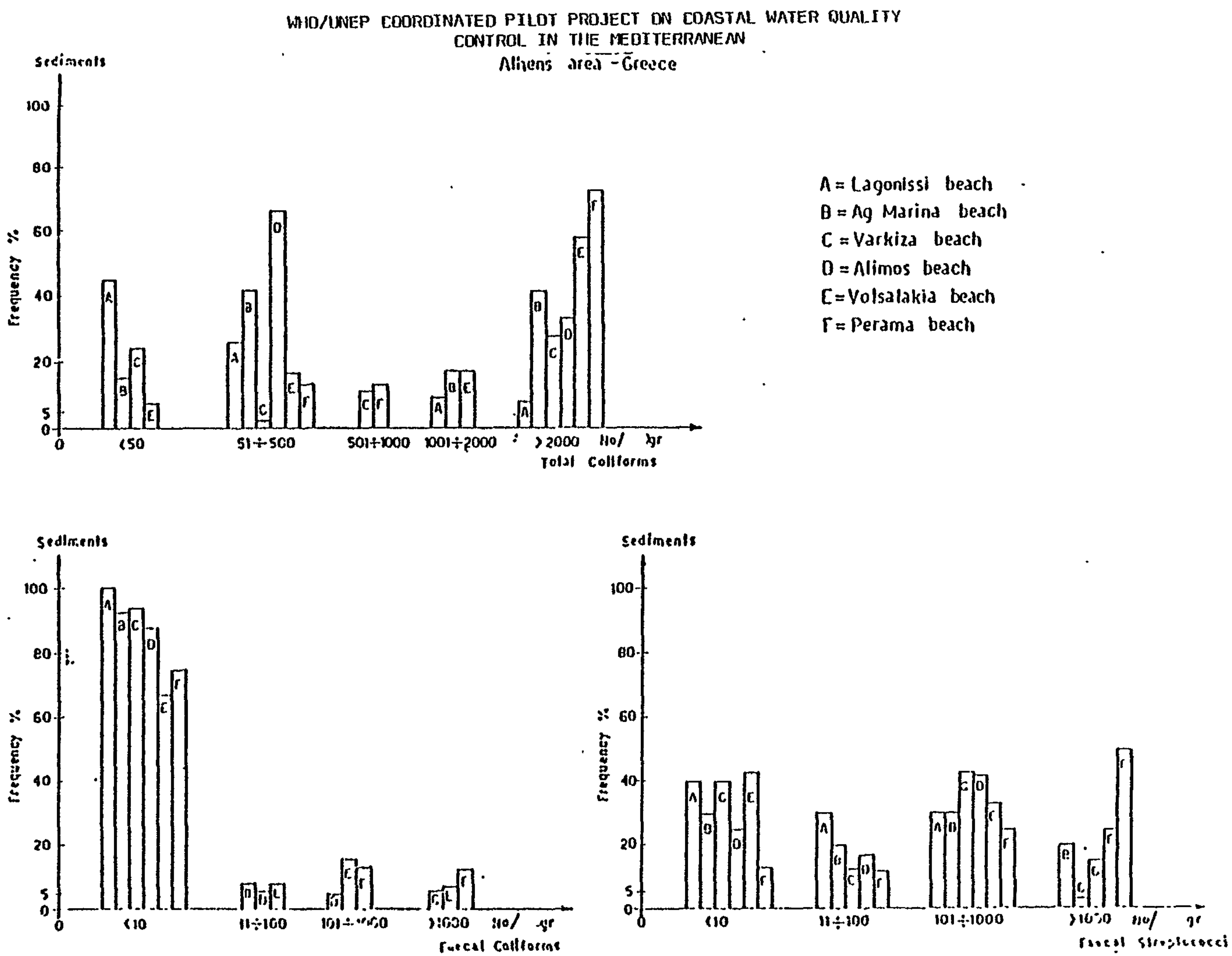

Fig. 4. Sediments quality data (Period Sept. 1978-Sept. 1979)

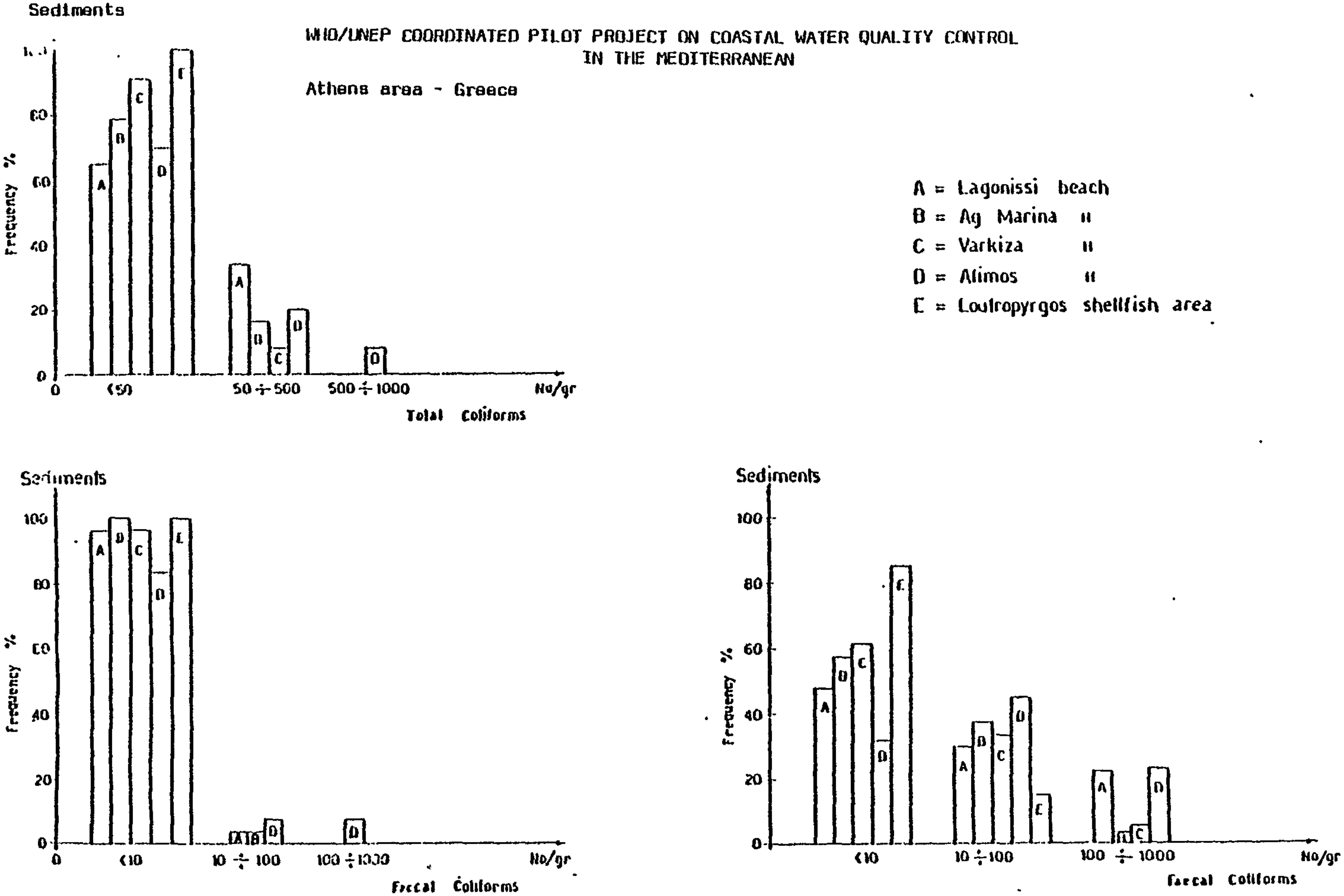

Fig. 5. Sediments quality data (Period May 1977-Sept. 1978)

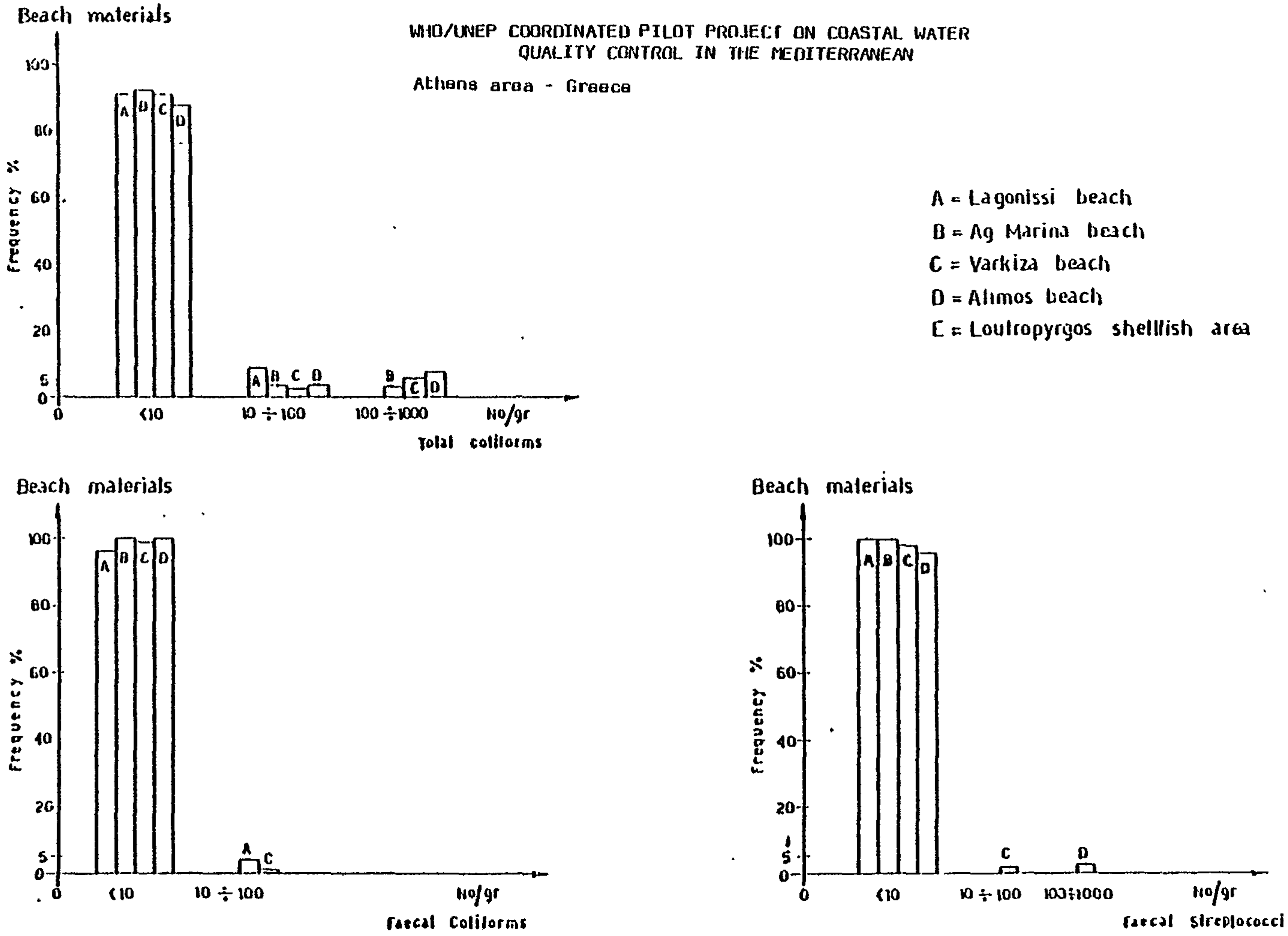

Fig. 6. Beach quality data (Period May 1977-Sept. 1978)

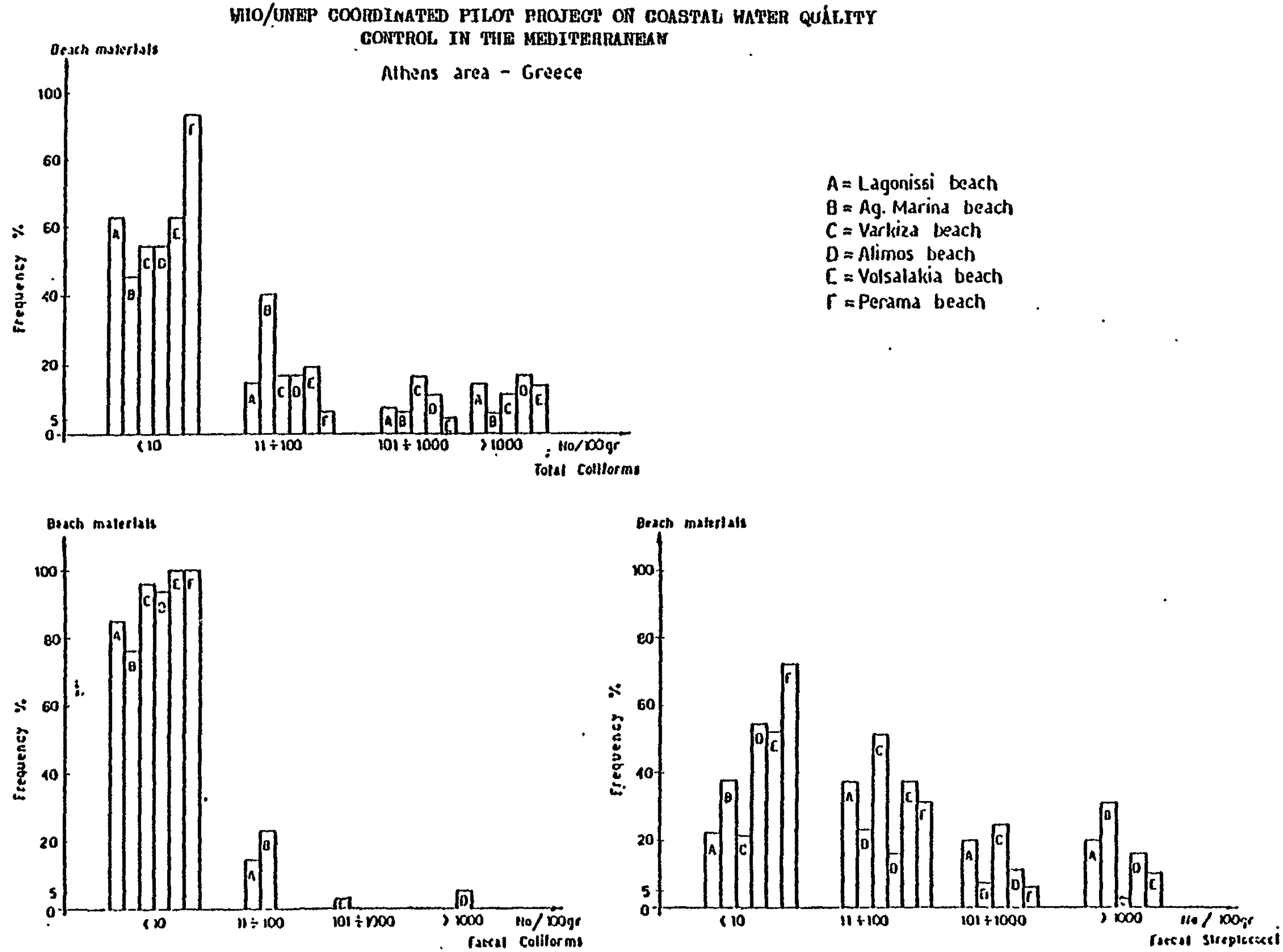

Fig. 7. Beach quality data (Period Sept. 1978-Sept. 1979)

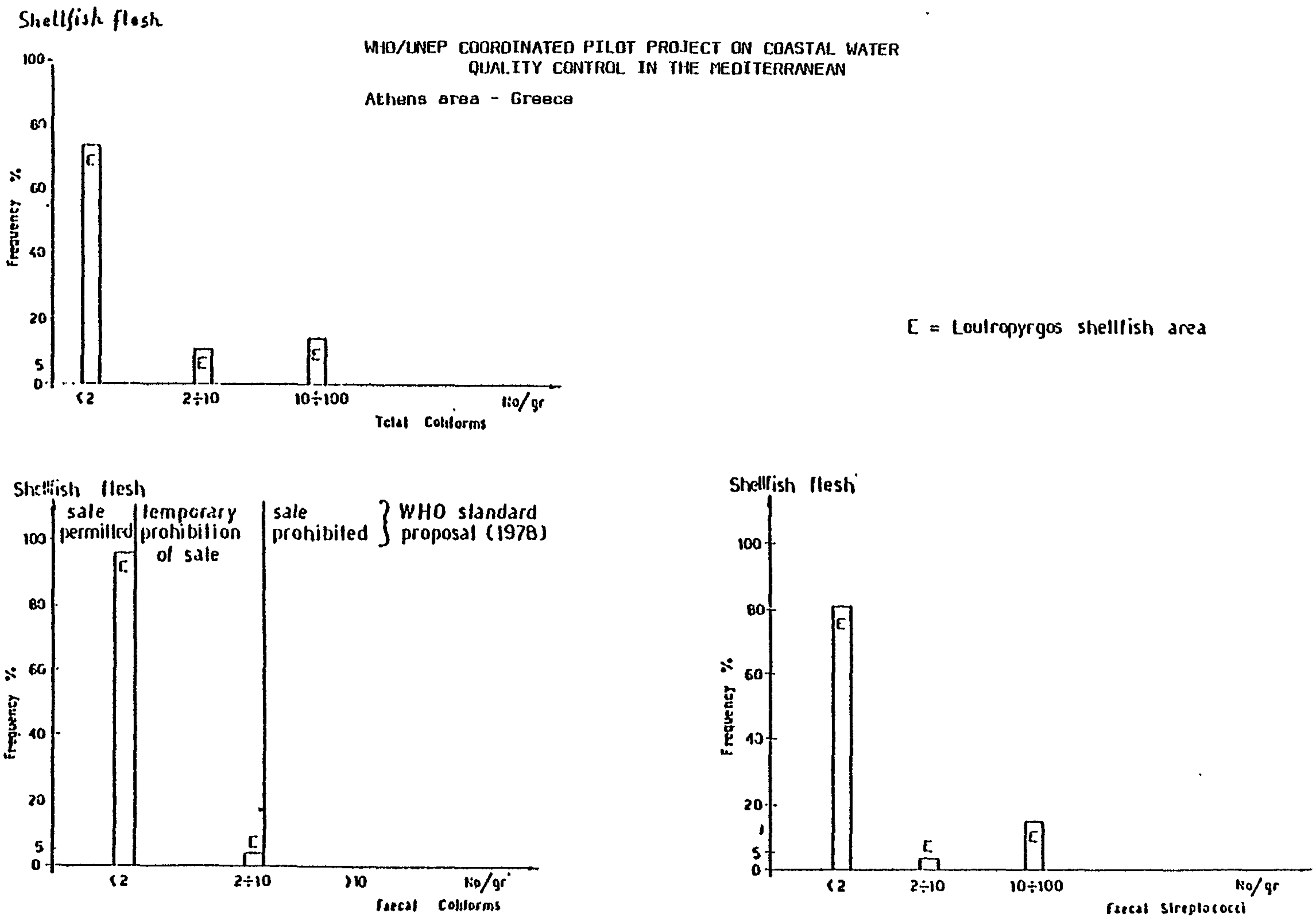

Fig. 8. Shellfish flesh quality data (Period May 1977-Sept. 1978)

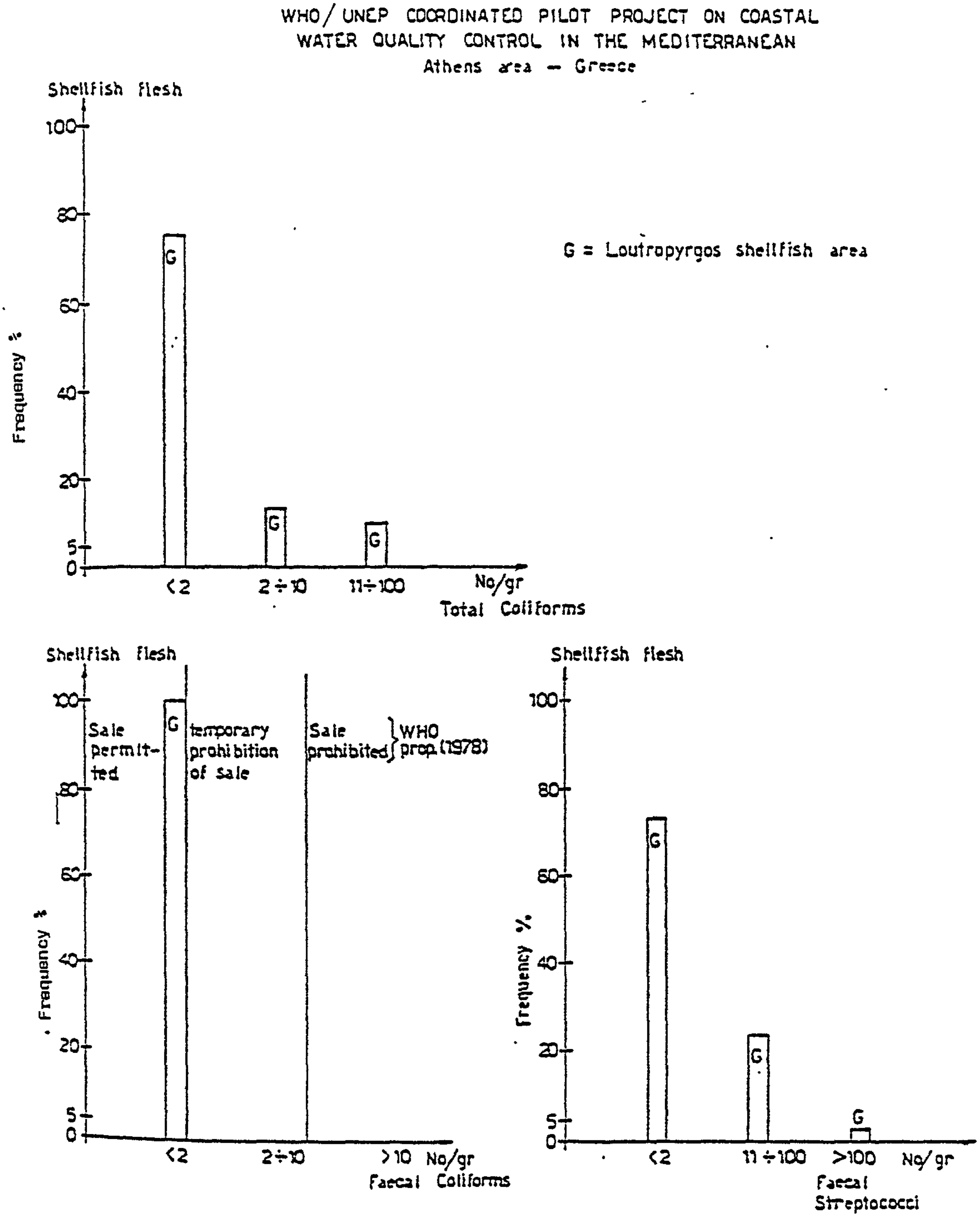

Fig. 9. Shellfish flesh quality data (Period Sept. 1978-Sept. 1979)

WHO/UNEP COORDINATED PILOT PROJECT ON COASTAL WATER QUALITY CONTROL IN THE MEDITERRANEAN

Athens area - Greece

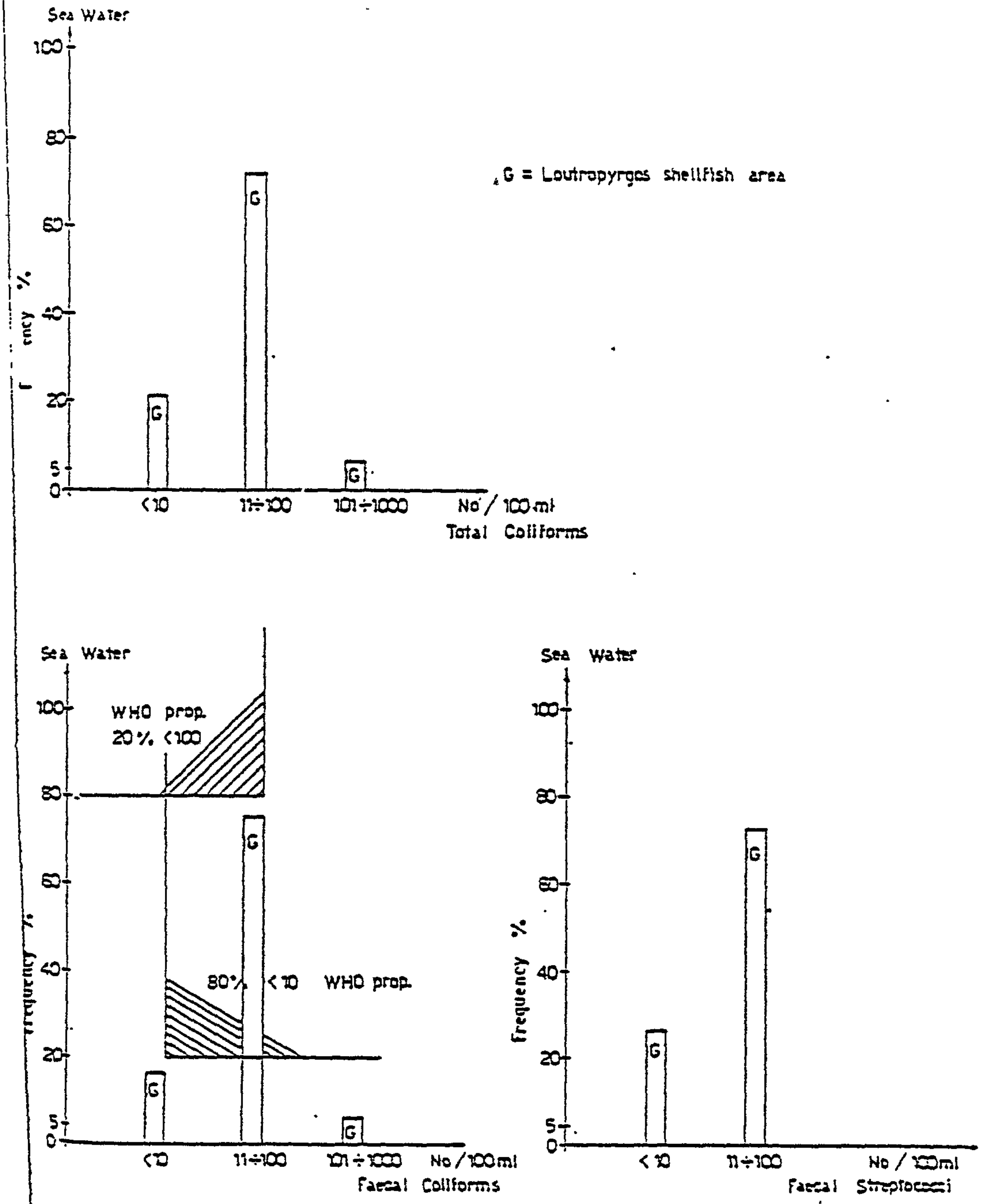

Fig. 10. Shellfish culture water quality data (Period Sept. 1978-Sept. 1979)

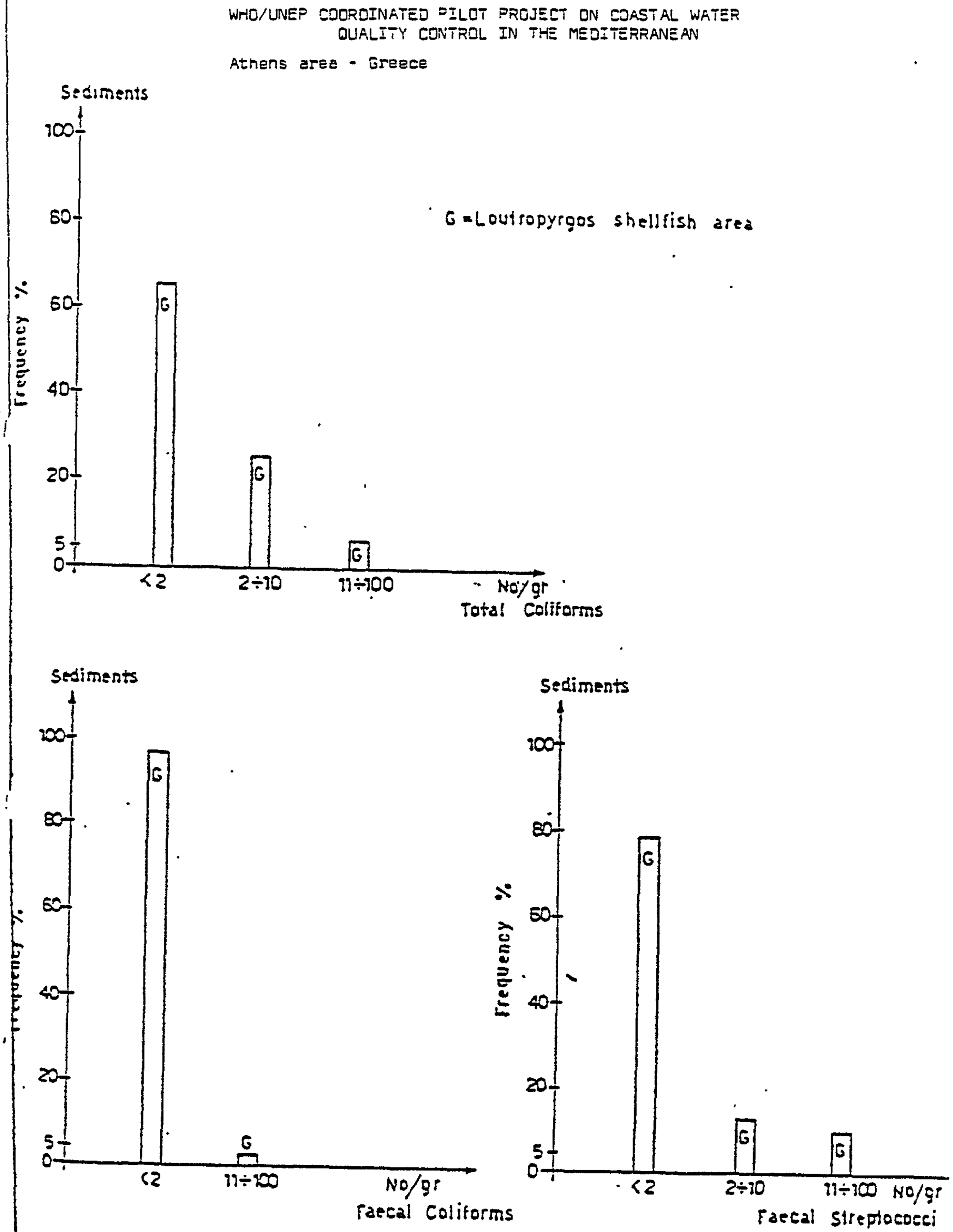

Fig. 11. Shellfish area sediments quality data (Period Sept. 1978-Sept. 1979)

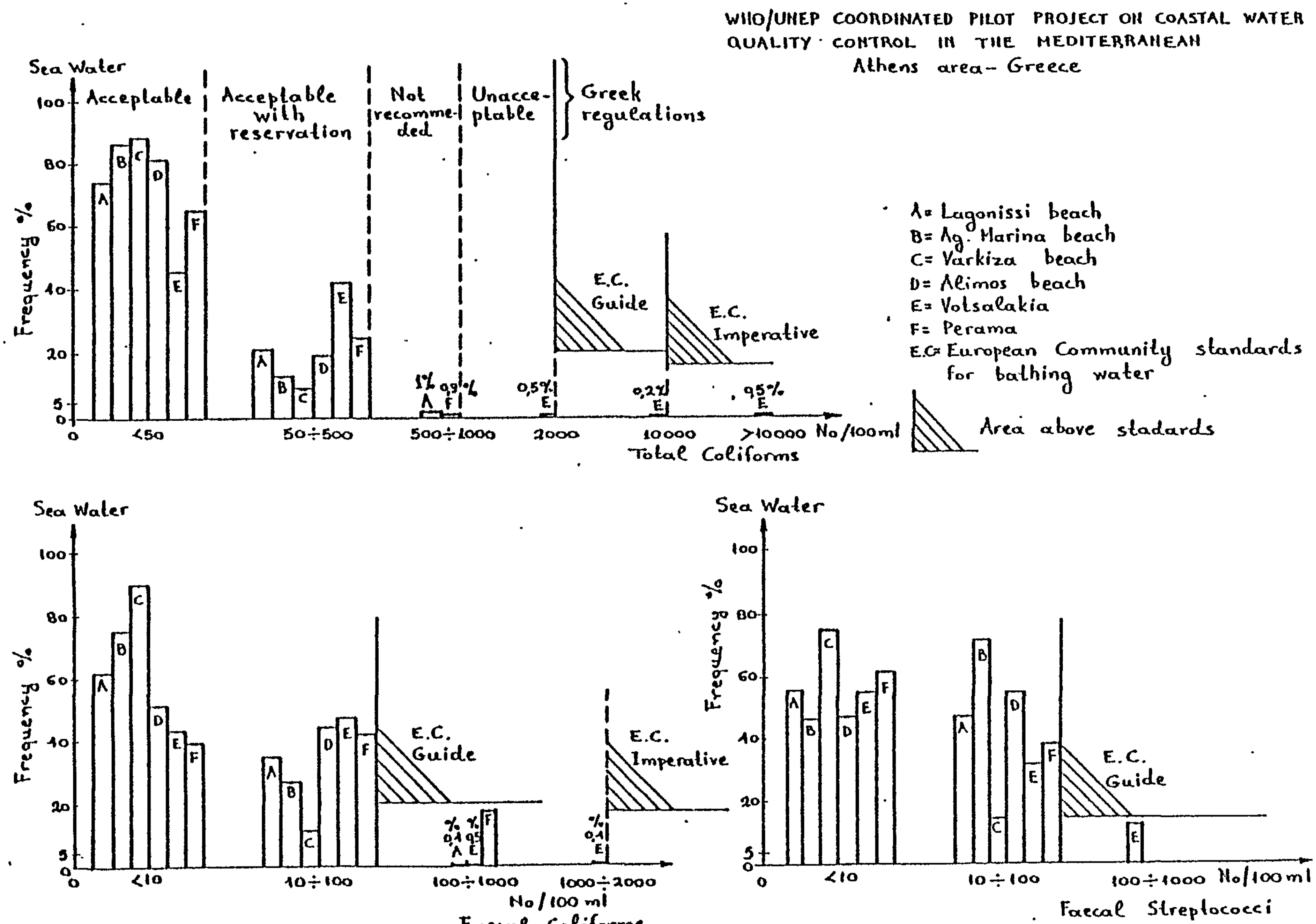

Fig. 12. sea water quality data (Period Sept. 1979-March 1981)

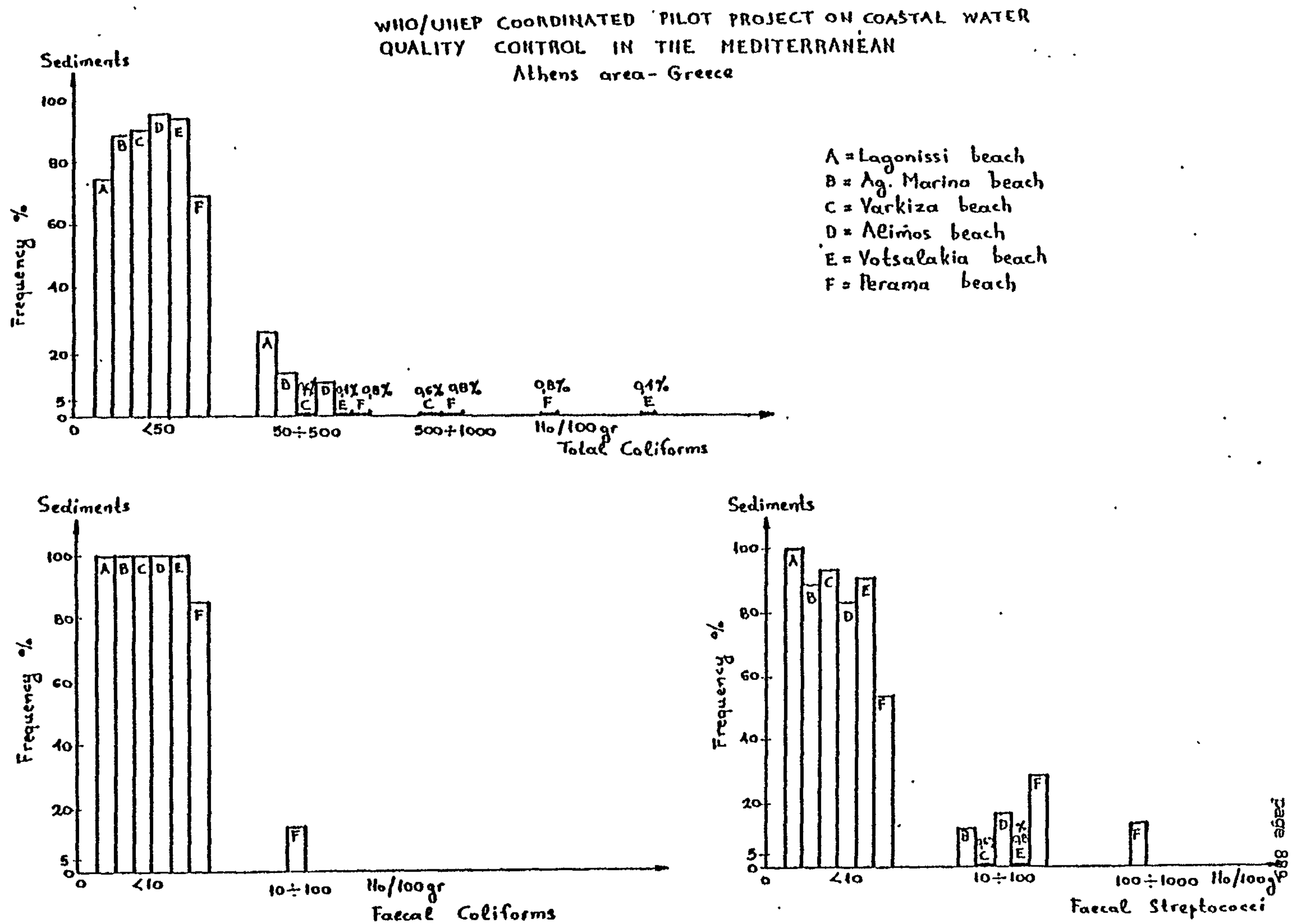

Fig. 13. Sediments quality data (Period Sept. 1979-March 1981)

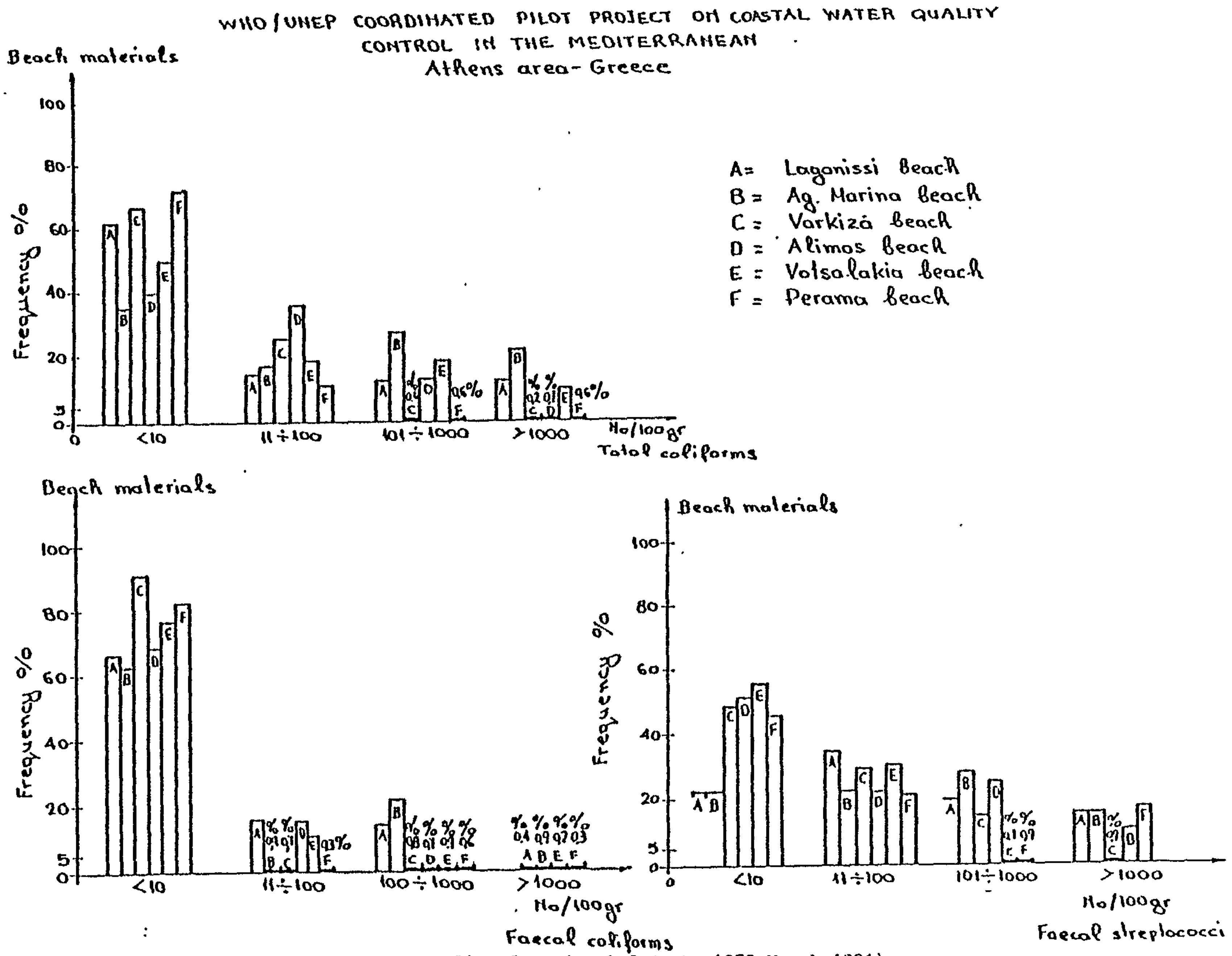

Fig. 14. Beach quality data (Period Sept. 1979-March 1981)

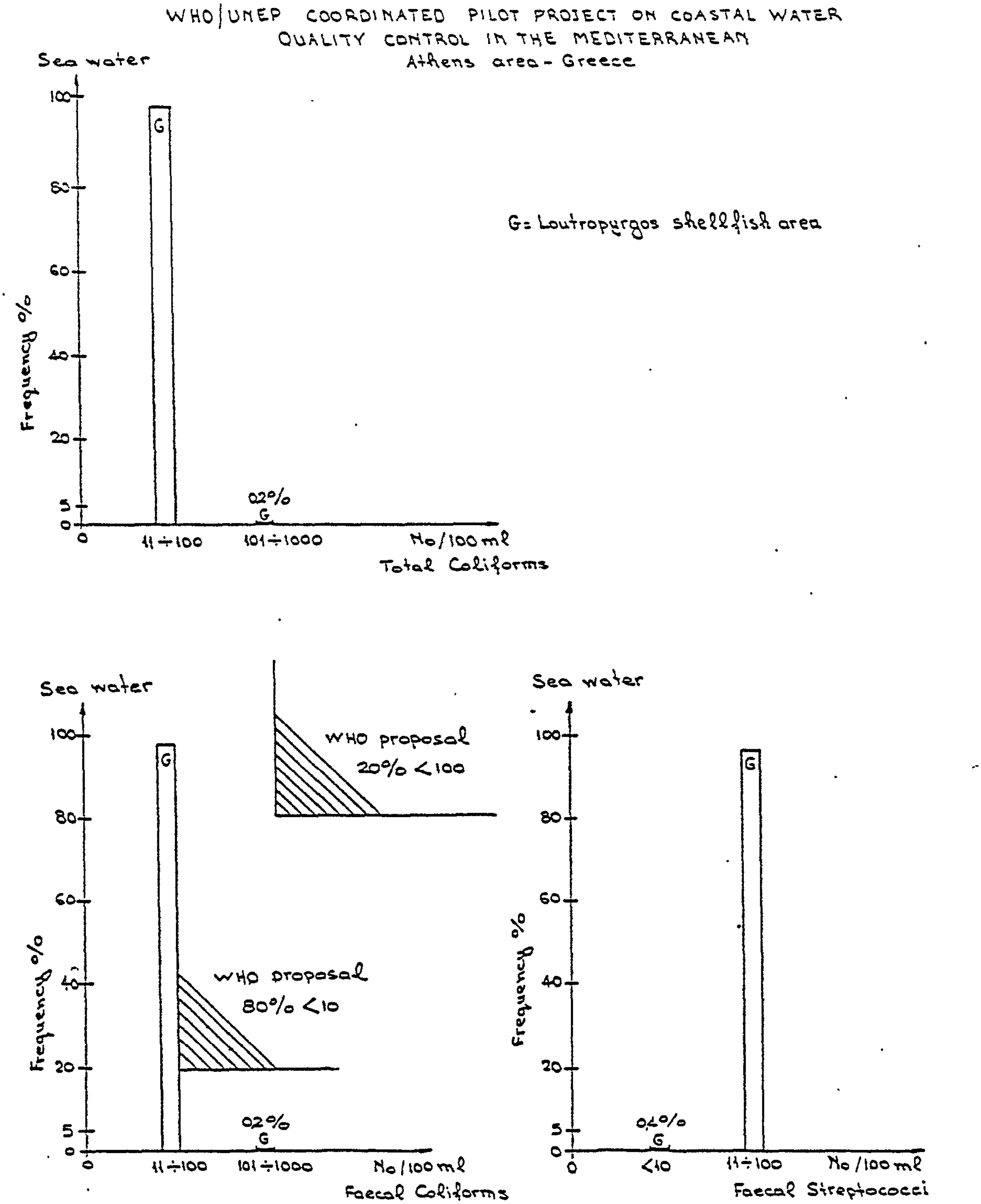

Fig. 15. Shellfish culture area quality data (Period Sept. 1979-March 1981)

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QUALITY CONTROL IN THE MEDITERRANEAN
Athens area - Greece

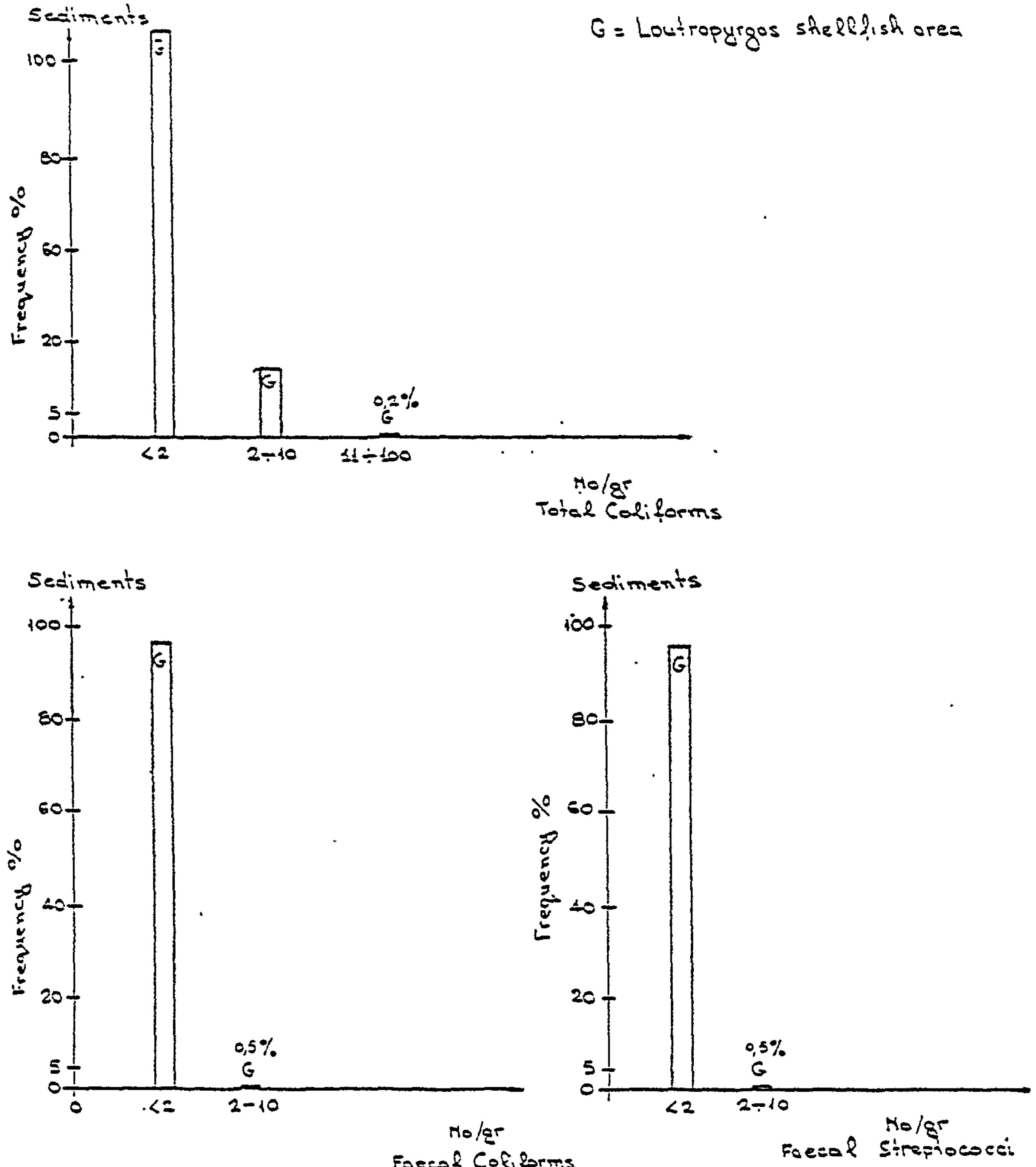

Fig. 16. Shellfish area sediments quality data (Period Sept. 1979-March 1981)

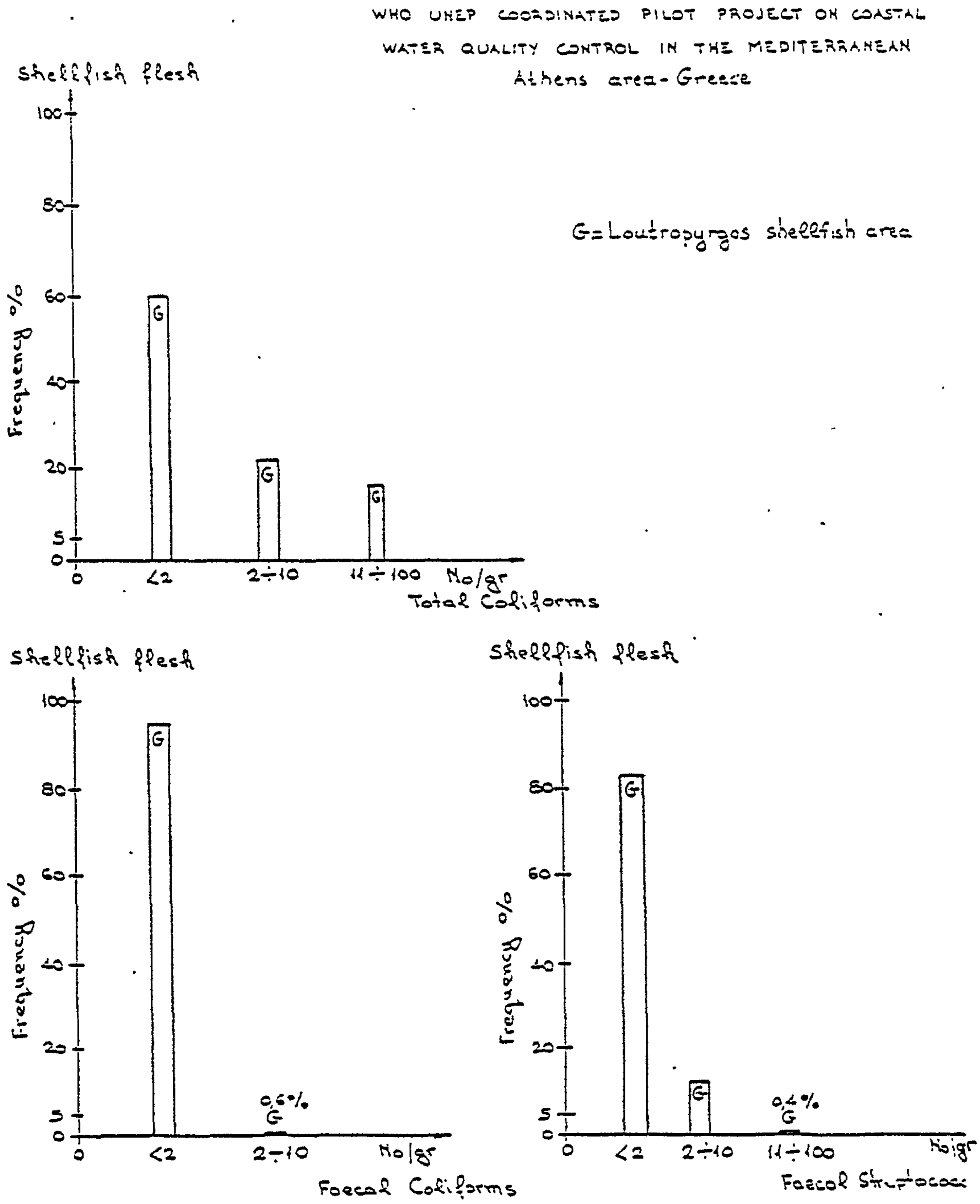

Fig. 17. Shellfish flesh quality data (Period Sept. 1979-March 1981)

Research Centre: Institute of Hygiene
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INTRODUCTION

A large body of investigations has been devoted to the study of the hygienic conditions of sea-water and of seafood, including monitoring.

Since many years (Petrilli, 1938) our Institute has been investigating the hygienic conditions of sea-water and seafood. These activities included the monitoring of certain areas, particularly in the northern Tyrrhenian Sea. However, some chemical aspects of pollution both of sea-water and of the hydric fauna have also been investigated in regions other than the Mediterrranean Sea and even in remote areas, e.g. in the Caribbean Sea, in the Indian Ocean, etc. Our activities included the study of physical (e.g. radioactivity), of chemical, including heavy elements, and of microbiological (bacteria and viruses) aspects.

AREA(S) STUDIED

The general topography of the areas monitored within MED POL project (Tuscany Littoral, Elba, Gorgona and Capraia Isles, Calambrone and Cecina Rivers) (latitude 43°35'N- 42°40'N, longitude 9°45'E- 10°33'E) is shown in Fig. 1.

The prevailing currents in the whole investigated area flow from south to north. However, the direction of the flow is sometimes reversed close to the coastline.

On the whole, 287 sampling stations were monitored in the periods indicated in Table I. Some clarifications are needed for the choice of monitoring stations:

(a) At variance with the previous summary report, we have now re-arranged the identification of stations in order to obtain consecutive numbers. Such a solution was more suitable for mechanographical computerization.

(b) According to the proposed methodolgy of the MED POL VII pilot project, the sampling stations should be located along the sea-shore at a distance of 250 m each from other.

(c) A distinctive enumeration of stations in non-influenced areas is, in our opinion, impracticable. In fact, some of the stations are certainly very far from pollution sources (e.g. in the Gorgona Isle). In other cases the term "non-influenced area" appears to be rather ambiguous, since the influence of pollution sources, even at a relative distance, is linked to a number of local and variable factors affecting the spread of pollutants. We feel that the identification of a non-influenced area should better rely on the results of the analyses performed, rather than on topographical criteria.

(d) Frequency of sampling: a frequency of at least 1 sampling per month was generally chosen in bathing areas during the summer season. Samplings were less frequent in bathing areas during the off-season, as well as in very clean or in heavily polluted areas. In same cases, surface and bottom sea-water samples were analysed and compared. In a few cases, sediment material (sand or slime) was also collected and examined. The total number of samples collected in the monitored areas is reported in Table I.

(e) According to the agreement, one shellfish purification area was included in our monitoring programme. However, analyses could not be performed because this purification plant is not yet working in Leghorn. Therefore, all the samples at dispatch points, at markets or in restaurants were not representative of the monitored area.

MATERIALS AND METHODS

The microbiological parameters determined in the monitored areas are reported in Table I. Briefly, total heterotrophic bateria were checked by the pour plate method after 48 hours at 35°C in Plate Count agar. Faecal streptococci were determined by the mebrane filter method on m-Enterococcus agar. Total coliforms and E. coli were determined by the multiple tube fermentation method, as follows: presumptive test in Lauryl Tryptose broth at 35°C (5 tubes/dilution) and confirmatory tests in Brilliant Green Lactose Bile broth at 35°C and 44°C, respectively. All the bacteriological media were from Difco. The MPN method has been used so far, instead of the suggested MF method, for two reasons:

(a) The MPN method is compulsory in Italy for the monitoring of bathing areas, and therefore is currently used in our laboratory and in those of collaborating institutions;

(b) We received only at the end of 1978 the filtration apparatus which was kindly supplied by WHO. However, comparative assays of the MPN and MF methods, according to the methods described in WHO Guidelines for Health Related Monitoring of Coastal Water Quality (1977), have been now carried out (see under "RESULTS" below). Animal viruses were concentrated from sea-water and from sediment eluates by absorption on insoluble polyelectrolytes (PE60, Monsanto Co., St. Louis, Mo., USA) (Wallis, C., Grinstein, S., Melnick, J.L. and Fields, J.E., Appl. Microbiol., 18, 1007-1014, 1969; Petrilli, F.L., De Flora, S., Vannucci, A. and Badolati, G., Giorn. Ig. Med. Prev., 12, 3-17, 1971). Polyelectrolyte eluates were seeded into primary cultures of African Green Monkey Kidney (AGMK) and in continuous-line KB cells. The viruses recovered were group classified according to CPE patterns agglutination ability and serological tests (haemagglutination inhibition and seroneutralization). The character of polioviruses was checked by mean of the temperature marker (T or rct/40).

RESULTS AND THEIR INTERPRETATION

Virological monitoring:

Examination of 11 samples at the beginning of 1975 (4 of surface water, 4 of bottom water at a depth ranging from 0.5 to 3 m, and 3 of sediment eluates) led to the detection of a large number of virus strains. The results of these virological analyses, together with other virological studies carried out in northern Tyrrhenian Sea in 1974, have been described in detail and discussed in previous papers (Crovari and Co-workers, 1974; Petrilli, De Flora and Lemori, 1975; De Flora, De Renzi and Badolati, 1975).

Bacteriological monitoring:

The median values of E. coli in the 287 monitoring stations considered (in all 2886 sea-water samples) are represented in Fig. 2. Fig. 3. shows the geometric mean (space between each couple of vertical bars) and the corresponding 95% confidential limits (vertical bars) for each of the monitoring stations where all the three bacteriological parameters (i.e. total coliforms, E. coli and faecal streptococci) had been considered (232 stations, for a total of 1216 samples). The bacteriological load of pollution in the coastal waters of the Tuscany littoral appeared to be highly variable. As expected, the bacteriological indicators were greatly influenced by the discharge of sewage effluents and polluted streams in coastal waters facing Leghorn port and town and other urban settlements, some of which receive large numbers of tourists in the summer season. Considerable pollution was caused by the so-called "Fossi Medicei", an ancient system of canals surrounding the older pentagonal Leghorn town where a number of sewage effluents are discharged. The Cecina river was heavily polluted, especially in the terminal tract, just before flowing into the sea. Conversely, the pollution load afforded by the Calambrone river was relatively low.

The bacteriological situation appeared to be rather satisfactory in the coastal waters surrounding the Isle of Elba, with a few exceptions in localized water bodies receiving sewage effluents from the major urban settlements and tourist resorts. The water around the islands Gorgona and Capraia, which are far away from pollution sources, appeared to be very clean, except in the port of Capraia.

Most bathing areas, which were generally checked at regular intervals (monthly in the bathing season and every 2-3 months in the other periods of the year), were found to be below the threshold limit fixed by Italian sanitary authorities (100 E. coli in 100 ml sea-water) in all the monitored areas. As shown by the amplitude of the confidential limits represented in Fig. 3, there was a very marked variability of results among the multiple samples collected throughout the year in some stations, and especially in heavily polluted waters. Such variability was in most cases consistent with a heavier pollution during the winter season. The factors which could be responsible for such variability are too numerous to be identified on the basis of the results obtained. They include for instance:

1. The sea and metereological conditions at the moment of sampling and in the days before.

2. The longer survival of micro-organisms in sea-water during the cold season.

3. The daily variability of pollution, as demonstrated in previous investigations (Petrilli, De Flora and Lemori, 1975).

4. The flow variability of small polluted streams, whose discharge into the sea is decreased or even interrupted during dry months. The same phenomenon was sometimes also observed for rivers, such as the Cecina river.

5. The variability of the resident population and of tourists, leading to seasonal variations of the sewage flow.

6. In the Leghorn municipality, plants are working during the summer season, which pump out the sewage from the effluents into the sea north of Leghorn, where bathing is prohibited and where favourable currents remove pollutants far from the coast-line.

Correlation between total coliforms, E. coli and faecal streptococci:

The statistical elaboration of the data obtained from 1,216 sea-water samples, where all the three bacteriological parameters had been checked provided evidence for a positive correlation between total coliforms and E. coli ($r = 0.829$); between total coliforms and faecal streptococci ($r = 0.793$), and between E. coli and faecal streptococci ($r = 0.929$). The corresponding regression lines are represented in Fig. 4.

Interaction between micro-organisms and industrial pollutants:

As clearly shown in Fig. 3, a peculiar situation was detected in stations 260 to 287 (Rosignano-Solvay), which are set out at regular intervals (25 m each from the other) in a coastal water receiving untreated wastes from an industry producing soda and a number of other chemicals. These warm and alkaline industrial wastes, carrying large amounts of calcareous matter, are combined with domestic sewage prior to discharge into the sea. We have carried out a multi-disciplinary study in this area (Petrilli and Co-workers, 1979).

The results obtained in laboratory investigations provided evidence for a selective inactivation of coliform bacteria by the industrial wastes. In particular, the greater inactivation of total and faecal coliforms, as compared with faecal streptococci, could be ascribed to three combined factors which are typical of the wastes under study, i.e. the high temperature (about 35°C in the terminal tract of the waste-water effluent), the alkaline reaction (pH about 9.4) and absorption phenomena on to suspended calcareous matter (2-3 g/l).

Correlation between animal viruses and E. coli:

The results of the microbiological investigations which were carried out in 4 stations of the monitored area, together with other samples collected in the northern Tyrrhenian Sea, for a total of 54 sea-water samples, were analysed in order to assess the correlation between animal viruses and E. coli (Petrilli and De Flora, 1977).

Briefly, viruses were detected in 100% of samples exceeding 920 E. coli per 100 ml, at a sensitivity level of 1 TCD (50% tissue culture infective dose) of virus per litre of sea-water.

A significant correlation was found between the numbers of E. coli and those of enteroviruses (Fig. 5). However, the slope of the regression line clearly showed that the ratio between enteroviruses and E. coli tends to increase with the pollution load (from 1:2,000 in moderately polluted waters up to 1:500,000 in heavily polluted waters). This might be ascribed to technical factors and mainly to the longer survival of viruses in the marine environment as compared with bacterial indicators. As reported more extensively in another paper (De

Flora, De Renzi and Badolati, 1975), the assessment of the microbiological contamination of coastal sediments, including those investigated in the Leghorn area led to the conclusion that sediments in shallow coastal waters can represent a transient reservoir of animal viruses.

Comparison of the MF and MPN methods:

A laboratory study on the efficiency of the MF method suggested by WHO guidelines and of the MPN method used in Italy for the quality control of bathing areas has been carried out (Rizzetto, et al., 1978). The results obtained, in agreement with other literature data on this subject, show that the MPN method has a greater accuracy and yields higher counts than the MF method. Conversely, the latter method is more precise, as far as homogeneity of results is concerned.

CONCLUSIONS

The results herein presented show a general picture of the microbiological contamination of coastal waters in the Tyrrhenian Sea. Moreover, they provide information on scientific problems involved in the assessment of coastal water quality.

PUBLICATIONS

Based on work covered in this report:

DE FLORA, S., DE RENZI, G.P. and BADOLATI, G. Appl. Microbiol. 30, 472-475, 1975.

PETRILLI, F.L. and DE FLORA, S. Rev. Int. Océanogr. Med. 48, 33-36, 1977.

PETRILLI, F.L., DE RENZI, G.P., PALMERINI MORELLI, R. and DE FLORA, S. Water Res. 13, 895-904, 1979.

PETRILLI, F.L., DE RENZI, G.P. and DE FLORA, S. IV[es] Journées Etud. Pollutions, Antalya, CIESM, pp 477-481, 1978.

PETRILLI, F.L., DE RENZI, G.P., ORLANDO, P. and DE FLORA, S. Progress Water Technol. 112, 129-136, 1980.

RIZZETO, R., COPPOLA, R, BENIKELLI, C. and CARBONARA, D. Giorn. Ig. Med., Prev. 19, 74-79.

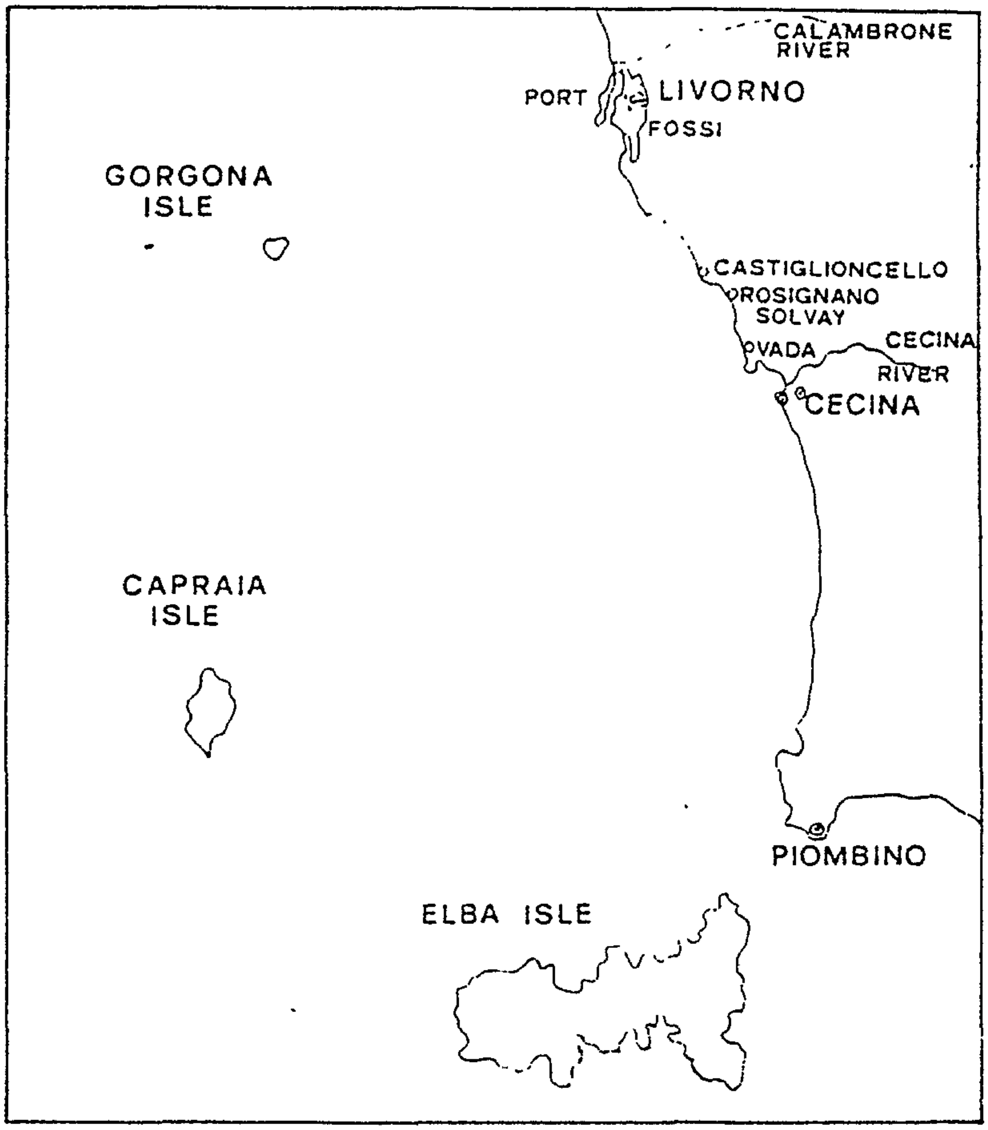

Fig. 1. General map of the monitored area, with the indication of the localities reported in Table 1

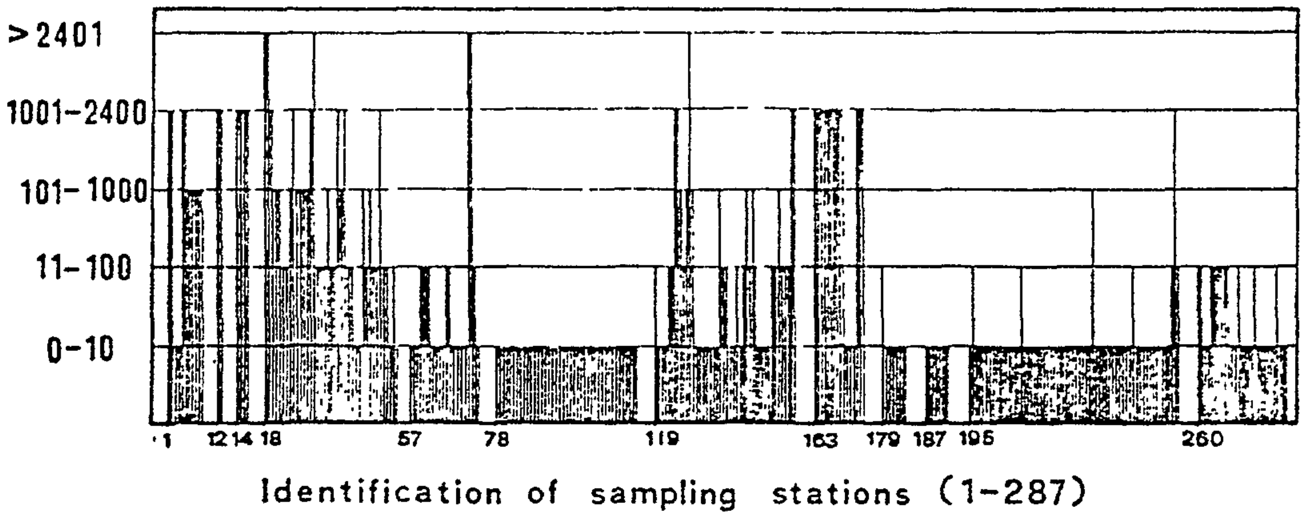

Fig. 2. Class distribution of E. coli concentration (median values) in 100 ml seawater in each of the 287 sampling stations monitored.

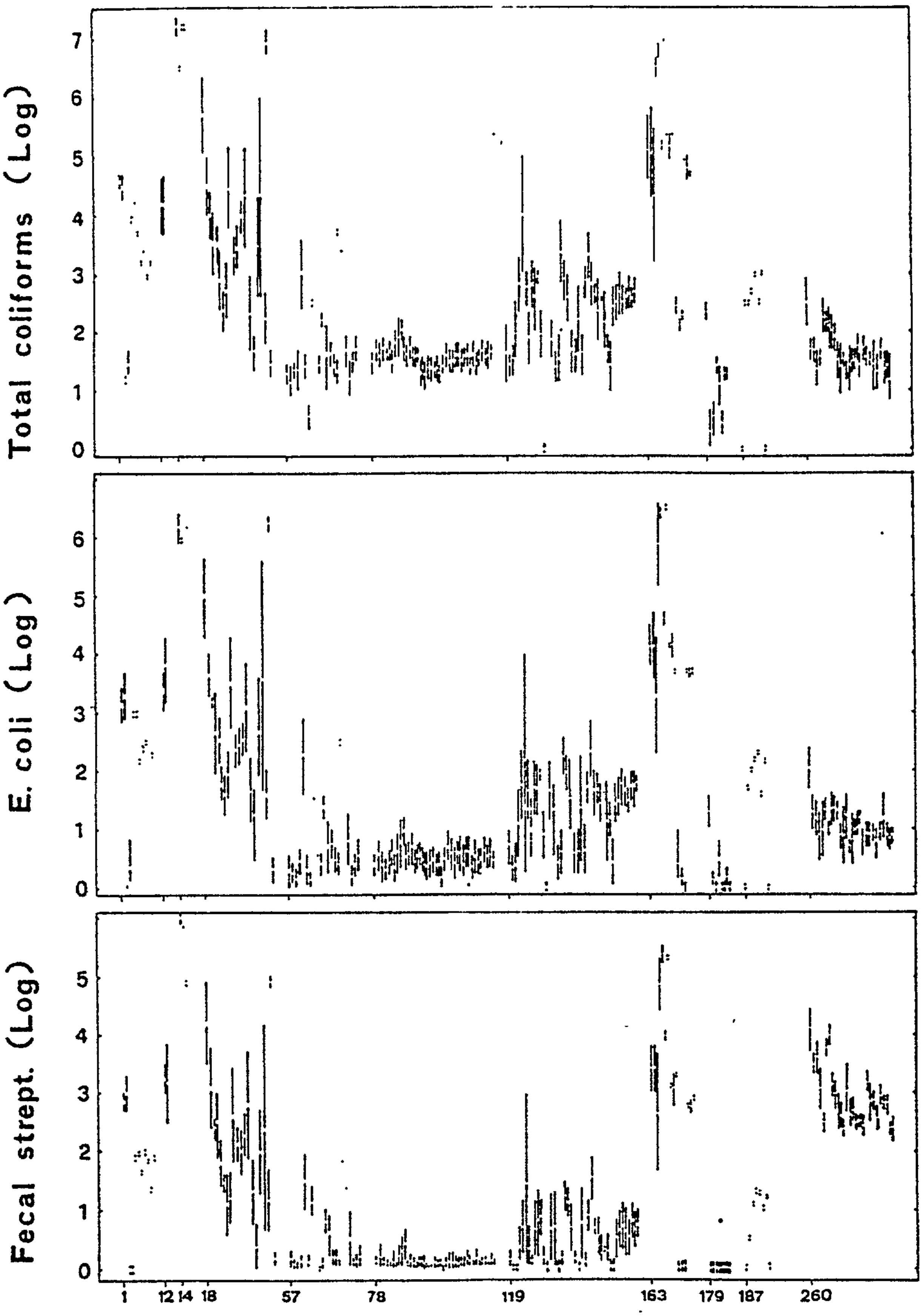

Fig. 3. Means and corresponding 95% confidential limits of bacteriological indicators (in 100 ml seawater) in 232 sampling stations (i.e. all those monitored, with the exception of Nos. 195-259, where only E. coli was considered). Two close points refer to stations where only one sample had been examined.

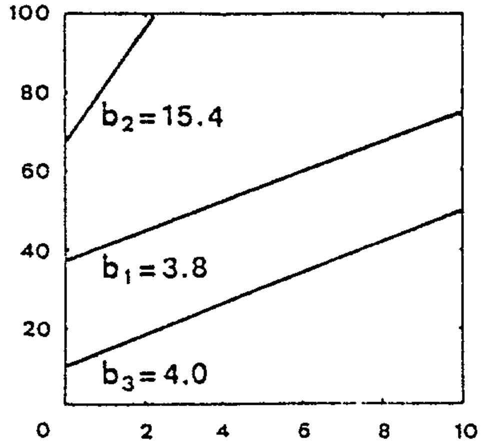

Fig. 4. Regression lines and regression coefficients (b) of E. coli to total coliforms (b1), of faecal streptococci to total coliforms (b2) and of faecal streptococci to E. coli (b3)

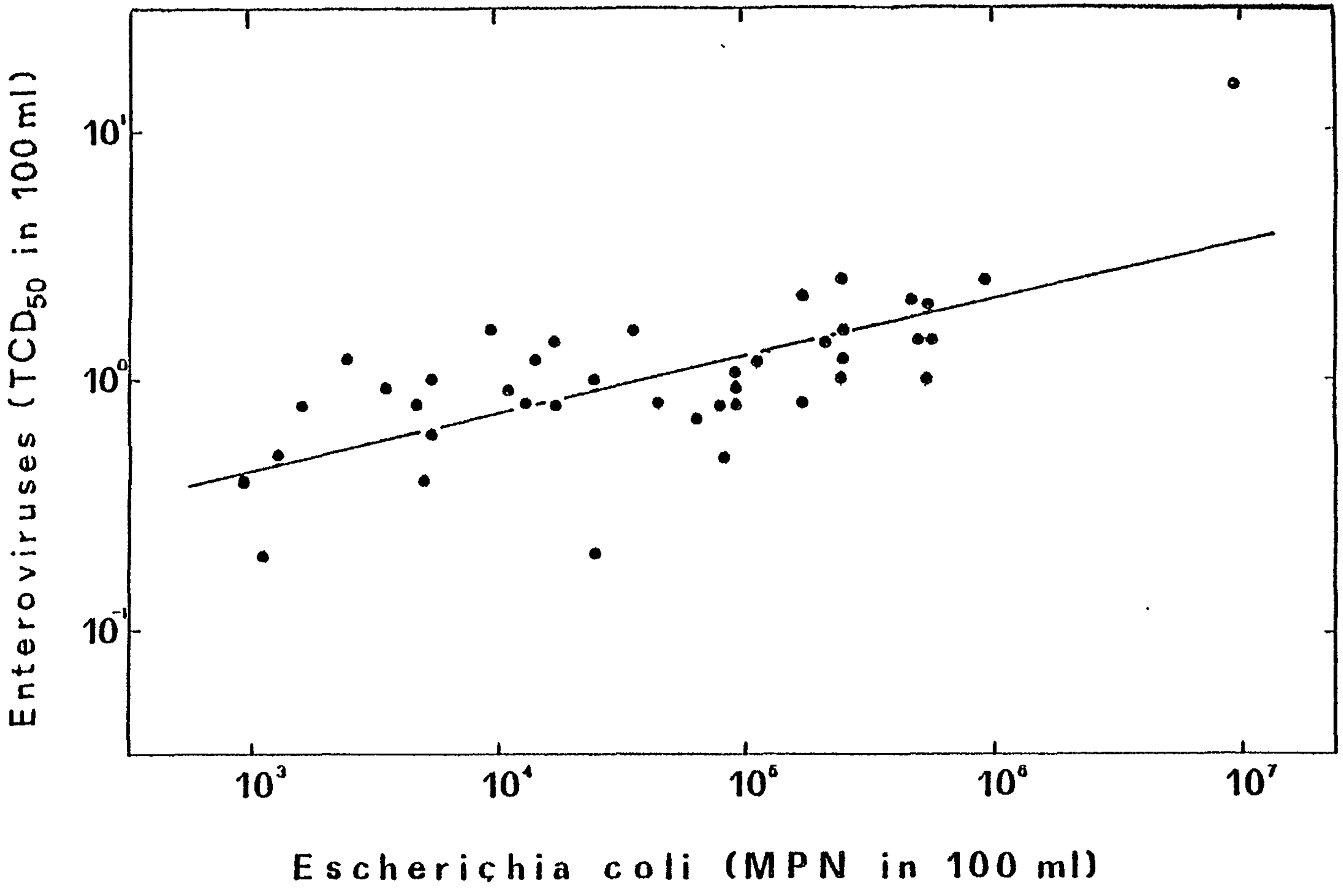

Fig. 5. Correlation between enteroviruses and E. coli in 41 seawater samples

Table I. Flow diagram of the sampling stations under monitoring and of the microbiological parameters examined.

Monitored area	Monitoring period	Sampling points Nos.	No. of samples				Microbiological parameters					
			surf.	depth	sed.	tot.	E. coli	Total colif.	Fecal strept.	Het.bact. 20°C	Het.bact. 35°C	Animal viruses
Calambrone River	Jan 75-Apr 75	1-11	16	3	1	20	20	20	20	-	-	3
Leghorn Port	Aug 75-Jul 76	12-13	3	2	1	6	6	6	6	-	-	3
Leghorn 'Fossi'	Jan 75	14-17	4	1	1	6	6	4	4	-	-	3
Littoral: Leghorn Municipality	Jan 75-Apr 79	18-56	973	17	-	990	990	189	189	-	-	2
Littoral: from Leghorn to Castiglioncello	Apr 75-Apr 79	57-77	266	6	-	272	272	171	171	-	-	-
Littoral: Rosignano and Vada	Jan 75-Mar 79	78-118	628	-	-	628	628	467	467	-	-	-
Littoral: from Cecina to Piombino	Apr 75-Aug 78	119-162	456	-	-	456	456	187	184	-	-	-
Cecina River	Aug 75-Jul 76	163-178	32	3	-	35	35	35	35	16	16	-
Gorgona Isle	Jul 77-Aug 78	179-186	16	4	-	20	20	20	20	-	-	-
Capraia Isle	Aug 77	187-194	8	-	-	8	8	8	8	-	-	-
Elba Isle	May 75-Aug 77	195-259	333	-	-	333	333	35	-	-	-	-
Rosignano-Solvay	Jun 76-Aug 77	260-287	112	-	-	112	112	112	112	112	-	-*
Total	Jan 75-Apr 79	1-287	2847	36	3	2886	2886	1254	1216	128	16	11

* Plus inactivation assays of bacteria and viruses

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Principal Investigator: S. GENOVESE

INTRODUCTION

The Institute of Hydrobiology has for a long time been carrying out intense research activity in order to evaluate the pollution rate in coastal and brackish Sicilian and Calabrian waters. Research started in 1964 and has concentrated on the eastern coast of Sicily, in the area between the Gulf of Patti and Siracusa and the western coast of Calabria, from Capo Suvero to Capo delle Armi. The Straits of Messina, the Augusta inlet and the Gulf of Milazzo have been studied in more detail.

During the period February 1979 to October 1979, for various reasons it has not been possible to carry out the intended intensive monitoring programme. The programme was limited to only four (4) sampling periods.

AREA(S) STUDIED

The study zone, shown in detail in figure 1, includes two coastal tracts, one located along the Tyrrhenian coast, the other along the Ionian coast, with 12 and 14 sampling stations, respectively, and two reference points, one for each zone, 1 km from the coast. These particular areas have been selected because during the summer, bathing and recreational activities take place here. We prefer to describe the two zones separately as, even if they are very close to each other, they are part of two completely different environments. Only very scarce scientific information is available about the Tyrrhenian zone. There is no evidence of the occurrence of natural or artificial draining of water effluents from very limited urban settlements. However, it must be noted that as there are many (nine) urban bathing establishments and numerous villas located in this zone, the density of the summer population is very high. Winds mainly influencing the zone are from the north-east; they are discontinuous, with brief gusts, but can cause violent sea-storms. Southern winds, frequent and strong in the Messina area, only indirectly influence the coastal tract examined.

There is quite extensive information concerning the Ionian zone, as the Straits of Messina have long been the object of study by various oceanographic disciplines because of their strong tidal currents and the consequent hydrological and biological processes. However, much of this research has little to do with the present project and we intend to summarize only what is known about the microbiological features of the Messina Straits, based on research carried out by the Institute of Hydrobiology in the period 1964-1978.

Drains of varied capacity, flood and torrent spillways, waste-waters coming from urban settlements, with varying pollution loads, either due to the number of inhabitants, or in proportion to the discontinuous and variable town water supply, are discharged along the coasts of the Messina Straits. When these waters reach the sea, the main alternating currents and the more complex littoral counter-currents distribute the pollution load irregularly. There is evidence that currents may disperse waters with heavy faecal flora content to zones not directly polluted just as, in the same way, it may occur that as a result of the dispersion, areas receiving sewage wastes are free from faecal pollution. The Straits' central axis itself is practically free from polluting phenomena and it is possible that the currents might act as an important self-depuration factor.

In this area the shore entrance is free and there are no recreational facilities. However, it should be noted that, from 1970, along almost all the Ionian coast between Messina and Capo Peloro, which includes the zone under study, bathing has been forbidden by a municipal injunction, as the faecal coliform rate exceeds the current Italian norm allowed. It should also be added that a new sewage system with a treatment plant is about to be constructed near Capo Peloro. There are two sewage outlets in this zone, one at Pace Village corresponding to station 17, and the other at S. Agata village close to station 25. Immediately to the north of the study zone there are four other sewers and two more to the south. All drains are of small capacity, receiving refuse waters from the houses close to them. The study zone includes the Pace torrent between stations 15 and 16 and the Guardia torrent in close proximity to station 23. Immediately to the north of our stations are the torrents S. Agata and Papardo. As to the wind system, easterly and southerly winds blow in the Straits, where they reach their greatest velocity; the north-east wind is the most prevalent but is of moderate strength and blows mainly during the summer. There are occasional west winds of short duration.

MATERIAL AND METHODS

As requested for this study, methods in which filter membranes are used on a single culture medium at different temperatures have been adopted. In this respect it might be pointed out that the filter membrane technique with different media for faecal and total coliforms, has been used for a long time in our microbiological laboratory with very good results. Comparative tests have been carried out, and the single medium at two temperatures was maintained in order to apply unified methods, even if some uncertainties arose about the results obtained with the recommended method.

RESULTS AND THEIR INTERPRETATION

Period up to December 1978:

From the results obtained to date it is impossible to draw general conclusions without the winter surveys, from which we expect to have useful indications regarding the relations between faecal flora and hydrological parameters. Table I shows the distribution in frequency classes of the microbiological data collected and the different pollution rate of the two zones examined is clearly indicated.

In the Tyrrhenian zone there are no signifcant pollution sources. In fact, only faecal coliforms up to a maximum of 12/100 ml have sometimes been noted. Streptococci distribution in these waters, because of their longer survival time in sea-water, shows that there may be pollution by sewage waters, but it

August 17 at 1 km from the shore. Most of the values were less than 100 streptococci/100 ml.

As regards the Ionian Sea, the present pollution level is clearly shown by faecal coliform numbers that are rarely absent and reach a maximum of 1.8 x 10^3/100 ml. Streptococci seem to follow the same development. Only in three water samples of 100 ml were these micro-organisms not observed; this pollution index, even at 1 km from the shore, has reached values of 10^3, and the maximum obtained (30 June 1978) near the coast, was of 1.3 x 10^4 streptococci/100 ml.

Period December to July 1979:

The results of four surveys are analysed. Table II gives the results obtained, grouped in frequency classes and Table III gives the mean values of the different parameters analysed.

From these results it is possible to state that the coastal tract of the Straits of Messina under investigation is subject the year round to a certain degree of pollution due to the urban sewage wastes discharged into the sea. There is no doubt that strong tidal currents are contributing to the spreading of these polluted waters even if the current action increases the autodepuration process. Therefore it is possible that areas used for recreational activities might receive excessive quantities of bacteria of faecal origin.

As regards the Tyrrhenian tract examined, the winter surveys show that the contamination of this zone is closely connected with the seasonal cycle. In fact, during the winter, the area may be considered practically free from polluting problems.

DISCUSSION OF RESULTS

It is possible to state that the Tyrrhenian coastal tract presents a good quality level while in the Straits of Messina area the pollution rate observed gives rise to problems for recreational purposes.

All the results obtained undoubtedly permit a better knowledge of the water qualities of the coastal zone of Messina.

The results are in an advanced stage of preparation and will be published.

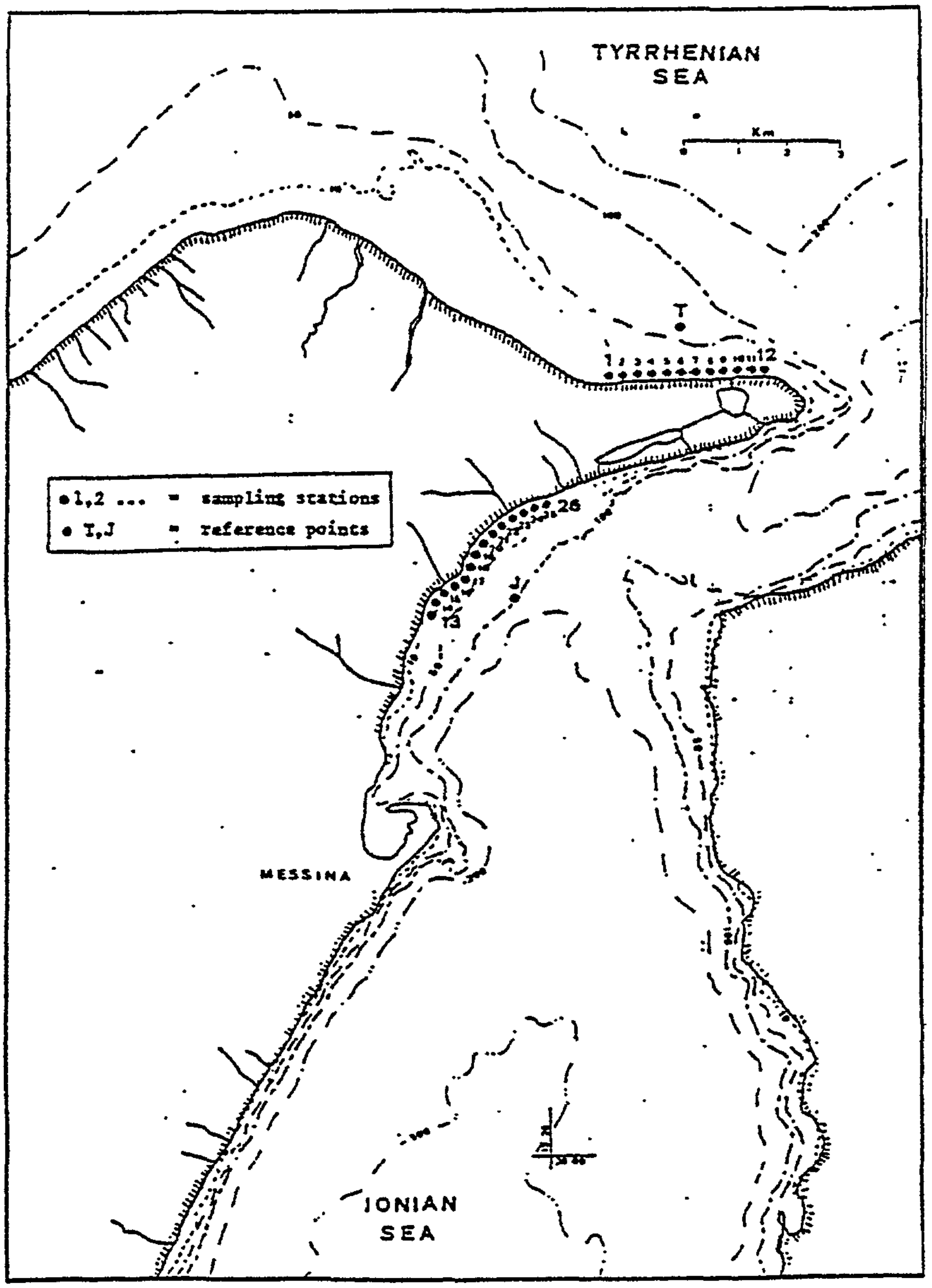

Fig. 1. Study zone

TABLE I

DISTRIBUTION IN FREQUENCY CLASSES OF THE RESULTS OBTAINED

			Frenquency classes				
			0 - 10	10 - 10^2	10^2 - 10^3	10^3 - 10^4	10^4 - 10^5
% from 60 samples	Tyrrhenian Sea	Faecal coliforms	98.3	1.7	0	0	0
		Faecal streptococci	70.0	18.3	10	1.7	0
% from 70 samples	Ionian Sea	Faecal coliforms	51.4	22.9	21.4	4.3	0
		Faecal streptococci	21.4	41.4	31.5	4.3	1.4

TABLE II

DISTRIBUTION IN FREQUENCY CLASSES OF THE RESULTS OBTAINED

(Period Jan. - July 1979)

			FREQUENCY CLASSES				
			0 - 10	10 - 10^2	10^2 - 10^3	10^3 - 10^4	10^4 - 10^5
% on 47 samples	Tyrrhenian Sea	Total Coliforms / 100 ml	74,5	4,3	21,2	0	0
		Faecal Coliforms / 100 ml	91,4	4,3	4,3	0	0
		Faecal Streptococci / 100 ml	83,0	17,0	0	0	0
% on 53 samples	Ionian Sea	Total Coliforms / 100 ml	24,5	43,4	20,8	9,4	1,9
		Faecal Coliforms / 100 ml	56,6	32,1	7,5	1,9	1,9
		Faecal Streptococci / 100 ml	47,2	39,6	11,3	1,9	0

TABLE III

MEAN OF THE VALUES OBTAINED FOR THE SINGLE SURVEYS

(Period Jan. - July 1979)

			Total Coliforms / 100 ml	Faecal Coliforms / 100 ml	Faecal Streptococci / 100 ml
2.12.78	Tyyrhenian	(12 samples)	$1,6 \times 10^{-1}$	0	$4,1 \times 10^{-1}$
	Ionian	(14 samples)	$8,0 \times 10^{2}$	$1,1 \times 10^{2}$	85
21.3.79	Tyrrhenian	(12 samples)	2,3	$1,7 \times 10^{-1}$	$8,3 \times 10^{-1}$
	Ionian	(13 samples)	$1,9 \times 10^{3}$	$1,3 \times 10^{3}$	$7,2 \times 10^{2}$
29.5.79	Tyrrhenian	(11 samples)	2,4	3,1	15,4
	Ionian	(13 samples)	15,6	6,2	10,5
12.7.79	Tyrrhenian	(12 samples)	$1,2 \times 10^{2}$	26	11,3
	Ionian	(13 samples)	$3,1 \times 10^{2}$	866	35,9

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ROME
Italy

Principal Investigator: T. LA NOCE

INTRODUCTION

An interdisciplinary programme of experimental investigations has been undertaken with the aim of evaluating the impact of the Tiber river on the receiving marine ecosystem. In this area the problems of pollution have reached an alarming level in recent years, mainly because of discharges of untreated waste-waters, industrial as well as domestic, from the city of Rome with a population of nearly 3,000,000 inhabitants.

In order to examine the phenomena of conveyance and diffusion of pollutants, and the characterization of the ecosystem affected by pollutants, the following actions have been taken:

(a) The study of the particular aspects of the diffusion of fresh water discharged through the two mouths of the Tiber in different hydrological and climatological conditions, by using the most advanced methods;

(b) The determination of basic parameters for a more detailed picture of the distribution of fresh water and of suspended and soluble matter carried by the river into the sea;

(c) The study of the main components of the marine ecosystem (plankton, nekton, benthos) and the assessment of the effects of pollution by "algal bioassays", measurements of biomass and of organic degradation rate;

(d) The construction of mathematical models, useful for the monitoring of operations.

AREA(S) STUDIED

The surveyed areas are the following:

- coastal water affected by the Tiber;
- the final stretch of the Tiber;
- other outlets, close to the Tiber mouths, either natural or artificial.

The main local currents and the main surface distribution of salinity, found during the period of field observation, are reported in Figure 1; this led to the conclusion that the area mostly affected by river discharges spreads mainly to the north of the river mouths.

MATERIAL AND METHODS

Taking the objectives of the MED POL VII projects into account, the parameters listed in Table I have been determined. The location of sampling points is reported in Figure 1. In ten of them, bacteriological examinations, including total coliforms, faecal coliforms and faecal streptococci, were performed in collaboration with the Institute of Hygiene, University of Rome.

The surface samples were collected in stations 1, 3, 23, 24, 25, 26. The frequency of sampling and measurement was fortnightly during 1976 and seasonal during 1977 and 1978.

The samples collected during the cruises of the vessel IRSAMARE were stored in polyethylene bottles at 4°C, filtered through 0,45 um millipore filters as soon as possible and analysed within one day after collection. The analytical methods used for the determination of nitrates, nitrites, ammonia and orthophosphates were those reported by Strickland and Parsons. Reactive silicates were determined by the method reported in the FAO manual.

Chlorophyll "a" (Ch-a) was measured both by the acetone extraction method and by direct fluorescence measurements on *in vivo* cells using continuous ship-board monitoring techniques. The measurement of turbidity was performed by Secchi disc. Salinity, temperature and pH were determined respectively by conductivity meter, bucket thermometer and pH meter. As far as bacteriological parameters were concerned, the MPN method was used for samples collected in the old grid. MPN as well as MF was used for sampling points 41 to 49.

RESULTS AND THEIR INTERPRETATION

The results of analysis on total coliforms (TC), faecal coliformss (FC) and faecal streptococci (FS) permitted us to characterize the bacterial load carried into the sea by the rivers (mean concentrations at the mouth per 100 ml are: $TC = 4.5 \times 10^7$, $FC = 6.0 \times 10^6$, $FS = 4.4 \times 10^3$).

The results concerning the evaluation of eutrophication conditions in the zone farther away from fluvial influence (stations 7, 27, 30, 31, 33) shows a situation which is typical of the oligotrophic feature of Mediterranean waters.

Due to the Tiber influence, the inshore coastal stations show higher values of N and P. In particular, station 1, having the highest nutrient levels, is characterized by values typical of waters with a tendency to eutrophication.

As far as the bacteriological data are concerned, the majority of the stations observed, including those 7°N off Ostia and 21°N off Ladispoli, both located 1 mile from the coast, show values which are under the limit established by the accepted interim microbiological quality criteria.

Only the area closest to the river mouths (stations 1, 2, 3, 12, 34 and 35) is characterized by a level of bacteria which is higher than the above-mentioned limits.

The results obtained are in agreement with the main local currents and the surface distribution of salinity showing that the area most involved in the river discharge extends mainly to the north of the river mouth. The results also show that the pollutant load may affect the bathing waters between the two small coastal towns of Fregene and Focene frequented by the inhabitants of

Rome for recreational purposes. Therefore, in 1979, ten additional sampling points (C and 41-49) (see Figure 2) were located in the above coastal stretch.

Bacteriological examinations (with the MF and MPN method) as well as the characterization of viruses (in 3 stations) were performed according to the scheme proposed by the WHO/UNEP MED POL VII project.

With a view to a more effective utilization of the data obtained, it was necessary to treat them by using computer facilities. In this respect, a programme has been set up, whereby the collected data can easily be submitted to variability and correlation analysis.

In such a way, it will be possible to study the correlation among the several parameters with a view to reducing the number and frequency of measurements and also to calculate some functions useful for the integration of the results.

In Tables II, III, and IV are reported the mean values, the standard deviations, the number of data collected from January 1976 to September 1979, the mandatory parameters of MED POL VII and their respective correlation analysis. Table V gives the relationship between the mandatory parameters in each station.

As far as the new stations are concerned, a statistical analysis of the compulsory parameters of the new stations (41-49), localized along the beach used for bathing north of the Tiber, is given in Table VI.

DISCUSSION OF RESULTS

The Tiber's highly polluting influence in the area under study was confirmed. The waters near the north of the Tiber have high nutrient concentrations indicating that eutrophication processes may be at work.

However these increases do not at present constitute a serious threat to health because the rapid water turnover prevents the formation of extensive algal blooms.

The water within a mile of the river mouth exhibited microbial "facies" equal in quantity and quality to the pollution load of the incoming river water.

Pollutant level drops off as distance from the river mouth increases. At about 3 miles from the shore the pollutant concentration drops down to normal levels.

The results obtained show how the discharged waters of the Tiber river scarcely affect the region between Fregene and Focene.

When meteorogical data are available it will be possible to study their role and to have a clearer picture of the contamination of the water of the area.

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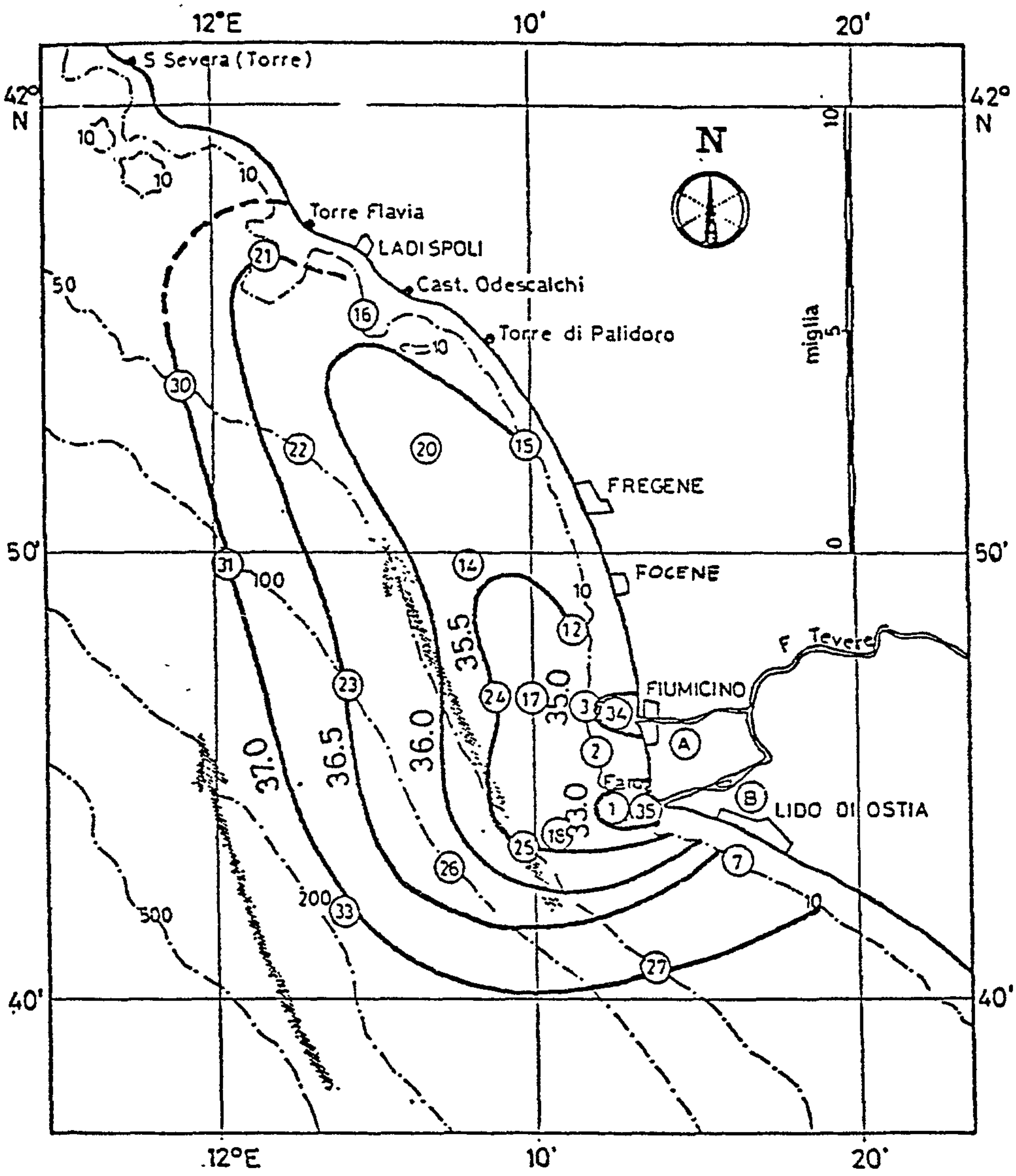


Fig. 1. Sampling stations and behaviour of mean surface salinity

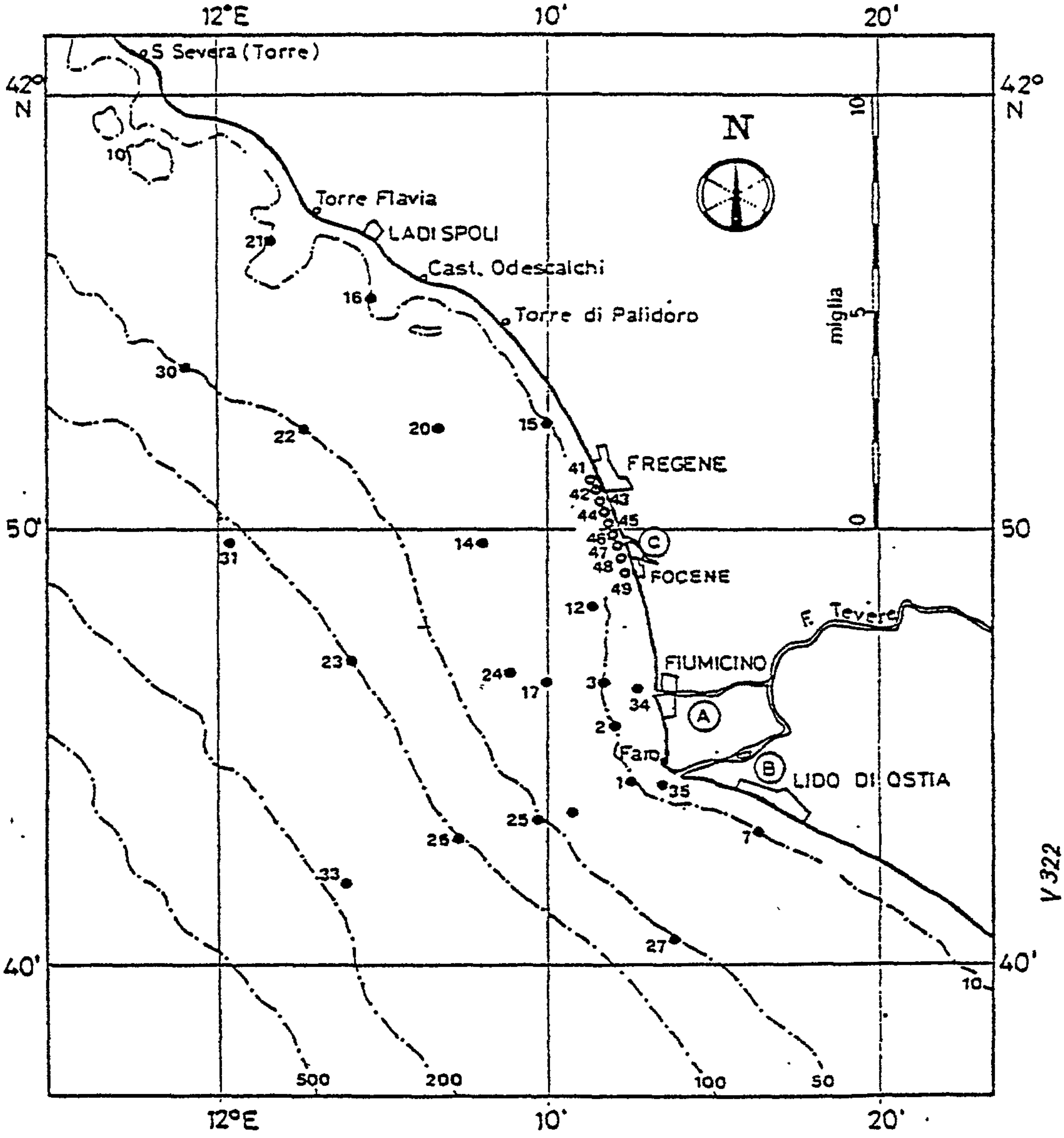


Fig. 2. Coastal area surrounding the Tiber river mouth. Black points indicate the first grid and circles indicate the sampling points chosen according to the "Guidelines" EHE/76.1

Table I: Parameters measured for the compulsory and optional parts of the programme

A - Parameters describing general conditions in the monitoring area at the time of sampling

1. Meteorological conditions (data supplied by Italian Air Force Meteorological Service):
   - wind direction and velocity
2. Hydrographic conditions:
   - sea temperature
   - salinity in $^{o}/oo$
   - oxygen in ml/l and % saturation
   - turbidity as Secchi in m
3. Dynamic conditions (in collaboration with the Hydraulic Research Station of Wallingford, UK):
   - state of waves
   - current measurements: direction and speed in m/sec
   - drifts: direction and speed in m/sec

B - Parameters measured on individual samples

1. Accompanying data: (a) air, sea and sample temperature during transportation
   (b) salinity in $^{o}/oo$
2. Bacteriological data (in collaboration with the Institute of Hygiene, University of Rome):
   (a) total coliforms as no. col./100 ml
   (b) faecal coliforms (*E. coli*) as no. col./100 ml
   (c) faecal streptococci (enterococci) as no. col./100 ml

C - Parameters applied to eutrophication conditions

1. Biomass and density of phytoplankton: (a) chlorophyll in mg/m^3
   (b) density of phytoplankton in no. cells/l
2. Nutrients: (a) PO_4 in mg/m^3
   (b) NH_3, NO_2, NO_3 in mg/m^3

Table II. Total coliforms: mean values, standard deviations, number of data collected from January 1976 to September 1979 and their correlation analysis with faecal coliforms (FC and faecal streptococci (FS). Mean and standard deviation are expressed in logs.

* = significance level 95%
** = significance level 99%

Point n°	Mean	Stan. dev.	n° data	Correlation with TC	Correlation with FC
1	5.55	1.76	32	r = 0.73 **	r = 0.72 **
3	4.19	1.78	31	r = 0.84 **	r = 0.58 **
7	1.76	1.43	15	r = 0.69 **	r = 0.62 *
12	2.74	1,69	23	r = 0.81 **	r = 0.66 **
21	0.31	0.62	11	r = 0.09	----
23	2.06	2.03	28	r = 0.85 **	r = 0.89 **
24	2.39	2.42	11	r = 0.90 **	r = 0.87 **
25	1.79	1.90	26	r = 0.91 **	r = 0.82 **
26	1.03	1.40	15	r = 0.71 **	----
34	3.91	1.28	15	r = 0.82 **	r = 0.52 *

Table III. Faecal coliforms: mean values standard deviations, number of data collected from January 1976 to September 1979 and its correlation analysis with total coliforms (TC) and faecal Streptococci (FS). Mean and standard deviations are expressed in logs

* = significance level 95%
** = significance level 99%

Point n°	Mean	Stand. dev.	n° data	Correlation with TC	Correlation with FC
1	4.49	1.86	32	r = 0.73 **	r = 0.56 **
3	3.14	2.05	31	r = 0.84 **	r = 0.69 **
7	1.76	1.43	15	r = 0.69 **	r = 0.75 **
12	2.69	1.69	23	r = 0.81 **	r = 0.66 **
21	0.04	0.14	11	r = 0.09	——
23	2.06	2.03	28	r = 0.85 **	r = 0.83 **
24	1.53	2.29	11	r = 0.90 **	r = 0.96 **
25	1.09	1.72	26	r = 0.91 **	r = 0.92 **
26	0.37	0.97	15	r = 0.71 **	——
34	3.03	1.35	15	r = 0.82 **	r = 0.61 *

Table IV. Faecal Streptococci: mean values, standard deviations, number of data collected from January 1976 to September 1979 and its correlation analysis with total coliforms (TC) and faecal coliforms (FC). Mean and standard deviation are expressed in logs

* = significance level 95%
** = significance level 99%

Point n°	Mean	Stand. dev.	n° data	Correlation with TC	Correlation with FC
1	2.40	1.16	32	r = 0.72 **	r = 0.56 **
3	1.77	1.48	31	r = 0.58 **	r = 0.69 **
7	0.22	0.49	15	r = 0.62 *	r = 0.49 **
12	0.57	0.70	23	r = 0.66 **	r = 0.41
21	--	--	--	----	----
23	0.71	1.25	28	r = 0.83 **	r = 0.89 **
24	0.67	1.05	11	r = 0.87 **	r = 0.96 **
25	0.53	1.02	26	r = 0.82 **	r = 0.92 **
34	1.50	1.18	15	r = 0.52 *	r = 0.62 *

Table V. Relationship between the mandatory parameters in each station. (TC = total coliforms; FC = faecal coliforms; FS = faecal streptococci)

Point n°	TC = x FC = y	TC = x FS = y	TC = x FS = y
1	y = 0.76x + 0.25	y = 0.42x – 0.22	y = 0.35x + 0.84
3	y = 0.97x – 0.93	y = 0.48x – 0.24	y = 0.50x + 0.20
7	y = 0.48x – 0.10	y = 0.21x – 0.15	y = 0.50x + 0.06
12	y = 0.74x – 0.15	y = 0.27x – 0.21	y = 0.19x + 0.22
21	y = 0.02x + 0.04	——	——
23	y = 0.77x – 0.30	y = 0.51x – 0.34	y = 0.60x – 0.07
24	y = 0.86x – 0.52	y = 0.38x – 0.24	y = 0.44x – 0.00
25	y = 0.83x – 0.40	y = 0.45x – 0.26	y = 0.55x – 0.06
26	y = 0.49x – 0.14	——	——
34	y = 0.86x – 0.34	y = 0.48x – 0.30	y = 0.54x – 0.12

Table VI. - Mean values, standard deviations, number of data collected and distribution in frequency classes of the results obtained (expressed in logs) by using MF methods.

Point No.		Mean	Stand.dev.	n. data	0-1 (%)	1-2((%)	2-3 (%)	3-4 (%)
41	TC	2.00	1.15	9	33.3	11.1	22.2	33.3
	FC	0.28	0.32	10	100.0	0	0	0
	FS	0.34	0.36	10	100.0	0	0	0
42	TC	1.32	1.14	9	33.3	33.3	22.2	11.1
	FC	0.47	0.55	10	80.0	20.0	0	0
	FS	0.24	0.47	10	90.0	11.1	0	0
43	TC	1.50	0.89	8	25.0	25.0	50.0	0
	FC	0.41	0.50	9	88.8	11.1	0	0
	FS	0.22	0.44	9	89.0	11.0	0	0
44	TC	1.36	0.55	9	44.4	33.3	22.2	0
	FC	0.49	0.51	10	90.0	10.0	0	0
	FS	0.73	0.66	10	60.0	40.0	0	0
45	TC	1.29	0.79	8	37.5	37.5	25.0	0
	FC	0.41	0.60	9	77.7	22.2	0	0
	FS	0.73	0.55	9	66.6	33.3	0	0
46	TC	1.71	1.39	10	40.0	10.0	20.0	30.0
	FC	0.19	0.33	9	90.0	10.0	0	0
	FS	1.09	0.76	10	30.0	70.0	0	0
47	TC	1.72	1.36	8	37.5	12.5	37.5	12.5
	FC	0.83	1.11	8	62.5	12.5	0	0
	FS	0.97	0.65	8	50.0	50.0	0	0
48	TC	0.80	1.23	8	63.5	25.0	0	12.5
	FC	0.14	0.28	9	100.0	0	0	0
	FS	0.67	0.76	9	66.6	22.2	11.1	0
49	TC	0.67	0.68	6	50.0	50.0	0	0
	FC	0.06	0.09	7	100.0	0	0	0
	FS	0.23	0.60	7	85.7	14.3	0	0

Research Centre: Institute of Hygiene
University of Trieste
TRIESTE
Italy

Principal Investigator: L. MAJORI

INTRODUCTION

The research activity of the Institute of Hygiene of the University of Trieste within the framework of project MED POL VII, started in May 1978. It participates in an integration of numerous other research activities in the field of marine pollution, from the microbiological as well as from the chemical point of view, which was initiated in 1970. This report presents the results of the work carried out as part of MED POL VII up to September 1980.

AREA(S) STUDIED

The study area is shown in the attached map (Figure 1). The urban and industrial quarters, the outfalls from domestic and industrial wastes, the recreational areas, the rivers and the currents are clearly indicated on the map.

Special reference may be made to:

(i) a petrol refinery, a terminal for an oil pipeline with a dock for oil-carriers, a metallurgic factory and shipyards;

(ii) the outlet of the sewerage system of Trieste at the northern part of the bay;

(iii) the port development immediately to the north of Muggia bay;

(iv) the long stretch of coast up to Duino, almost exclusively devoted to recreation and shellfish cultures;

(v) the outlet of the sewerage systems of Barcola; and

(vi) the urban and industrial wastes of Monfalcone discharged at the bay of Panzano.

The distribution of the sampling points is shown in Figure 2. The 55 sampling stations are located along the coast as well as along a line perpendicular to the coast and at increasing distance from the beach (10 m, 500 m, 1000 m, 1500 m).

MATERIALS AND METHODS

Physico-chemical parameters:

Initial treatment: The measurement of ammonia, nitrites, nitrates and dissolved phosphorus are carried out on the filtered sample by millipore membrane with 0.45 um pore size.

Temperature, conductivity and salinity are measured by an induction salinometer with a sounding probe for recording temperatures at each point.

Dissolved oxygen is measured by iodometric titration.

Ammonia, nitrites, nitrates and dissolved phosphorus are measured by spectrophotometric method.

Bacteriological parameters:

The methodology recommended in the Guidelines for Health related Monitoring of Coastal Water Quality, EURO/WHO/UNEP, Copenhagen 1977, was followed with some minor modifications.

Total coliforms are determined by the filtration method (millipore membrane (0.45 um) using m-Endo agar incubated at 37°C (24 hours). Faecal coliforms are determined by the same method with m-FC agar incubated at 44.5°C (24 hours). Enterococcus is determined by the same method with m-enterococcus agar at 37°C (48 hours). In some sampling points an analysis for qualitative detection of Salmonellae was undertaken (stations No. 5, 10, 11, 12 and 24 (Figure 2).

Monitoring of the following parameters: total coliforms, faecal coliforms, enterococci and qualitative determination of salmonellae, has also been performed for shellfish.

RESULTS AND THEIR INTERPRETATION

Part of the results concerning the physico-chemical parameters during the period May 1978 to February 1979 appear in Figures 3, 4, 5, 6, 7, 8, 9 and 10. Figures 11 and 12 give respectively a tentative evaluation of the quality of coastal sea-waters of the Gulf of Trieste based on E. coli and enterococci counts and the Italian legislation.

The results for the period March-September 1979 tend to confirm the values of the first period, as far as the physico-chemical parameters are concerned. This has also been the case for the period October 1979 - September 1980.

Table I gives the summarized results of the microbiological monitoring of the coastal sea-water of the Gulf of Trieste for the period May 1978 - April 1979. Tables II, III and IV give the corresponding results for the period May 1978 to September 1978, for October 1978 to April 1979 and for May - September 1979. Tables V and VI give the frequency distribution respectively for faecal coliforms and for enterococci for the period May 1978 to April 1979, as related to major areas and to season. Table VII gives a summary of the results of the monitored microbiological parameters during the period October 1979 - September 1980, which confirms the distinction of specific zones of faecal pollution as indicated in previous periods.

The areas where pollution is the greatest are limited to the Bay of Muggia corresponding to the inhabited zone (stations 6, 7, 9) and along the perpendicular line (stations 10, 11) as well as at the harbour base in the north (stations 13, 14 and 15). Strains of salmonella have also been isolated (stations 11, 12 and 15). Probably the discharge of liquid wastes from urban and industrial areas is the origin of the pollution. During the period October

1979 - September 1980 qualitative analysis of salmonella was undertaken at the stations 5, 10, 11, 12 and 24. Salmonella has been identified once in two stations (12 and 24).

Two polluted zones are found south of the Barcola outfall bordering the Port of Trieste and in the Duino area.

The areas intended for bathing between Lazzaretto and Muggia and between Barcola and Sistiana seem largely satisfactory.

Some worsening of the situation, as far as faecal indicators are concerned, has been experienced during the period October 1979 - September 1980. This probably is due to seasonal factors discussed in relevant reports.

DISCUSSION OF RESULTS

From the preliminary results described above, we can conclude that there are two areas of high concentrations of pollution, both chemical and bacteriological.

The first area is located along the northern dispersion line originating in the Bay of Muggia, into which most of the municipal sewage and the harbour waste from the city of Trieste is discharged.

The second is located in the northern section of the Gulf section off the little town of Duino and is probably due to a defective or absent sewerage network and to occasional pollution from other human settlements in the neighbouring touristic areas.

A comprehensive assessment of the state of pollution in the Gulf of Trieste is decribed in the two reports mentioned below.

PUBLICATIONS

MAJORI, L., CAMPELLO, C., LACH, S., CREVATIN, E., MODONUTTI, G.B., DARIS, F., and NEDOCLAN, G. Observations about coastal sea-water pollution in the Gulf of Trieste: bacteriological investigations.

MAJORI, L., NEDOCLAN, G., DARIS, F., MODONUTTI, G.B., CAMPELLO, C. Observations about coastal sea-waters pollution in the Gulf of Trieste: physical - chemical investigations.

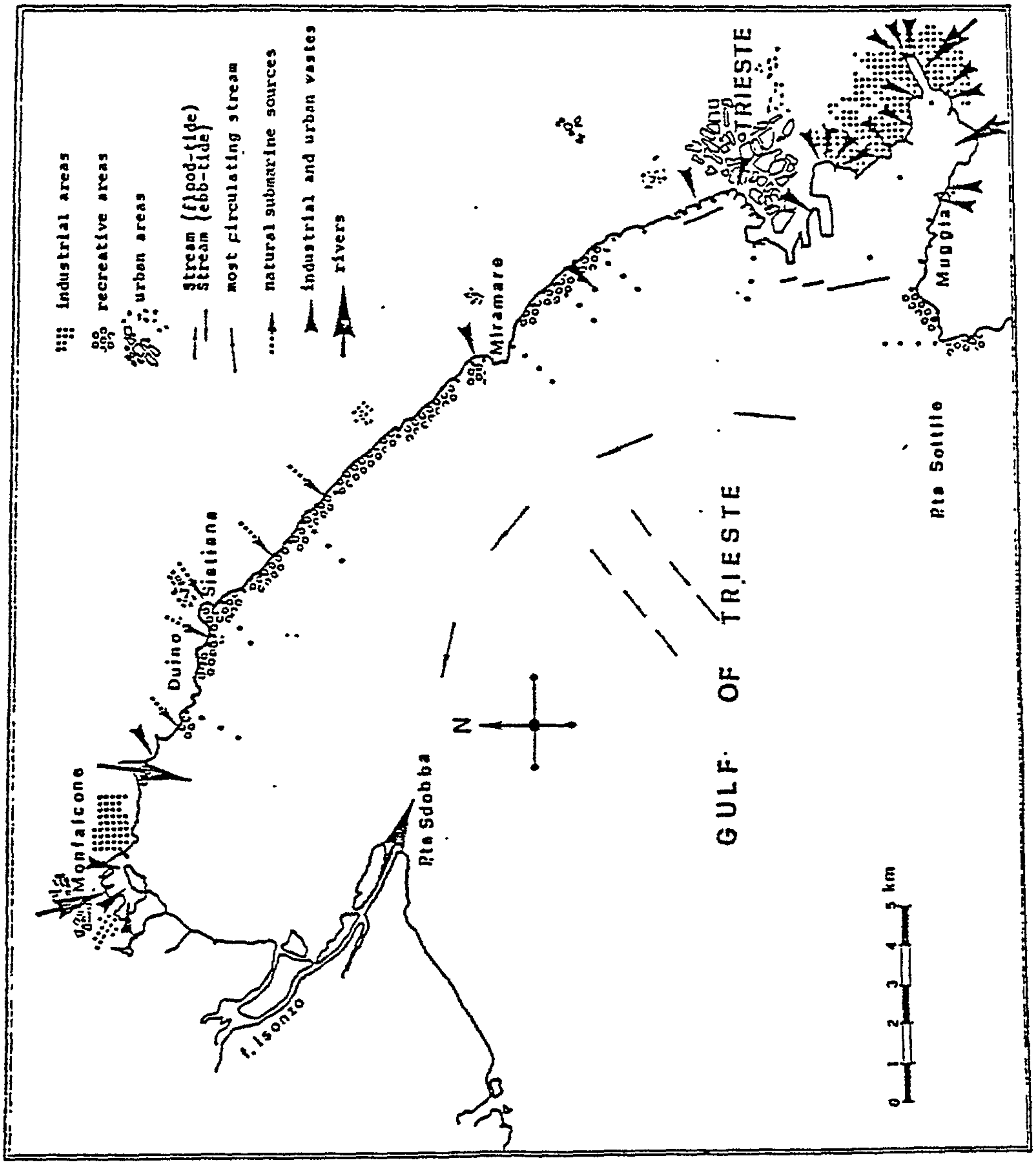


Fig. N. 1 - OVERALL ASSESMENT OF THE EXAMINED AREA.

Figure 2

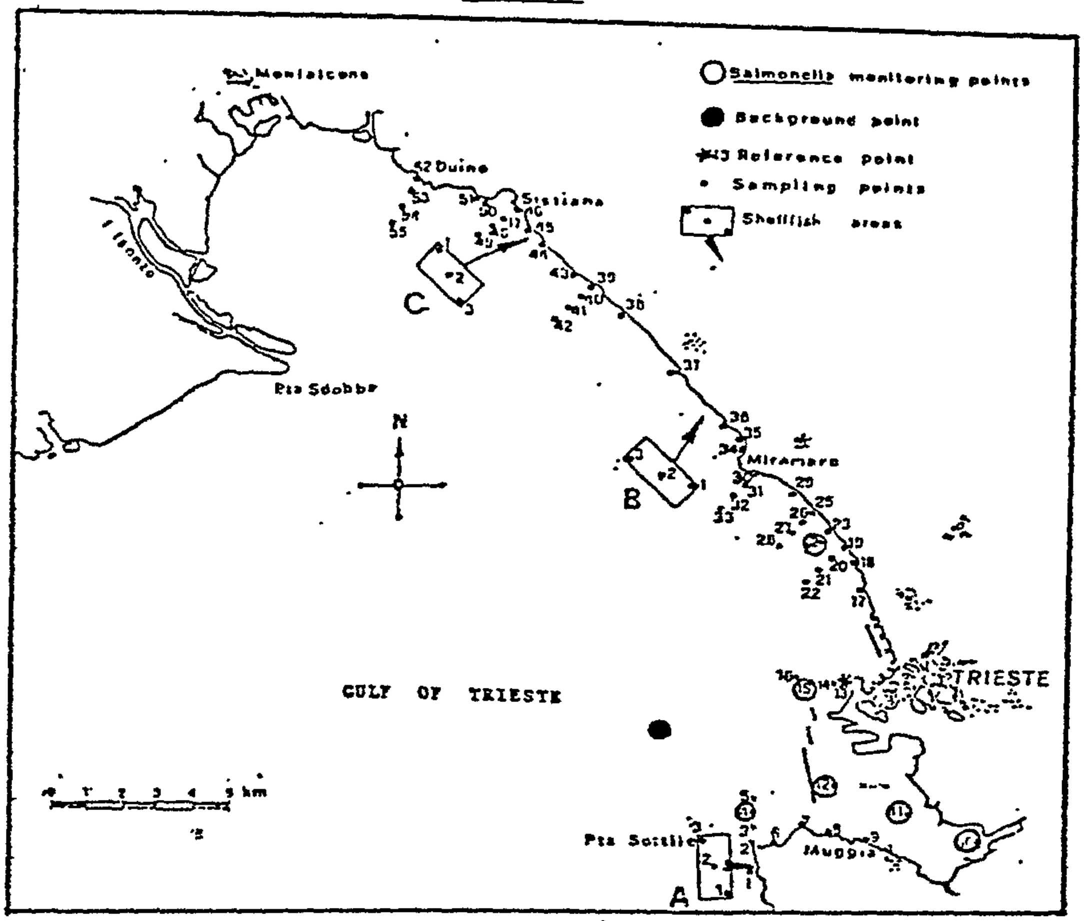


Figure 3

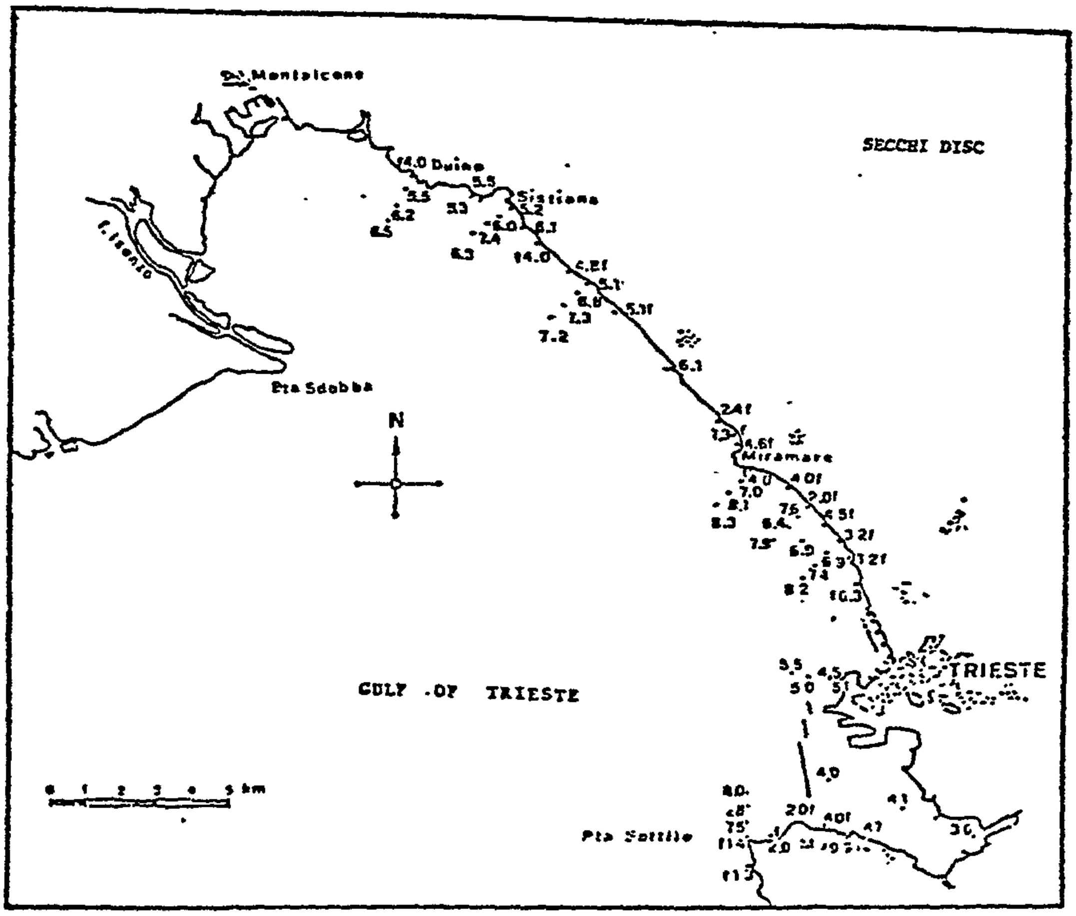


Figure 4

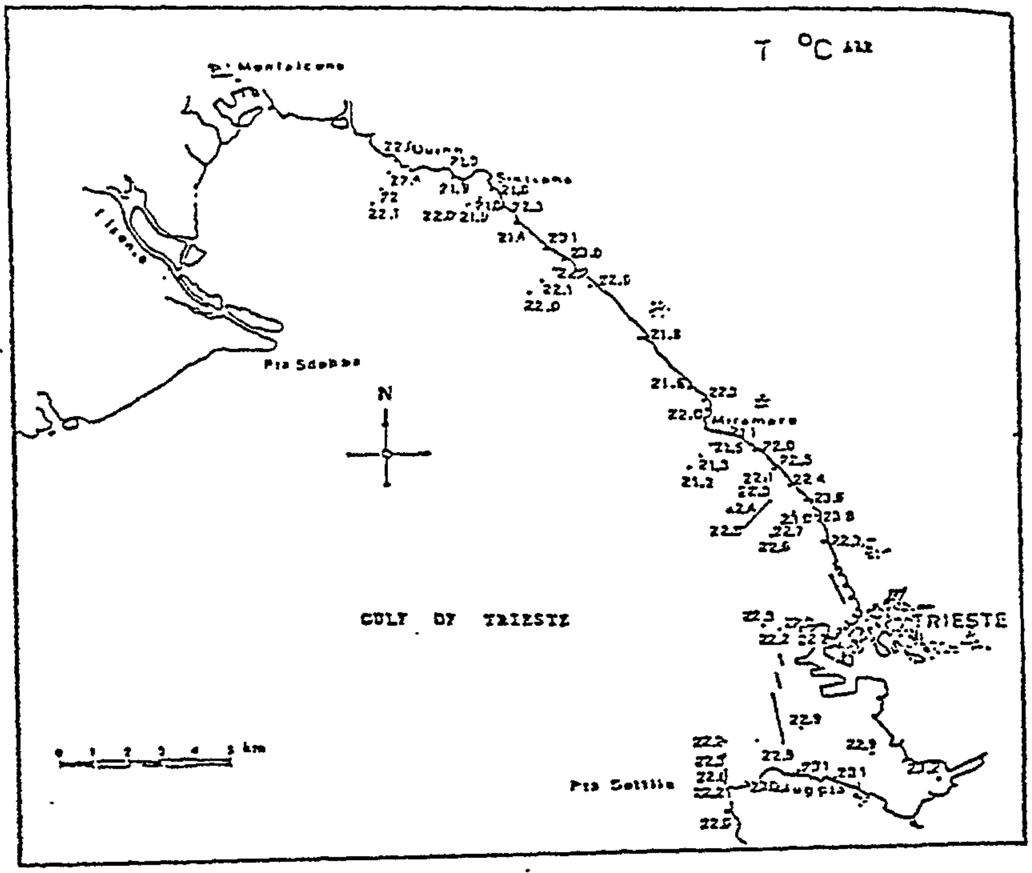


Figure 5

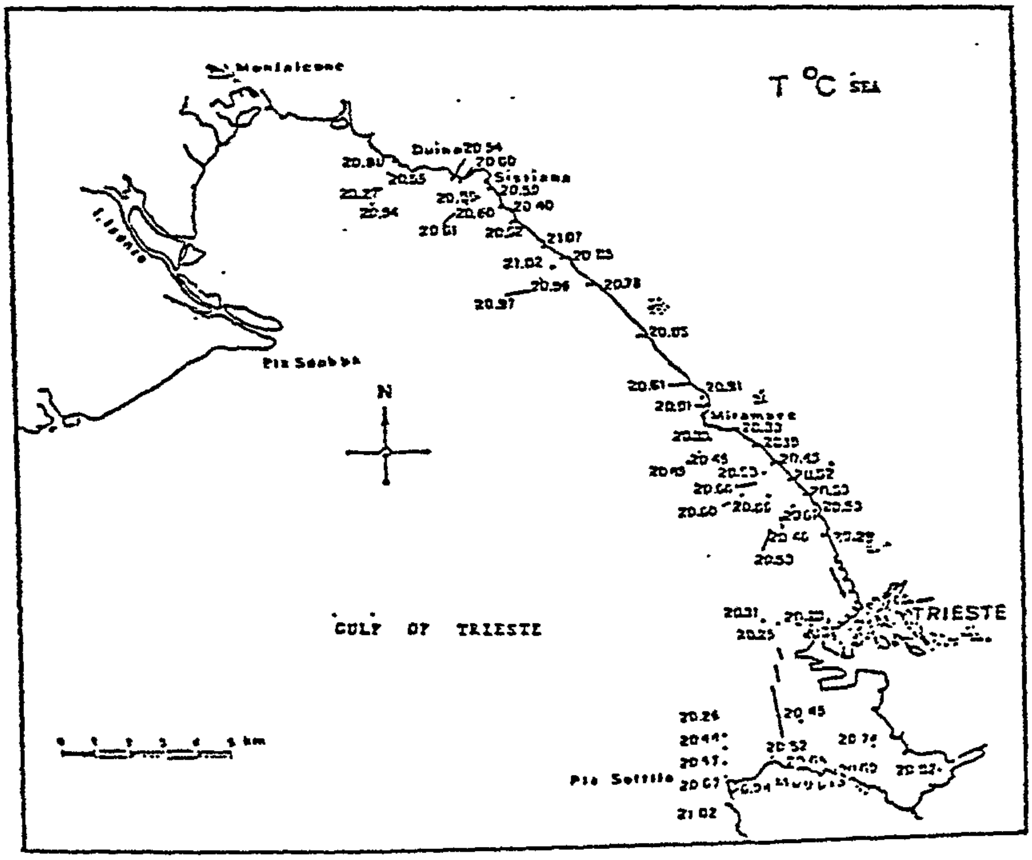


Figure 6

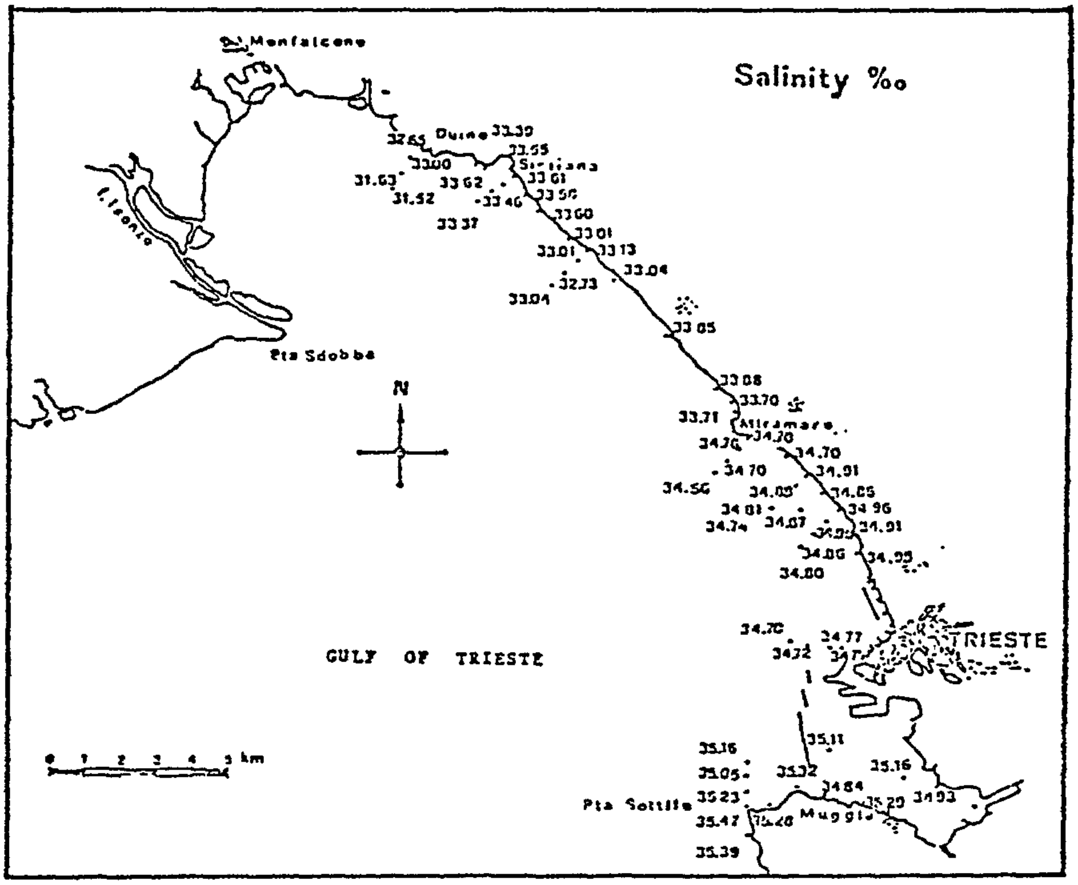


Figure 7

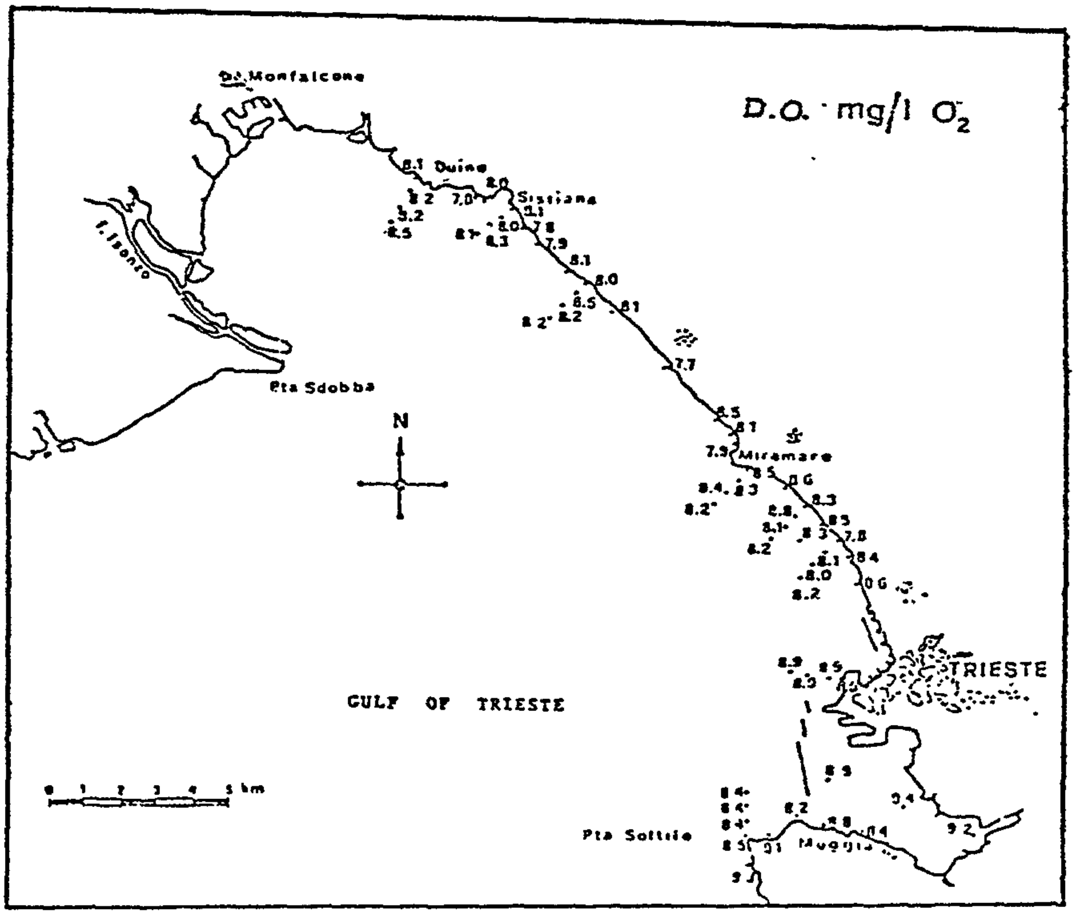


Figure 8

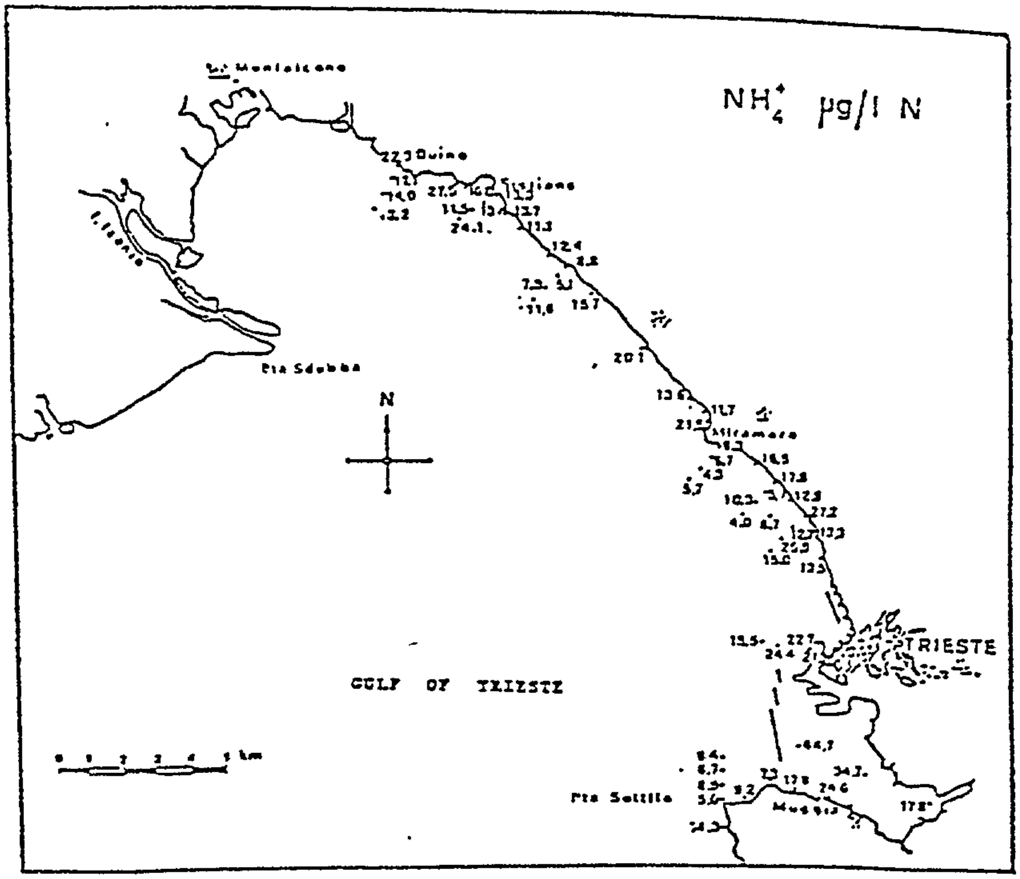


Figure 9

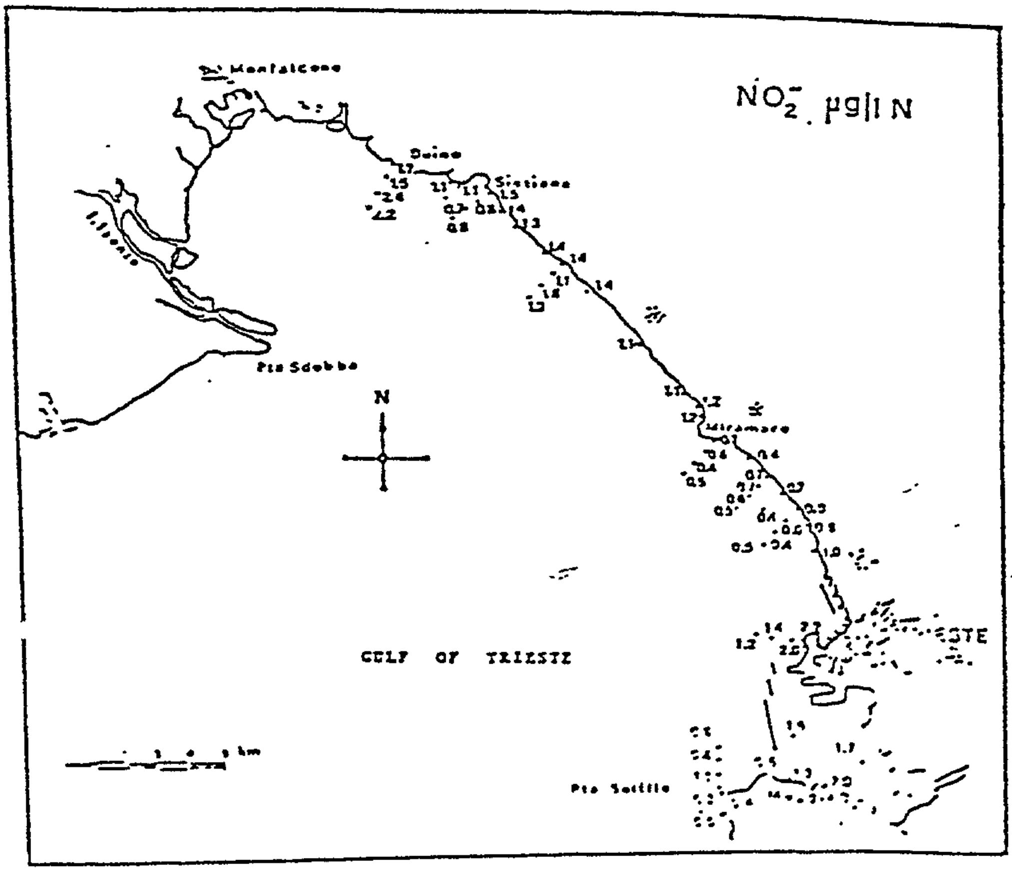
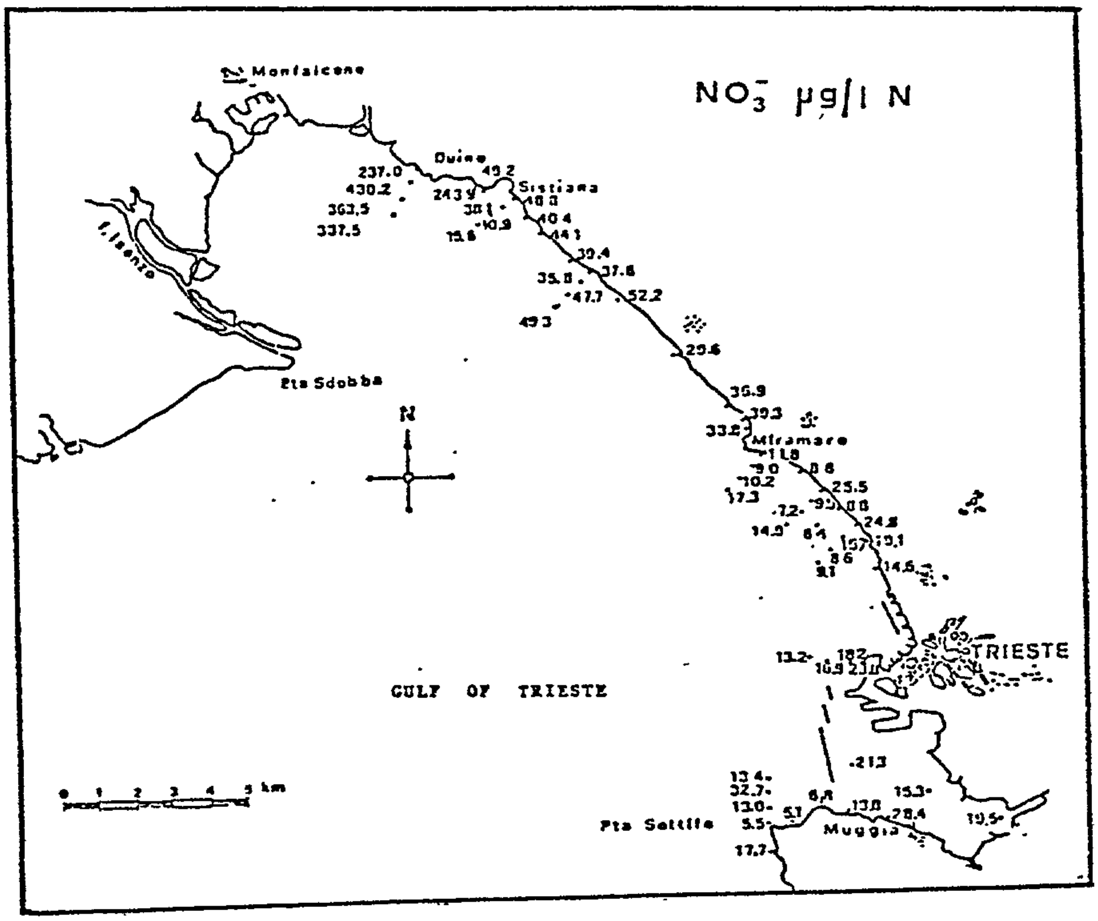


Figure 10


NO$_3^-$ µg/l N
Monfalcone
Duino
Sistiana
Pta Sdobba
N
Miramare
TRIESTE
GULF OF TRIESTE
Pta Sottile
Muggia
0 1 2 3 4 5 km

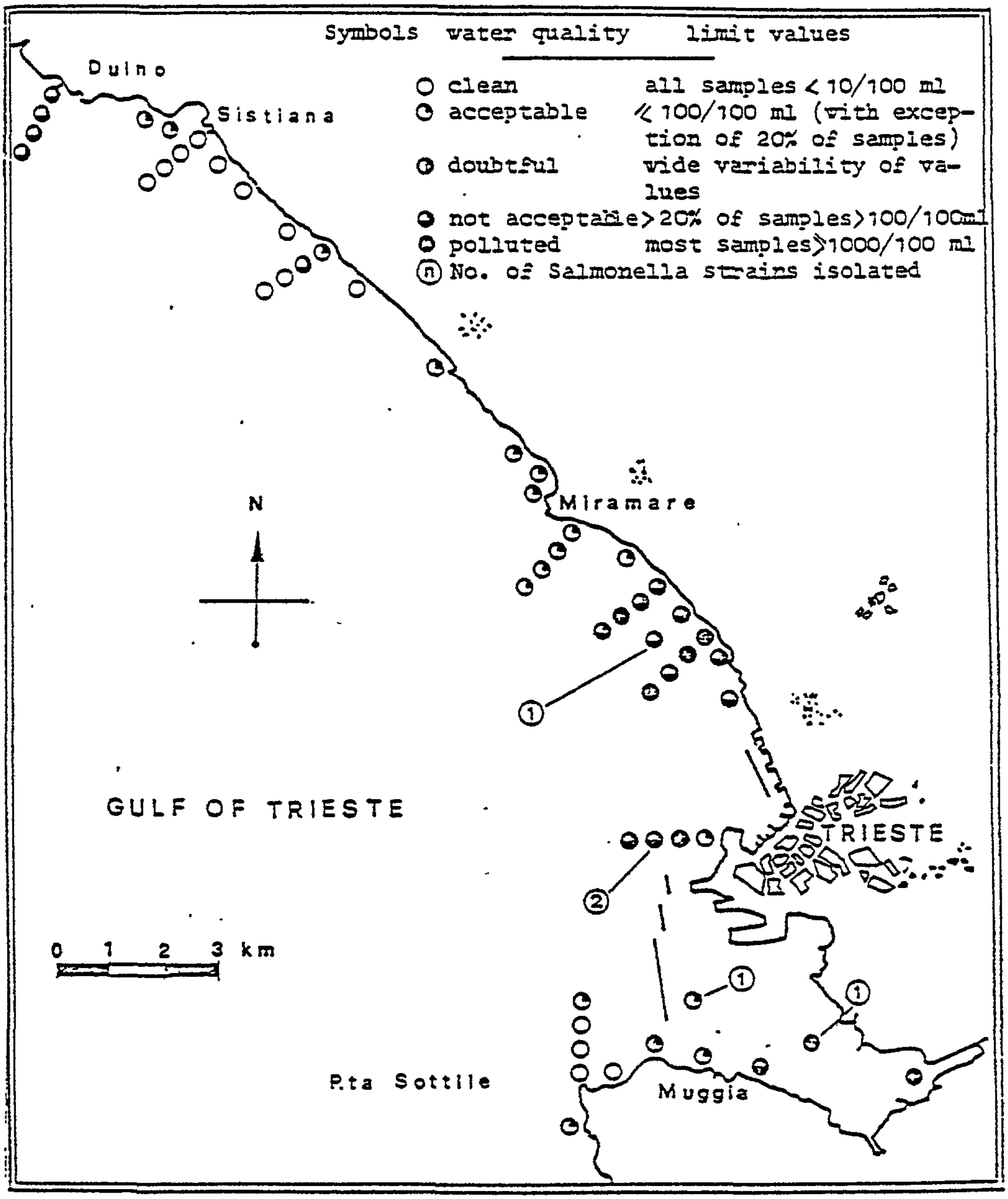


Fig. 11 - Tentative evaluation by means of Escherichia coli counts of the quality of coastal seawaters of the Gulf of Trieste. (May 1978 - April 1979).

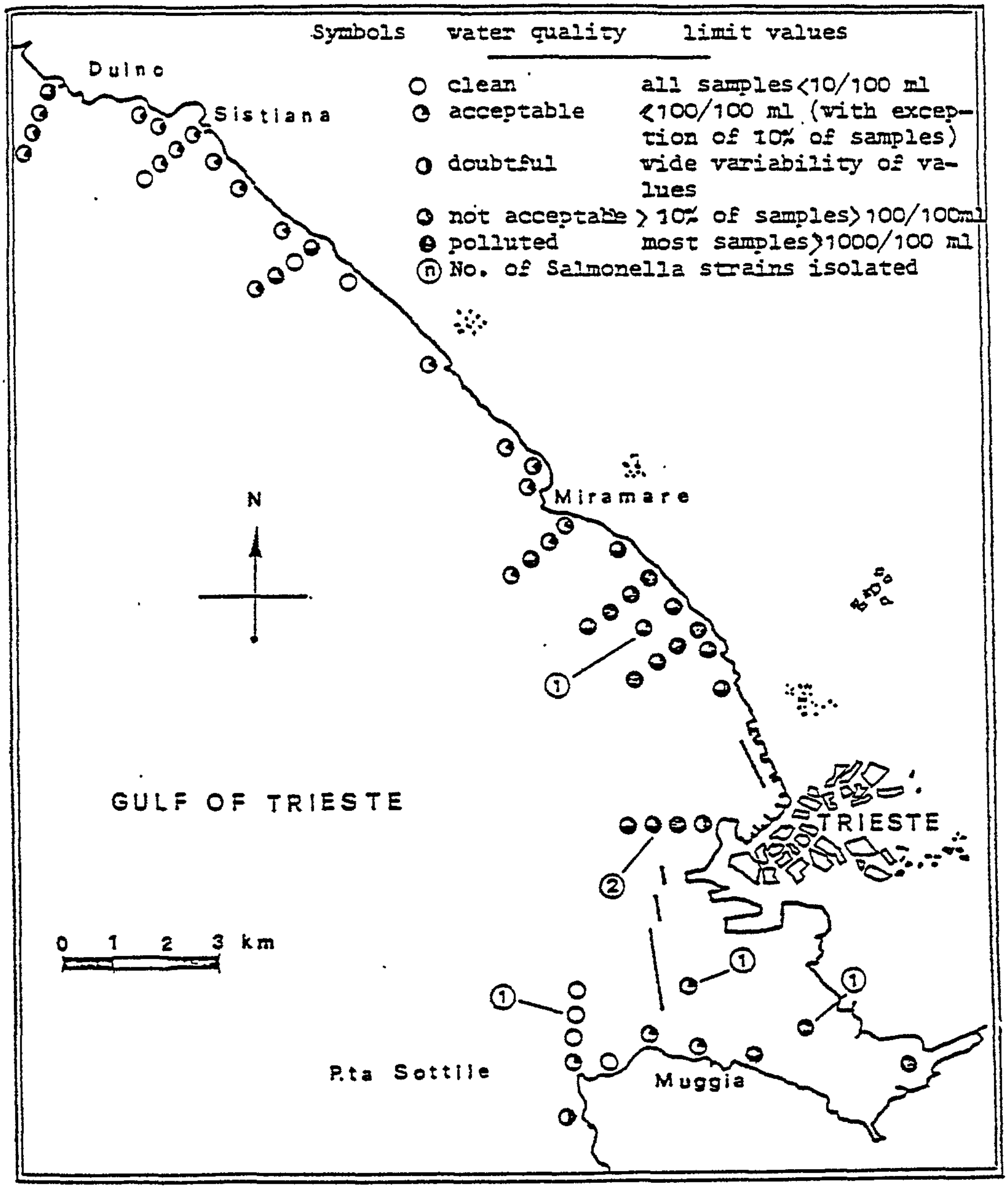


Fig. 12 - Tentative evaluation by means of enterococcal counts of the quality of coastal seawaters of the Gulf of Trieste. (May 1978 - April 1979).

Table N°I - Summarized data on microbiological monitoring of coastal seawater of the Gulf of Trieste : distribution of microbial counts by the indicated parametric values (May 1978–April 1979).

Station	No. of samplings	TOTAL COLIFORMS/100 ml				FAECAL COLIFORMS/100 ml				ENTEROCOCCI/100 ml				SALMONELLA /5 l	
		<1	1–100	101–10^3	>10^3	<1	1–100	101–10^3	>10^3	<1	1–100	101–10^3	>10^3	pos.	neg.
1	11	2	8	1	0	4	6	1	0	3	7	0	1		
2	11	2	9	0	0	5	6	0	0	2	8	1	0		
3	11	3	6	2	0	7	4	0	0	7	4	0	0		
4	11	4	7	0	0	5	6	0	0	4	7	0	0		
5	11	3	5	1	2	6	4	1	0	2	9	0	0	1	10
6	11	3	6	1	1	6	5	0	0	7	4	0	0		
7	11	0	8	2	1	2	8	1	0	1	10	0	0		
8	11	0	9	1	1	5	8	0	0	5	7	0	0		
9	10	0	3	4	3	2	3	4	1	0	5	5	0		
10	11*	0	2	5	3	2	6	1	2	1	8	1	1	0	11
11	11	0	4	3	4	3	3	3	2	1	8	3	1	1	10
12	11	1	4	5	1	3	6	2	0	4	7	0	0	1	10
13	11	0	7	1	3	1	9	1	0	1	8	0	2		
14	11	0	3	3	5	0	5	4	2	0	6	3	2		
15	11	1	3	4	3	1	4	5	1	1	6	4	0	2	9
16	11	1	3	3	4	5	2	3	1	4	3	3	1		
17	11	1	3	2	5	1	5	4	1	2	4	4	1		
18	10	1	6	2	1	5	2	3	0	2	4	2	2		
19	11	1	5	1	4	3	3	0	5	2	3	2	4		
20	11	2	4	2	3	5	2	1	3	5	2	1	3		
21	11	3	5	2	1	5	4	1	1	3	5	2	1		
22	11	4	2	3	2	5	2	0	2	3	5	1	2		
23	11	1	7	2	1	5	4	1	1	4	3	3	1		
24	11	2	4	3	2	3	4	4	0	4	5	1	1	1	10
25	11	0	7	2	2	3	5	2	1	2	6	1	2		
26	11	2	7	1	1	6	3	1	1	3	5	1	1		
27	11	3	6	0	2	5	4	0	2	7	2	0	2		
28	11	3	6	1	1	7	3	0	1	6	4	0	1		
29	11	0	7	2	0	3	7	1	0	2	7	2	0		
30	11	2	7	2	0	5	6	0	0	5	4	2	0		
31	11	2	7	2	0	6	4	1	0	5	5	0	1		
32	10	0	9	0	1	6	3	0	1	3	5	1	1		
33	11*	7	3	0	0	6	5	0	0	8	3	0	0		
34	10	3	6	1	0	4	6	0	0	2	8	0	0		
35	11	4	3	4	0	5	6	0	0	4	6	1	0		
36	11	1	5	5	0	2	9	0	0	2	9	0	0		
37	11	2	6	3	0	5	6	0	0	8	3	0	0		
38	11	2	7	2	0	4	7	0	0	6	5	0	0		
39	10	2	6	0	2	7	2	1	0	6	2	2	0		
40	11*	5	5	0	0	8	3	0	0	7	4	0	0		
41	11	6	3	0	2	7	2	1	1	6	3	1	1		
42	11*	6	4	0	0	8	3	0	0	6	5	0	0		
43	11	3	7	1	0	6	5	0	0	5	6	0	0		
44	10	2	7	1	0	7	3	0	0	4	5	1	0		
45	11	2	8	1	0	9	2	0	0	6	4	1	0		
46	11	5	6	0	0	6	5	0	0	3	7	1	0		
47	11	3	8	0	0	9	2	0	0	5	5	1	0		
48	11	3	8	0	0	9	2	0	0	5	6	0	0		
49	11	4	7	0	0	9	2	0	0	5	6	0	0		
50	11	1	7	3	0	6	5	0	0	5	6	0	0		
51	11	0	5	5	1	3	7	1	0	2	9	0	0		
52	11	0	2	5	4	1	6	3	1	0	9	2	0		
53	11	3	0	3	5	3	3	5	3	3	8	0	0		
54	11	2	1	4	4	2	7	2	0	3	7	0	1		
55	10	2	3	3	2	4	3	3	0	3	6	1	0		

* One total coliforms count not done.

Table N° II. Summarized data on microbiological monitoring of coastal seawater of the Gulf of Trieste: distribution of microbiol-counts, by the indicated parametric values (May–September 1976).

Station	No. of samplings	TOTAL COLIFORMS/100 ml				FAECAL COLIFORMS/100 ml				ENTEROCOCCI/100 ml				SALMONELLA /5 l	
		<1	1–100	101–10^3	>10^3	<1	1–100	101–10^3	>10^3	<1	1–100	101–10^3	>10^3	pos.	neg.
1	5	0	4	1	0	1	3	1	0	1	3	0	1		
2	5	0	5	0	0	1	4	0	0	1	4	0	0		
3	5	1	3	1	0	2	3	0	0	3	2	0	0		
4	5	1	4	0	0	1	4	0	0	1	4	0	0		
5	5	0	2	1	2	2	2	1	0	3	2	0	0	0	5
6	5	2	2	1	0	2	3	0	0	5	0	0	0		
7	5	0	4	1	0	1	4	0	0	1	4	0	0		
8	5	0	4	1	0	2	3	0	0	2	3	0	0		
9	5	0	1	3	1	1	0	4	0	0	1	4	0		
10	5	0	1	3	1	0	3	1	1	0	4	1	0	0	5
11	5	0	2	1	2	1	3	0	1	1	4	0	0	1	4
12	5	0	1	3	1	1	4	0	0	2	3	0	0	0	5
13	5	0	3	1	1	0	5	0	0	1	4	0	0		
14	5	0	1	1	3	0	2	1	2	0	4	1	0		
15	5	1	1	1	2	0	1	3	1	0	4	1	0	2	3
16	5	0	2	1	2	1	2	1	1	2	2	1	0		
17	6	1	3	1	1	1	5	0	0	2	4	0	0		
18	5	1	4	0	0	3	2	0	0	1	4	0	0		
19	6	1	3	0	2	2	2	0	2	2	2	1	1		
20	6	1	3	1	1	3	2	0	1	3	2	0	1		
21	6	2	3	1	0	4	2	0	0	2	3	1	0		
22	6	3	1	2	0	3	3	0	0	2	3	1	0		
23	6	1	5	0	0	4	2	0	0	4	2	0	0		
24	6	1	3	0	2	2	3	1	0	3	3	0	0	0	6
25	6	0	4	2	0	2	3	1	0	2	3	1	0		
26	6	1	5	0	0	5	1	0	0	4	2	0	0		
27	6	3	3	0	0	4	2	0	0	6	0	0	0		
28	6	1	4	1	0	5	1	0	0	4	2	0	0		
29	6	0	4	2	0	2	4	0	0	2	4	0	0		
30	6	1	4	1	0	3	3	0	0	4	2	0	0		
31	6	1	4	1	0	5	1	0	0	4	2	0	0		
32	5	0	5	0	0	4	1	0	0	3	2	0	0		
33	6	4	2	0	0	4	2	0	0	5	1	0	0		
34	6	3	3	0	0	3	3	0	0	2	4	0	0		
35	6	3	2	1	0	3	3	0	0	3	3	0	0		
36	6	0	2	4	0	1	5	0	0	1	5	0	0		
37	6	1	2	3	0	2	4	0	0	5	1	0	0		
38	6	1	3	2	0	2	4	0	0	5	1	0	0		
39	6	1	4	0	1	1	4	1	0	5	1	0	0		
40	6	3	3	0	0	5	1	0	0	5	1	0	0		
41	6	2	3	0	1	4	1	0	1	4	1	0	1		
42	6	3	2	0	1	4	2	0	0	3	3	0	0		
43	6	3	2	1	0	4	2	0	0	3	3	0	0		
44	5	1	3	1	0	3	2	0	0	3	2	0	0		
45	6	1	5	0	0	6	0	0	0	4	2	0	0		
46	6	3	3	0	0	3	3	0	0	3	3	0	0		
47	6	2	4	0	0	5	1	0	0	4	1	1	0		
48	6	2	4	0	0	5	1	0	0	3	3	0	0		
49	6	1	5	0	0	5	1	0	0	3	3	0	0		
50	6	0	5	1	0	4	2	0	0	4	2	0	0		
51	6	0	3	2	1	1	4	1	0	2	4	0	0		
52	6	0	2	2	2	1	4	0	1	1	5	0	0		
53	6	2	0	0	4	2	1	3	0	2	4	0	0		
54	6	1	1	1	3	1	3	2	0	2	4	0	0		
55	5	1	2	1	1	3	0	2	0	2	3	0	0		

Table III. Summarized data on microbiological monitoring of coastal seawater of the Gulf of Trieste. distribution of microbiol counts by the indicated parametric values (October 76–April 79).

Station	No. of samplings	TOTAL COLIFORMS/100 ml				FAECAL COLIFORMS/100 ml				ENTEROCOCCI/100 ml				SALMONELLA/5 l	
		<1	1–100	101–10^3	>10^3	<1	1–100	101–10^3	>10^3	<1	1–100	101–10^3	>10^3	pos.	neg.
1	6	2	4	0	0	3	3	0	0	2	4	0	0		
2	6	2	4	0	0	4	2	0	0	1	4	1	0		
3	6	2	3	1	0	5	1	0	0	4	2	0	0		
4	6	3	3	0	0	4	2	0	0	3	3	0	0		
5	6	3	3	0	0	4	2	0	0	4	2	0	0	1	5
6	6	1	4	0	1	4	2	0	0	2	4	0	0		
7	6	0	4	1	1	1	3	2	0	0	6	0	0		
8	6	0	5	0	1	2	4	0	0	2	4	0	0		
9	5	0	2	1	2	1	3	0	1	0	4	1	0		
10*	6	0	1	2	2	2	3	0	1	1	4	0	1	0	6
11	6	0	2	2	2	2	0	3	1	0	3	2	1	0	6
12	6	1	3	2	0	2	0	4	0	2	2	2	0	1	5
13	6	0	4	0	2	1	4	1	0	0	4	0	2		
14	6	0	2	2	2	0	3	3	0	0	2	2	2		
15	6	0	2	3	1	1	3	2	0	1	2	3	0	0	6
16	6	1	1	2	2	4	0	2	0	2	1	2	1		
17	5	0	0	1	4	0	0	4	1	0	0	4	1		
18	5	0	2	2	1	2	0	3	0	1	0	2	2		
19	5	0	2	1	2	1	1	0	3	0	1	1	3		
20	5	1	1	1	2	2	0	1	2	2	0	1	2		
21	5	1	2	1	1	1	2	1	1	1	2	1	1		
22	5	1	1	1	2	2	1	0	2	1	2	0	2		
23	5	0	2	2	1	1	2	1	1	0	1	3	1		
24	5	1	1	3	0	1	1	3	0	1	2	1	1	1	4
25	5	0	3	0	2	1	2	1	1	0	3	0	2		
26	5	1	2	1	1	1	2	1	1	0	3	1	1		
27	5	0	3	0	2	1	2	0	2	1	2	0	2		
28	5	2	2	0	1	2	2	0	1	2	2	0	1		
29	5	0	3	2	0	0	3	1	0	0	3	2	0		
30	5	1	3	1	0	2	3	0	0	1	2	2	0		
31	5	1	3	1	0	1	3	1	0	1	3	0	1		
32	5	0	4	0	1	2	2	0	1	0	3	1	1		
33*	5	3	1	0	0	2	3	0	0	3	2	0	0		
34	4	0	3	1	0	1	3	0	0	0	4	0	0		
35	5	1	1	3	0	2	3	0	0	1	3	1	0		
36	5	1	3	1	0	1	4	0	0	1	4	0	0		
37	5	1	4	0	0	3	2	0	0	3	2	0	0		
38	5	1	4	0	0	2	3	0	0	1	4	0	0		
39	4	1	2	0	1	3	1	0	0	1	1	2	0		
40*	5	2	2	0	0	3	2	0	0	2	3	0	0		
41	5	4	0	0	1	3	1	1	0	2	2	1	0		
42*	5	2	2	0	0	4	1	0	0	3	2	0	0		
43	5	0	5	0	0	2	3	0	0	2	3	0	0		
44	5	1	4	0	0	4	1	0	0	1	3	1	0		
45	5	1	3	1	0	3	2	0	0	2	2	1	0		
46	5	2	3	0	0	3	2	0	0	0	4	1	0		
47	5	1	4	0	0	4	1	0	0	1	4	0	0		
48	5	1	4	0	0	4	1	0	0	2	3	0	0		
49	5	3	2	0	0	4	1	0	0	2	3	0	0		
50	5	1	2	2	0	2	3	0	0	1	4	0	0		
51	5	0	2	3	0	2	3	0	0	0	5	0	0		
52	5	0	0	3	2	0	2	3	0	0	3	2	0		
53	5	1	0	3	1	1	2	1	1	1	4	0	0		
54	5	1	0	3	1	1	4	0	0	1	3	0	1		
55	5	1	1	2	1	1	3	1	0	1	3	1	0		

* One total coliforms count not done.

Table IV.

- Summarized data on microbiological monitoring of coastal seawater of the Gulf of Trieste : distribution of microbial counts by the indicated parametric values (March-September 1979)

		TOTAL COLIFORMS/100 ml				FAECAL COLIFORMS/100 ml				ENTEROCOCCI/100 ml				SALMONELLA/5 l	
		1	1-100	101-10^3	10^3	1	1-100	101-10^3	10^3	1	1-100	101-10^3	10^3	pos.	neg.
1	8	1	3	2	2	2	6	0	0	1	7	0	0		
2	8	2	4	2	0	6	2	0	0	2	5	1	0		
3	8	1	6	1	0	6	2	0	0	4	3	1	0		
4	8	1	5	2	0	8	0	0	0	3	5	0	0	0	8
5	8	4	4	0	0	7	1	0	0	2	4	2	0		
6	8	0	6	0	2	6	2	0	0	1	7	0	0		
7	8	0	5	2	1	5	3	0	0	1	7	0	0		
8	8	0	6	2	0	3	5	0	0	4	3	0	1		
9	8	0	4	2	2	1	6	0	1	1	6	1	0		
10	8	0	3	3	2	4	4	0	0	1	7	0	0	0	8
11	8	0	3	3	2	2	4	1	1	3	4	1	0	1	7
12	8	1	6	1	0	3	5	0	0	3	5	0	0	1	7
13	8	0	2	2	4	2	5	1	0	0	4	1	3		
14	8	1	3	1	3	1	4	2	1	1	4	1	2		
15	8	0	3	5	0	4	2	2	0	5	3	0	0	1	7
16	8	1	2	3	2	3	4	1	0	7	0	0	1		
1	8	1	2	4	1	3	2	3	0	0	5	2	1		
1•	8	1	3	2	2	3	4	1	0	1	4	2	1		
19	8	0	3	2	3	2	2	2	2	0	5	1	2		
20	8	2	3	2	1	5	2	0	1	4	2	0	2		
21	8	3	2	2	1	5	2	0	1	3	3	1	1		
22	8	1	5	1	1	5	2	0	1	4	3	0	1		
23	8	1	5	2	0	5	3	0	0	4	2	2	0		
24	8	2	5	1	0	6	1	1	0	5	2	1	0	0	8
25	8	2	1	4	1	3	4	1	0	2	5	0	1		
26	8	4	2	1	1	6	1	0	1	5	1	1	1		
27	8	2	5	0	1	5	2	0	1	1	5	0	2		
28	8	3	5	0	0	7	1	0	0	6	2	0	0		
29	8	1	3	4	0	4	4	0	0	2	5	1	0		
30	8	2	4	2	0	4	4	0	0	3	3	2	0		
31	8	2	6	0	0	6	2	0	0	3	5	0	0		
32	8	1	7	0	0	5	3	0	0	4	3	1	0		
33	8	4	3	1	0	6	2	0	0	4	3	1	0		
34	8*	1	5	2	0	3	4	0	0	3	3	1	0		
35	8	2	3	2	1	6	2	0	0	4	3	1	0		
36	8	3	2	2	1	3	5	0	0	4	3	1	0		
37	8	2	4	1	1	6	2	0	0	5	3	0	0		
38	8	2	2	4	0	3	5	0	0	3	5	0	0		
39	7	1	3	2	1	4	3	0	0	4	2	1	0		
40	8**	2	4	1	0	4	4	0	0	3	5	0	0		
41	8	3	4	1	0	6	2	0	0	6	2	0	0		
42	8**	2	5	0	0	8	0	0	0	7	1	0	0		
43	8	2	3	3	0	4	3	1	0	2	6	0	0		
44	8	1	3	4	0	4	4	0	0	4	4	0	0		
45	8	0	6	1	1	5	3	0	0	3	4	0	1		
46	8	2	3	3	0	5	3	0	0	3	4	1	0		
47	8	3	4	1	0	5	3	0	0	4	4	0	0		
48	8	3	4	1	0	6	2	0	0	5	2	1	0		
49	8	3	4	1	0	5	3	0	0	7	0	0	1		
50	8	2	1	4	1	3	4	1	0	3	3	1	1		
51	8	1	4	2	1	2	5	1	0	0	7	1	0		
52	8	1	0	3	4	1	3	3	1	1	5	2	0		
53	8	2	2	1	3	2	4	1	1	2	5	1	0		
54	8	2	1	2	3	3	2	2	1	4	1	2	1		
55	8	2	2	2	2	3	2	3	0	4	3	1	0		

* one total faecal coliforms and enterococci count not done;

** one total coliforms count not done.

Table v. - Frequency distribution for faecal coliform counts as related to major areas and to seasons.

Stations	No. of samples	Season	% samples with counts/100 ml of		
			$\leqslant 100$	$101 - 10^3$	$> 10^3$
1 - 15	75	S	78.9	14.7	6.7
	89	W	79.8	16.8	3.4
16 - 28	76	S	90.7	3.9	5.3
		*			
	66	W	51.5	25.7	22.7
29 - 55	159	S	93.1	5.7	1.2
	133	W	92.5	6.8	0.7
All stations	310	S	89.1	7.4	3.5
		*			
	288	W	79.5	13.5	6.9

Table VI – Frequency distribution for enterococcal counts as related to major areas and to seasons.

Stations	No. of samples	Season	% samples with counts/100 ml of		
			$\leq$ 100	101 – 10^3	> 10^3
1 – 15	75	S	89.3	9.3	1.3
	89	W	85.4	7.9	6.7
16 – 28	76	S *	90.8	6.6	2.6
	66	W	45.4	27.3	27.3
29 – 55	159	S	98.7	0.6	0.6
	133	W	86.5	11.3	2.2
All stations	310	S *	94.5	4.2	1.3
	288	W	76.4	13.5	10.1

Table VII. - Summarized data on microbiological monitoring of coastal seawater of the Gulf of Trieste: distribution of microbial counts by the indicated parametric values

		TOTAL COLIFORMS/100 ml				FAECAL COLIFORMS/100 ml				ENTEROCOCCI/100 ml				SALMONELLA/5 l	
		1	1–100	101–10^3	10^3	1	1–100	101–10^3	10^3	1	1–100	101–10^3	10^3	pos.	neg.
1	3	0	3	0	0	0	3	0	0	0	3	0	0		
2	3	1	2	0	0	2	1	0	0	0	3	0	0		
3	3	2	1	0	0	2	1	0	0	2	1	0	0		
4	3	1	2	0	0	2	1	0	0	2	1	0	0		
5	3	3	0	0	0	2	1	0	0	2	1	0	0	0	4
6	3	2	0	1	0	1	2	0	0	0	3	0	0		
7	3	3	0	0	0	2	1	0	0	2	1	0	0		
8	3	1	2	0	0	1	2	0	0	0	3	0	0		
9	3	0	3	0	0	0	3	0	0	0	3	0	0		
10	3	1	0	1	1	1	1	0	1	0	2	1	0	0	4
11	3	0	1	1	1	0	1	2	0	1	0	2	0	0	4
12	3	0	2	0	1	0	2	0	1	1	2	0	0	1	3
13	3	1	1	1	0	1	1	1	0	1	2	0	0		
14	3	1	1	1	0	0	2	1	0	0	2	1	0		
15	3	1	1	1	0	2	0	1	0	1	2	0	0		
16	3	1	1	1	0	1	1	1	0	1	1	1	0		
17	3	1	0	1	1	1	0	1	1	1	0	1	1		
18	3	1	2	0	0	0	3	0	0	0	3	0	0		
19	3	1	0	1	1	1	0	1	1	0	1	0	2		
20	3	2	1	0	0	2	0	1	0	2	0	1	0		
21	3	2	1	0	0	2	1	0	0	1	2	0	0		
22	3	2	0	1	0	1	1	1	0	1	1	0	1		
23	3	0	3	0	0	1	2	0	0	0	3	0	0		
24	3	2	1	0	0	2	0	1	0	1	1	1	0	1	3
25	3	1	2	0	0	0	3	0	0	1	1	1	0		
26	3	2	0	1	0	2	0	1	0	0	2	1	0		
27	3	2	0	1	0	2	0	1	0	1	1	1	0		
28	3	2	1	0	0	2	0	1	0	2	0	1	0		
29	3	1	2	0	0	2	0	1	0	0	2	1	0		
30	3	2	0	1	0	2	0	1	0	2	1	1	0		
31	3	0	3	0	0	2	0	1	0	1	1	1	0		
32	3	1	1	1	0	2	0	1	0	1	1	1	0		
33	3	2	0	1	0	2	0	1	0	0	2	1	0		
34	3	2	1	0	0	1	2	0	0	0	3	0	0		
35	4	1	2	0	1	2	1	1	0	1	3	0	0		
36	4	2	2	0	0	1	3	0	0	1	3	0	0		
37	4	1	3	0	0	1	3	0	0	2	1	1	0		
38	4	2	2	0	0	3	1	0	0	3	1	0	0		
39	4	2	2	0	0	2	2	0	0	2	2	0	0		
40	4	2	2	0	0	4	0	0	0	4	0	0	0		
41	4	4	0	0	0	3	1	0	0	3	1	0	0		
42	4	3	1	0	0	3	1	0	0	4	0	0	0		
43	4	2	0	2	0	2	2	0	0	2	2	0	0		
44	4	3	1	0	0	4	0	0	0	4	0	0	0		
45	4	2	2	0	0	4	0	0	0	0	4	0	0		
46	4	1	3	0	0	2	2	0	0	4	0	0	0		
47	4	3	1	0	0	3	1	0	0	3	1	0	0		
48	4	2	2	0	0	3	1	0	0	3	1	0	0		
49	4	2	2	0	0	3	1	0	0	3	1	0	0		
50	4	1	3	0	0	3	1	0	0	2	2	0	0		
51	4	1	3	0	0	1	3	0	0	1	3	0	0		
52	4	0	1	1	2	1	2	1	0	1	3	0	0		
53	4	1	1	2	0	1	2	1	0	1	2	1	0		
54	4	1	1	1	1	1	2	1	0	1	2	1	0		
55	4	1	1	0	2	1	1	2	0	1	2	1	0		

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Zoological Station of Naples
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Principal Investigator: L. MENDIA

INTRODUCTION

The constant sampling in the Gulf of Naples began in 1976 and has been regularly continued at the Naples Zoological Station together with the *Sanitary Engineering Centre (Institute of Water Supply and Wastes Disposal)* from September 1977 until today.

Work began in 1976 in collaboration with Dr. Lilian M. Evison of the Department of Civil Engineering, University of Newcastle upon Tyne, U.K. and it continued thanks to the collaboration even of E. Tosti and L. Voltezza of *Zoological Station of Naples*.

Samples of sea-water were taken at frequent intervals in the Bay of Naples from Nisida to the harbour of S. Lucia. The sampling points were selected so that both unpolluted and polluted waters could be investigated in order to make a comprehensive analysis of the coastal water quality.

AREA(S) STUDIED

The sea stretch between Nisida and S. Lucia harbour was monitored within the framework of the MED POL VII pilot for recreational coastal water control. Along this area 40 stations were located. Two reference points were chosen: station No. 102 (Rotonda Diaz) for locations 109 to 87; and station No. 76 (Villa Beck) for locations 86 to 64.

Two sampling stations (Bacoli and Coroglio) located in the Gulf of Pozzuoli, were chosen for shellfish monitoring activities. Moreover shellfish samples collected in the market were analysed.

The two maps (Figure 1 and Figure 2) give details of the selected areas.

MATERIAL AND METHODS

Sea-water monitoring:

Sea-water samples were collected by boat at a distance of approximately 10 m from the shore. At each point triplicate samples were taken.

(a) 500 ml in a sterile bottle for bacteriological analysis

(b) 250 ml sample, immediately fixed for D.O. analysis

(c) 125 ml sample for salinity determination.

In addition, water temperature and "Secchi disc" readings were measured at the same sites. Air temperature, wind direction and wind speed were also measured at the reference points using an anemometer. Sea-water samples were taken from the surface, mid-depth and bottom. River and effluents samples were collected from the land.

Biological tests:

All samples were analysed by membrane filtration using 47 mm diameter membrane filters, 0.45 um pore size. For every sample three different volumes of water (1, 10, 100 ml) were filtered in triplicate for three different analyses: one set was analysed for coliforms, one set for E. coli and one set for faecal streptococci.

Coliform counts (37°C for 18 hours)	- Eosin methylen blue agar (MF) Membrane faecal coliform agar (MF) Teepol broth (MF)
E. coli counts (44°C for 18 hours)	- Membrane faecal coliform agar (MF)
Faecal Streptococci counts (44°C for 48 hours)	- Slanetz and Bartley agar (MF) m-Enterococcus agar (MF)

Chemical tests:

Salinity was determined on a Beckman Model R67-C induction salinometer. D.O. was determined on the fixed samples (2ml $MnSO_4$ plus 2 ml Alkali- Iodide - Azide reagent) by acidifying with H_2SO_4 and titrating. The percentage saturation of oxygen in water was calculated at 20,000 mg/l chloride at the appropriate temperature.

Shellfish monitoring:

A total of 55 shellfish samples and 36 of culture water were analysed up to September 1979.

MPN method was followed for enumerating total coliforms and *Escherichia coli* in the shellfish flesh, according to the directives fixed by the working group at the meeting held in Rome, April 1978, and in water. Parallel analyses were carried out according to the MF method on water only.

Faecal streptococci and heterotrophic bacteria were detected with the PP method as described in the Guidelines. Enterococci detection was performed according to the MF method on water samples only.

The analyses on shellfish were performed adding to the samples four times the diluent equivalent to the flesh weight.

In addition to the above-mentioned methods simultaneous analyses with the PP technique were carried out in triplicate for coliform and E. coli recovery in order to establish possible correlations between results obtained using different methodologies.

Coliform counts (37°C for 18 hours)	-	Lactose broth (MPN) MacConkey broth (MPN) MacConkey agar (PP) Teepol broth (MF for water only)
E. coli counts (44°C for 18 hours)	-	Brilliant Green Bile Lactose broth (MPN) + indole production test MacConkey broth (MPN) + indole production test MacConkey agar (PP) Teepol broth (MF for water only)
Faecal streptococci counts (44°C for 48 hours)	-	m-Enterococcus agar (PP and MF for water only)
Total bacterial counts (26°C for 4 days)	-	Plate Count agar (PP)

Additional analyses using the above-mentioned criteria were also carried out on the liquor in order to identify its influence on the shellfish bacterial counts when these are carried out on mixed samples (flesh plus liquor).

DISCUSSION OF RESULTS

Recreational waters:

The results of the analysis of superficial water samples are summarized in Tables I, II and Figure 3 where only maximum and minimum values are reported and where also the EEC "G" and "I" values are given. The following comments may be made:

1. The coliform count is generally higher than the E. coli count. The enterococci count invariably gives the lowest count values in respect of the others.

2. All the bacterial counts show the same general pattern and the major sources of contamination can be identified.

3. The inherent variability of bacteriological testing is also shown in graphs of Figure 4. Samples taken from the same point can differ by a factor of 1,000, even if the samples themselves are collected at the same time in the same day. Higher counts, in fact, are generally obtained when wind strength increases and sediments are resuspended. This is particularly noticeable in counts in Via Caraccioli, with E. coli values fluctuating above and below the EEC "G" value of 100 E. coli/100 ml.

4. The dissolved oxygen concentration for the various samplings is more or less near saturation; for seven samples among the 25, the D.O. is less than 90 per cent but always higher than 63 per cent.

5. The majority of samples present salinities in the range 36.4-37.8°/oo. Seven samples show salinities between 33.9 and 35.9°/oo (Table I).

6. Wide fluctuations in bacteriological results were found in certain stations, i.e. Punta Cavallo (68), Villa Beck (76), Mergellina (94 - 96), Aliscafi (97) and Rotonda Diaz (100 - 102). There is no evidence that the variations can be related to changes in D.O. or salinity, but in many instances high bacterial counts occur when Secchi disc depths are very low (that is, when the water is very turbid). This is particularly true of results at sites between Mergellina and S. Lucia. At some sampling stations, e.g., Rotonda Diaz (central point) most of the variations in the results can be explained by the intermittent discharge of sewage from some outfalls (sometimes abusively used for sewage). Other sites do not have outfalls in the vicinity and the variation must be caused by other factors. It is suggested that the wind direction in the previous days and the direction of the current at the time of the sampling are particularly important factors. At Coroglio when the current flows from the west or south-west, sewage is carried towards Faiola. Form Mergellina to S. Lucia the worst bacteriological conditions probably occur following a period of strong winds from the south, which may cause the current to flow from a south-east or easterly direction. In this situation the more highly polluted waters from San Giovanni to Teduccio-Portici drift into the Bay.

Table I shows the results obtained during various periods of time at three different stations, as follows: (1) (point 64) at the outfall of Coroglio; (2) (point 76) and authorized bathing place; and (3) (point 101) an unauthorized bathing place.

7. A high correlation between the total coliforms and faecal coliforms has been noted for 66-67% of the locations. At the same time, a high correlation also exists between faecal coliforms and faecal streptococci (64.44% of the total locations); a lower correlation between total coliforms and faecal streptococci was found: only 42.22% of the stations show high correlation indices between these two parameters.

8. Starting from the hypothesis of a normal distribution of the results obtained in each station in order to identify significant locations where it would be better to concentrate the future monitoring efforts, a statistical analysis has been performed. The "t-test" and variance analysis between pairs of consecutive stations for each microbiological parameters were calculated

9. A comparison of all the statistical evaluations calculated for each location and each indicator was carried out. On the basis of the tests' over-all results it appears that only a few stations should be excluded from future studies, i.e. 73, 74, 79, 87, 97, 101, 102 and 103, while the correlation results suggest that stations 77, 78, 82, 85, 86, 99, 106 and 109 should also be excluded.

10. The oxygen deficit varies widely due to the effect of bacterial degradation of organic matter and of surface aeration. Low levels of dissolved oxygen have been measured around the Cuma outfall. San Giovanni to Teduccio outfall and the River Sarno. The extended observation in 1978 confirmed previous results (1976-1977) regarding Coroglio (one of the five polluted areas). Here the vigorous wind and wave action results in super-saturated water. Along Via Caracciolo, because of some organic pollution sources and some wind protection, the oxygen deficit reaches about 10%.

11. The salinity values are less variable than the D.O. data and the majority of samples show salinities in the range 37-38^{o}/oo. Varitations in results in Via Caracciolo samples are caused by discharges of salinities, lower temperatures and lower % oxygen saturation at the bottom.

It is possible to note that at point 64 (polluted water), even during meteorological changes, the values of E. coli remain the same. These values are higher than the standard ones; in fact they are in the order of 104. It is clear that the sewage coming from the outfall is not influenced by external conditions. It is in fact diluted very slowly as is proved by the samples collected along the coast (see also Table II from points 64 to 74). At point 76 (an authorized bathing place) it has been noted that the values of E. coli are lower than the standard ones. Higher counts are generally noted when wind strength increases and it exceeds 10 m/sec. At point 101 (an unauthorized bathing place) the values of E. coli are very high only when the current comes from the east. The strength of the current influences the dispersion of the sewage from the San Giovanni outfall. Without the influence of this current, the values of E. coli are in accordance with the standard.

Table II gives the results of sample collection during two days in the summer of 1978 - 20 sampling points each day (in total 45 points). The values measured during these two days are significative of the water quality of the sampling points. In fact the results obtained are more or less the same as those of sample collections during other periods of the year at the same points.

During 1980 the collected data were statistically analysed.

Shellfish:

A marked difference was found between Bacoli, an authorized shellfishing area, and Coroglio, a polluted zone. Local currents may cause suspended material and bacteria to drift from one place to the other. Most of the analyses carried out on water samples exceed the Italian standards. The concentration and accumulation of bacteria in shellfish is higher during the summer.

Correlation indices were calculated for the four microbial parameters namely, total coliforms (TC), faecal coliforms (FC), faecal streptocccci (FS) and total bacterial count (TBC) analysed in Bacoli, Coroglio and the shellfish market.

In general, total coliforms and faecal coliforms were always closely related. In summer the correlation was higher than in winter.

TBC is the least correlated of the four parameters.

An evaluation of the influence of liquor added to the shellfish flesh on the bacterial counts (TC, FC and FS) showed how liquor may increase or decrease the counts in the shellfish flesh depending upon the quality of the shellfish culture water and the state of shellfish natural self purification.

The histograms appearing in Figures 5, 6, 7 and 8 give frequencies of faecal coliforms in 100/ml for shellfish growing waters and shellfish flesh in summer and in winter of 1980.

CONCLUSIONS

The m-FC medium for total coliforms detection was unsuitable. Pink colonies often influenced large areas on the membranes; as a result the development of lactose-fermented colonies was not always appropriate.

The *E. coli* counts appear to reflect the faecal contamination of the water more accurately than total coliforms, (too widespread in the environment), or faecal streptococci counts (too low to be sensitive).

Teepol broth was more suitable for total coliform detection.

The water pollution level is always over the quality standards as regards the stations near the collectors (points 64 up to 67). Within a few meters the water quality improves reaching the values accepted as quality standards for the bathing areas.

The bacteriological water quality at the same points show constant values. Also as regards the D.O. and the salinity values; in particular the D.O. value is near the saturation while the salinity is in the range of 36-37^{o}/oo.

The bacteriological quality of the shellfish is worse in summer than in winter. The Coroglio shellfish grow freely on the rocks and near a big collector.

The faecal coliforms/100 gr of flesh pass the 10^5 values.

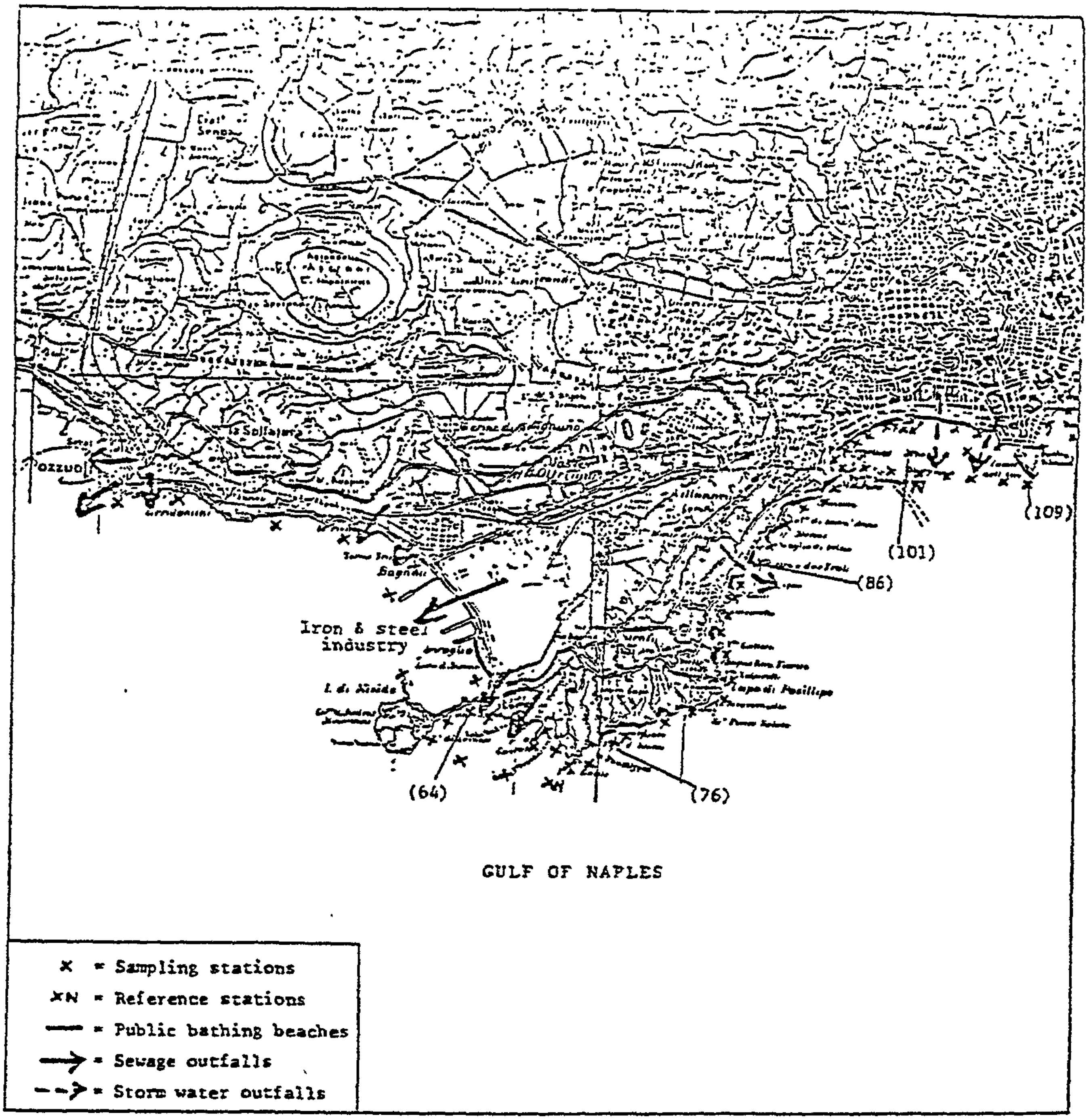


Fig. 1. Gulf of Naples

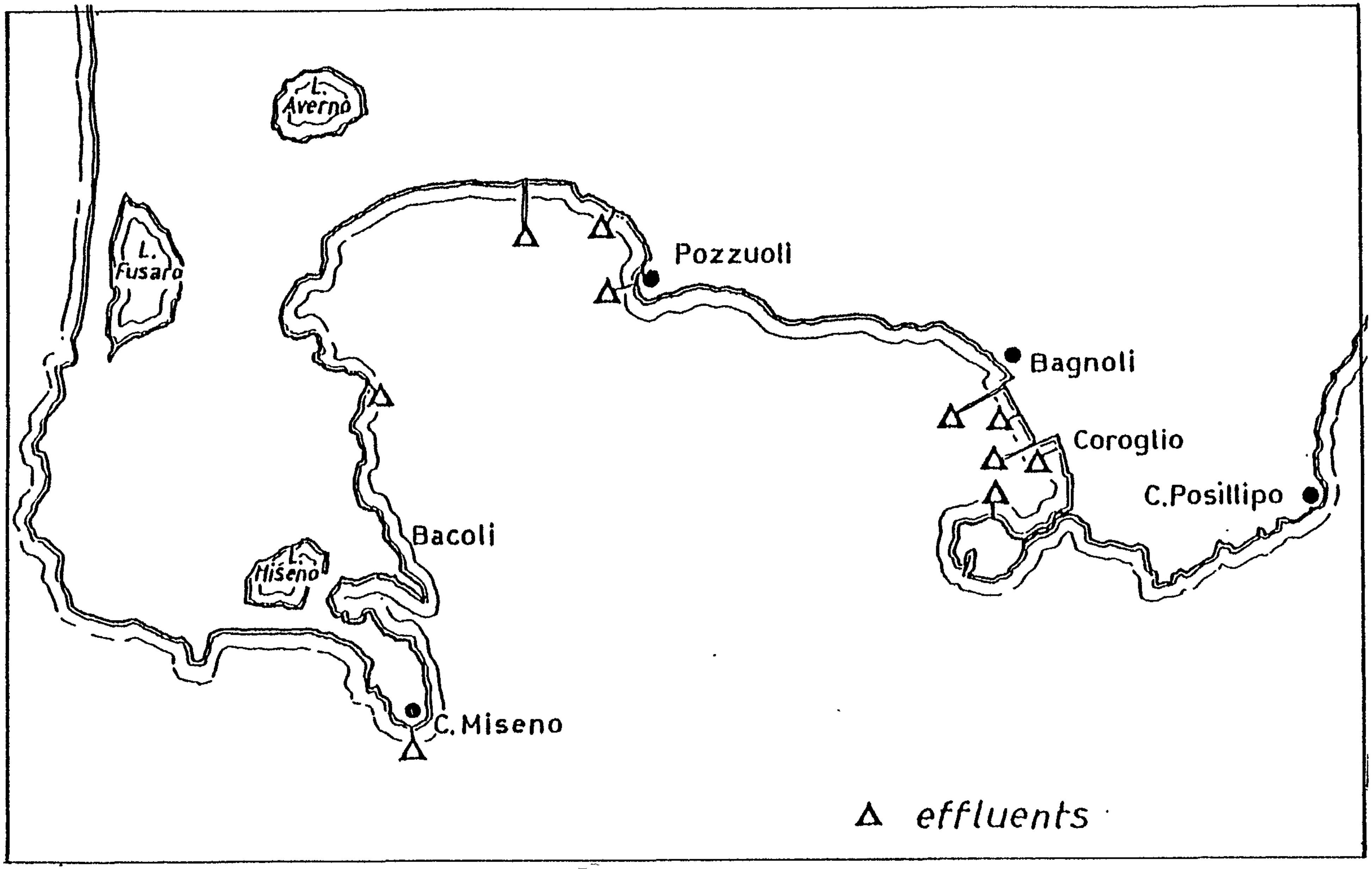


Fig. 2. Area studied

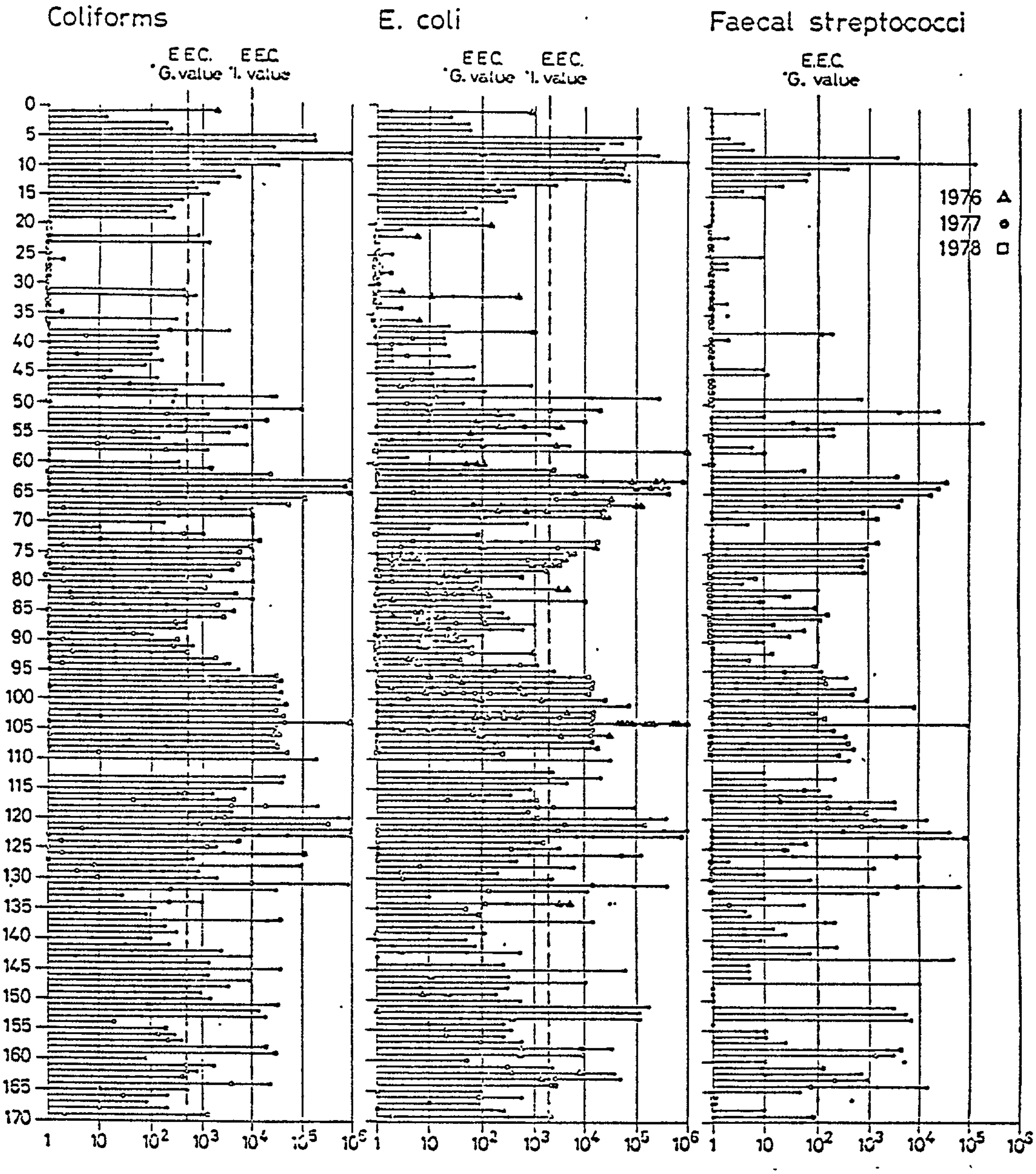


Fig. 3. Maximizing and Minimizing Values

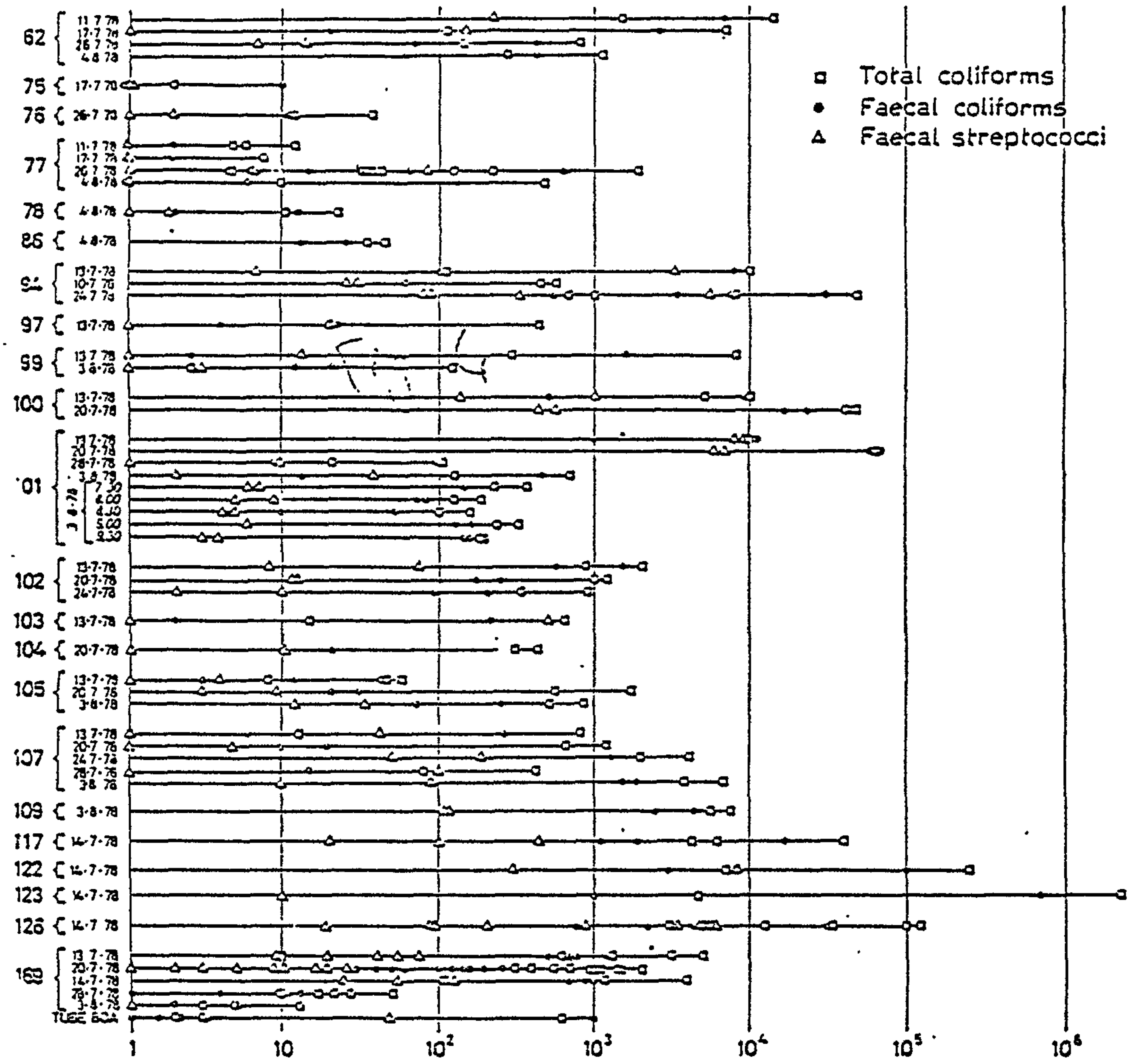


Fig. 4. Variability of Results Obtainable on Parallel Samples

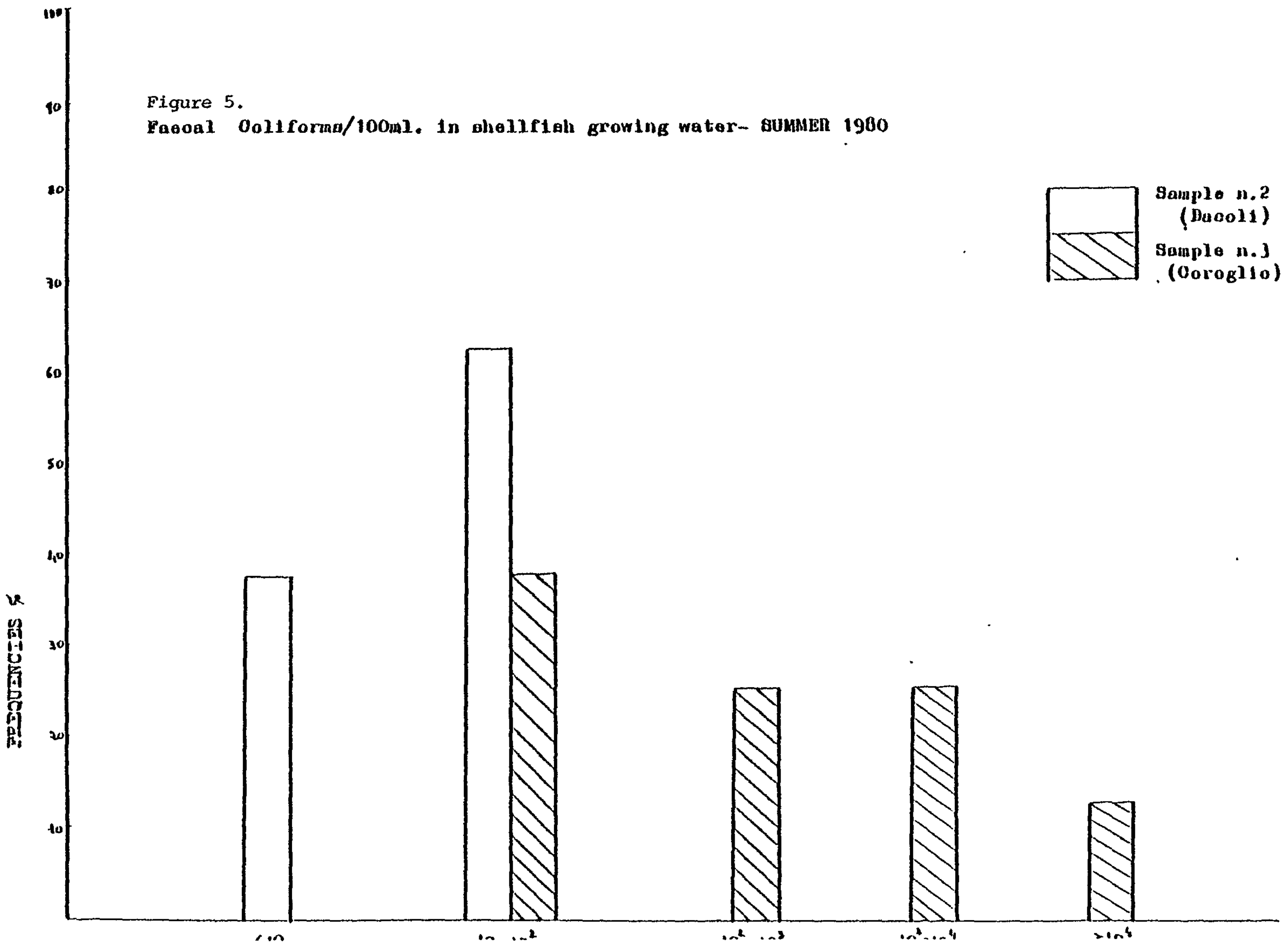
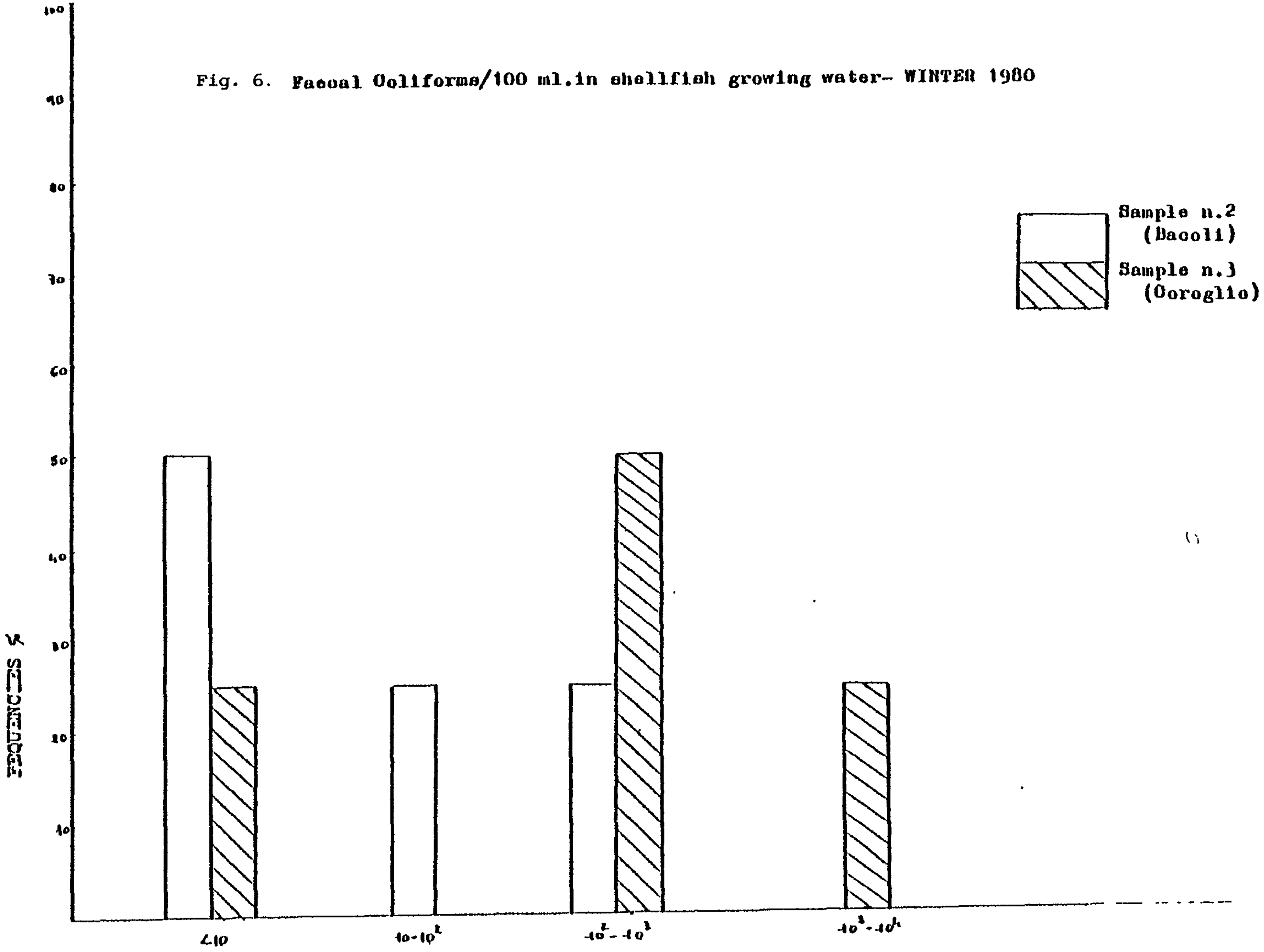


Figure 5.
Faecal Coliforms/100ml. in shellfish growing water– SUMMER 1980

Fig. 6. **Faecal Coliforms/100 ml. in shellfish growing water– WINTER 1980**



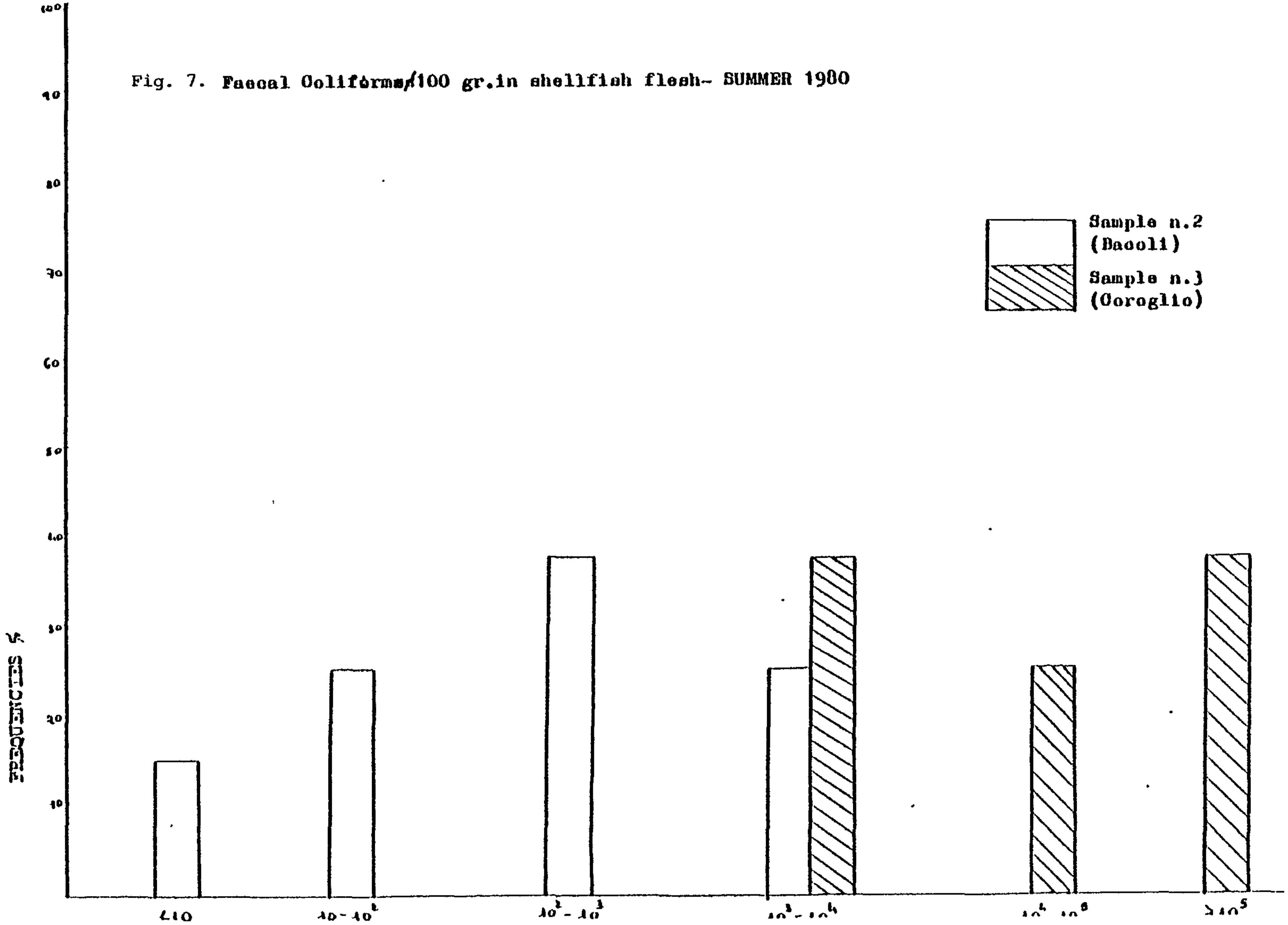


Fig. 7. Faecal Coliforms/100 gr.in shellfish flesh- SUMMER 1980

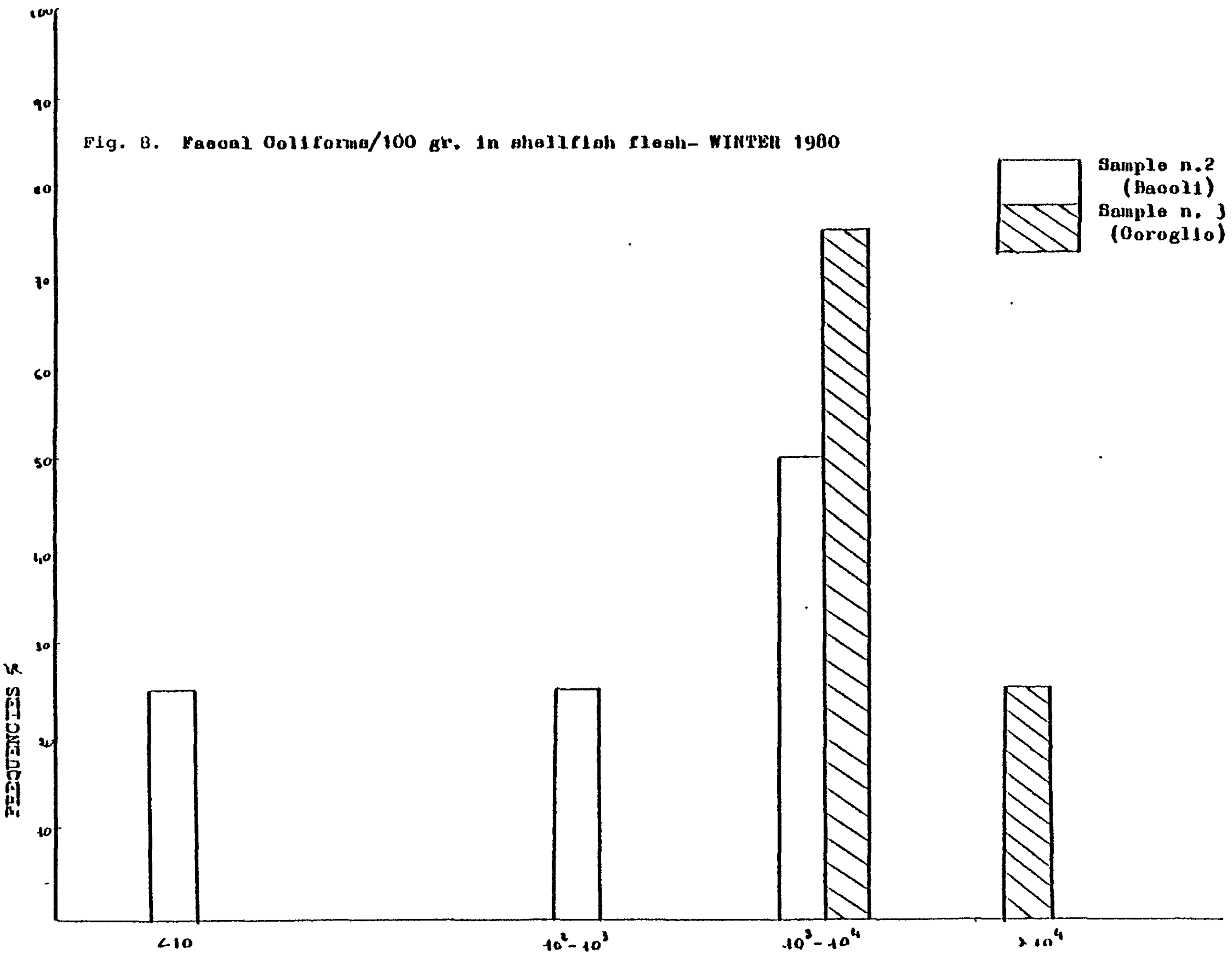


Fig. 8. Faecal Coliforms/100 gr. in shellfish flesh- WINTER 1980

Table I

Point 64 - near the collector of Coroglio (polluted water)

Date	Wind	Water temp. (°C)	D.O. (%)	Salinity (%)	Coliforms (/100 ml)	*E. coli* (/100 ml)	Enterococci (/100 ml)
13.6.78	9 km/h	22	87	36.436	1.23×10^5	4.7×10^4	1.3×10^4
26.6.78	3 km/h	23	63.8	-	2.52×10^4	4.08×10^4	1.7×10^3
11.7.78	0.5 m/sec	22	100	33.94	7×10^5	3×10^5	2.6×10^4
17.7.78	calm	24	85	35.16	1.06×10^4	3×10^5	2.4×10^4
21.7.78	5 m/sec	24	95	37.45	2.4×10^5	1.3×10^3	4.7×10^3
26.7.78	calm	23	90	36.87	7.5×10^5	3.1×10^5	3.1×10^3
9.11.78	calm	17.5	83	35.63	TNTC	TNTC	5.7×10^3
21.11.78	calm	17.7	94	35.47	TNTC/1 ml	TNTC/1 ml	3900

Point 76 - authorized bathing place (unpolluted water)

Date	Wind	Water temp. (°C)	D.O. (%)	Salinity (%)	Coliforms (/100 ml)	*E. coli* (/100 ml)	Enterococci (/100 ml)
13.6.78	9 km/h	22	100	37.24	1.08×10^3	7.2×10^2	4
26.6.78	3 km/h	23	68	36.68	2×10^3	3.28×10^3	6.8×10^2
11.7.78	0.5 m/sec	22	118	37.15	3	0	0
17.7.78	calm	24	108	37.21	0	0	0
21.7.78*	5 m/sec	24	> 100	37.45	33	3	0
26.7.78	calm	23	105	37.51	12	12	2
9.11.78	calm	17.5	95	37.80	206	28	1
21.11.78	calm	17.7	95	37.67	TNTC	52	152

Point 101 - Rotonda Diaz - unauthorized bathing place

Date	Wind	Water temp. (°C)	D.O. (%)	Salinity (%)	Coliforms (/100 ml)	*E. coli* (/100 ml)	Enterococci (/100 ml)	Current
6.6.78	-	-	121	35.74	3.2×10^4	1.58×10^4	60	east
20.6.78	2 km/h	23	104	36.61	30	0/10 ml	0	west
6.7.78	calm	24	99	36.87	43	32	1	west
13.7.78	calm	23	104	35.96	$>1 \times 10^4$	$>1 \times 10^4$	8×10^3	east
20.7.78	3 m/sec	25	77	35.21	6×10^4	7×10^4	6×10^3	east
24.7.78	2 m/sec	23.5	130	36.99	9×10^2	1×10^2	10	east
28.7.78	calm	23.5	106	37.40	1×10^2	10^2	10	west
15.11.78	calm	17	89	37.84	18	3	1	west
6.12.78	-	15	94	37.68	760	19	1	west

*Salmonella test negative

Table II Results of monitoring in forty sampling points during two days of summer 1978

Date	Point	Wind	Water temp. (°C)	D.O. (%)	Salinity (%)	Coliforms (/100 ml)	*E. coli* (/100 ml)	Enterococci (/100 ml)
13.6.78	64	9 km/h	23	87	36.43	1.23×10^5	4.7×10^4	1.3×10^4
"	65	"	"	83	36.33	6.5×10^4	5.4×10^4	9×10^2
"	66	"	"	66	33.60	2.8×10^4	3.3×10^4	3.3×10^4
"	67	"	"	90	36.33	3.4×10^3	2.3×10^3	19
"	68	"	"	91	36.65	1.95×10^3	1.66×10^3	4
"	69	"	"	91	36.91	2.52×10^3	1.77×10^3	3
"	73	"	"	91	36.96	3.4×10^3	1.28×10^3	1
"	74	"	"	95	37.20	2×10^3	1.2×10^3	2
"	75	"	"	90	37.22	2.5×10^3	1.21×10^3	4
"	76	"	"	100	37.26	1.08×10^3	7.2×10^2	4
"	77	"	"	95	37.19	610	410	2
"	78	"	"	101	37.25	650	560	2
"	79	"	"	95	37.29	710	560	7
"	80	"	"	102	37.31	120	80	0
"	81	"	"	90	37.32	1.29×10^3	82	1
"	82	"	"	105	37.37	280	54	0
"	83	"	"	85	37.77	TNTC	TNTC	3
"	84	"	"	101	37.33	10	2	0
"	85	"	"	98	37.35	6	6	0
"	86	"	"	100	37.32	6	6	0
20.6.78	109	2 km/h	25	106	36.84	10	0	0
"	108	"	"	105	36.63	0	0	0
"	107	"	"	107	36.63	0	0	0
"	106	"	"	107	36.62	0	0	0
"	105	"	"	107	36.62	0	0	0
"	104	"	"	101	36.61	0	0	0
"	103	"	"	114	36.59	10	10	0
"	102	"	"	105	36.62	30	0	0
"	100	"	"	104	36.60	10	10	0
"	99	"	"	101	36.59	10	0	0
"	98	"	"	104	36.61	0	10	0
"	97	"	"	106	36.62	10	0	0
"	93	"	"	104	36.61	6	4	0
"	92	"	"	103	36.84	12	0	0
"	91	"	"	101	36.82	0	10	0
"	90	"	"	106	36.86	20	0	0
"	89	"	"	97	36.87	30	0	0
"	88	"	"	102	36.87	0	0	0
"	87	"	"	107	36.87	10	0	0

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INTRODUCTION

The ISS has previously worked on problems concerning Mediterranean coastal environmental hygiene through activities aimed at pointing out the qualitative aspects of the input of coastal, civil or industrial installation effluent waters in coastal waters. We mention, as more precise examples, the survey of microbiological parameters carried out in the Anzio coastal area by L. Villa, et al., and the surveys of hydrological parameters and qualitative input in the coastal waters in the areas of Montalto di Castro (Argentario), Nettuno, Circeo, Ponza Island and Elba Island, carried out by G. Ugolini.

AREA(S) STUDIED

The ISS group has monitored a stretch of coast (Castel Porziano) with characteristics representative of the whole Italian coastline. This area is not greatly affected by concentrated discharge but receives waters from inland areas of inhabited land and parkland areas. Moreover, it is close to a large city (Rome) whose population use the area for bathing.

The stretch of coastline examined (Castel Porziano, 41°41'N, 12°31'E; 41°40'N, 12°32'E) is delimited by two water courses, Fosso Focetta and Fosso del Tellinaro. Fosso del Tellinaro originates in the parkland of Castel Porziano and collects only rain water. Moreover, it does not reach the sea because it is frequently obstructed at the mouth. On the contrary Fosso Focetta receives water from domestic discharges. The sea currents affecting the sampling points have an offshore course towards the coast from a SW direction in the daylight hours and come from the SE, parallel to the coast, at sunset and dawn (Figure 1). The prevailing winds (40 per cent) in the area blow from the SW with an average velocity of 4.5 m/s, and the water temperatures, jointly with solar irradiation, for the latitude of 41°N, were measured. The sea-bed on the 3 m bathometric line is sandy with areas of rock, mud and seaweed.

MATERIAL AND METHODS

The total coliform, faecal coliform and enterococci were detected using the MF method agreed by the MED POL VII project and the recommended media and incubation. In addition the detection of the above indicators was carried out by the MPN method as laid down by Italian regulations.

Sampling is carried out on a bathometric line of about one (1) metre. In addition to the microbiological parameter the following chemical and physical parameters were measured: sea conditions, currrents, wind, air and water temperatures and the absolute values of salinity, D.O., NH_4 NO_2, PO_4.

Dissolved oxygen was measured both with an cxygenmeter and chemically using the Winkler method (WHO), modified. The salt residue was measured both with a conductivity instrument and by evaporation and then weighed at 180°C; the ratio of the values obtained was practically constant; therefore salinity is, as a rule determined by the conductivity instrument using the above ratio and, from time to time, as a control, by evaporation.

Pathogenic organisms and bacteriophages in the water courses deliminating the area studied, were identified. They included salmonella, bacteriophages and sulphite reducers. Chlorophyll and phytoplankton were also detected. Additional chemical parameters related to possible eutrophication were analysed: ammonium; nitrite ion; phosphate ion. Moreover hydrogen sulphide was investigated in some samples.

RESULTS AND THEIR INTERPRETATION

From the evaluation of the analytical data it appears that the pollution indices in the studied area do not bear any relation to time. This reflects the homogeneous climatic condition (sea calm or nearly calm, velocity of wind and current moderate, clear sky, lack of relief rainfall) during the last three days under which the sampling took place.

As far as spatial distribution is concerned, it can be observed that slight variations exist for some indices (microbiological, such as the faecal coliform and physico-chemical, such as D.O. and salinity). This is related to Fosso Focetta which affects, in particular, sampling point No. 2 situated 200 m from its outlet and, periodically, sampling point No. 3 situated about 400 metres from the outlet. The content of streptococci shows a tendency to increase, at times even noticeably, but bearing no relation to the parallel parameter of faecal coliform and the discharge in the area.

The results of the monitoring during the period September 1979 - March 1981 show that the hygienic condition of the area studied is satisfactory. Faecal coliform concentrations were below the established levels. However, during 4 sampling periods a noticeable increase of all the microbial indicators was experienced. This was attributed to a heavy rainfall which occured in the area at a time not exceeding 24 hours before the sampling. In these conditions the increase of the concentration of the indicators, and particularly of the faecal coliforms is evident throughout the monitored area. Moreover there is a tendency that the indicators are levelled out at a high point throughout the various sampling stations.

DISCUSSION OF RESULTS

Observations over a longer period might confirm the data so far collected. It would be advisable to correlate analytical data obtained with the seasonally fluctuating population living in the area which drains into the monitored coastal line.

The samples seem to indicate a confirmation of the repetition of seasonal trends in the area as far as characteristics of rainfall, temperature and sea conditions are concerned. The effluent waters of the summer pollution, still under evaluation, are not significant in the determination of a variation of mean values, at least on the basis of data so far available.

It can be concluded that, with the object of evaluating the coastal hygiene in the area used for bathing, the most indicative and specific index is the faecal coliform. The faecal streptococcus which shows an irregular trend would not seem a suitable index of pollution.

From the results experienced during the period September 1979 - March 1981 it appears that in order to obtain results which are not influenced by heavy rainfall it is advisable to take samples at least four days after their occurrence.

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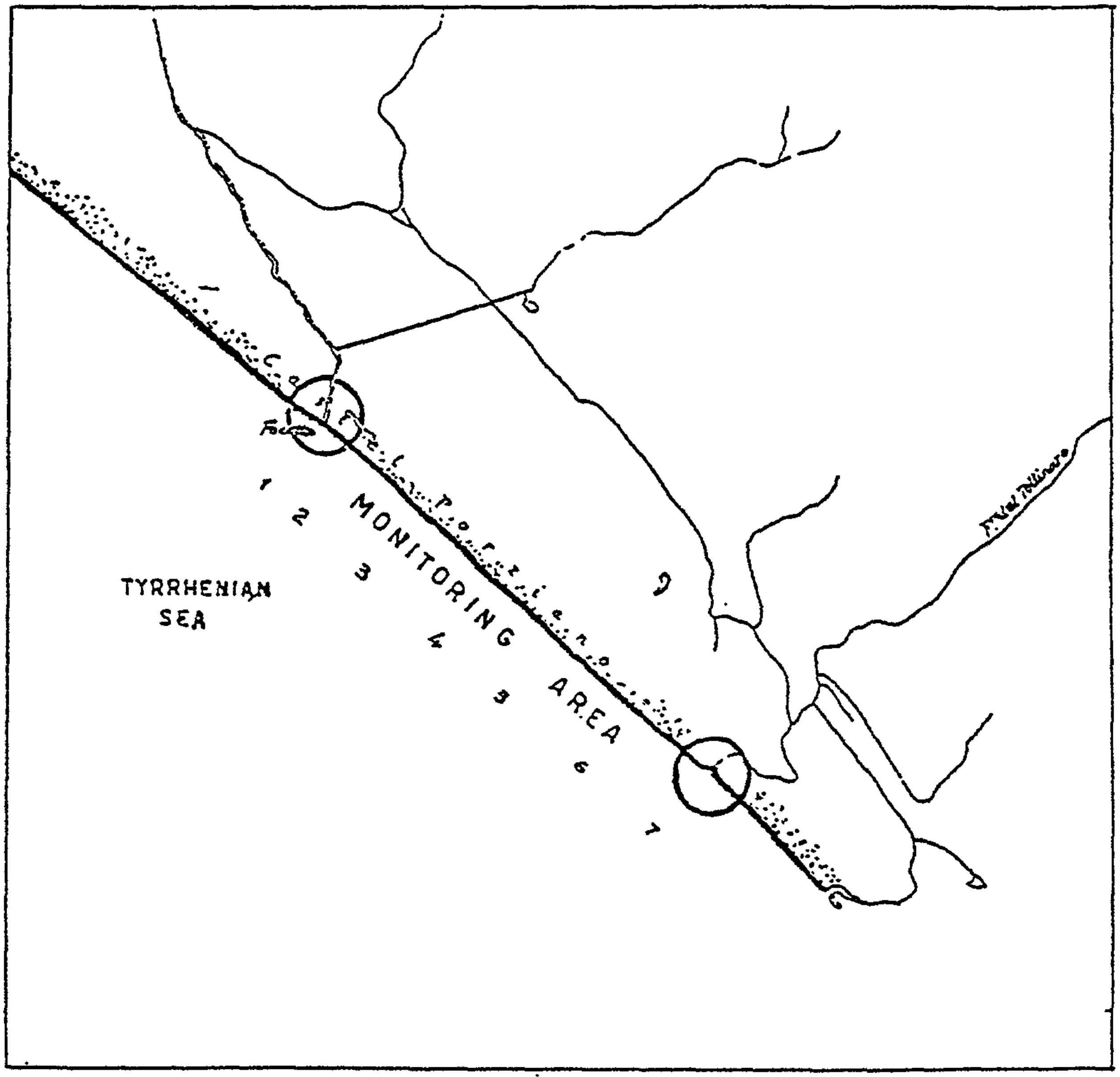

Fig. 1. Details of area monitored showing location of sampling points

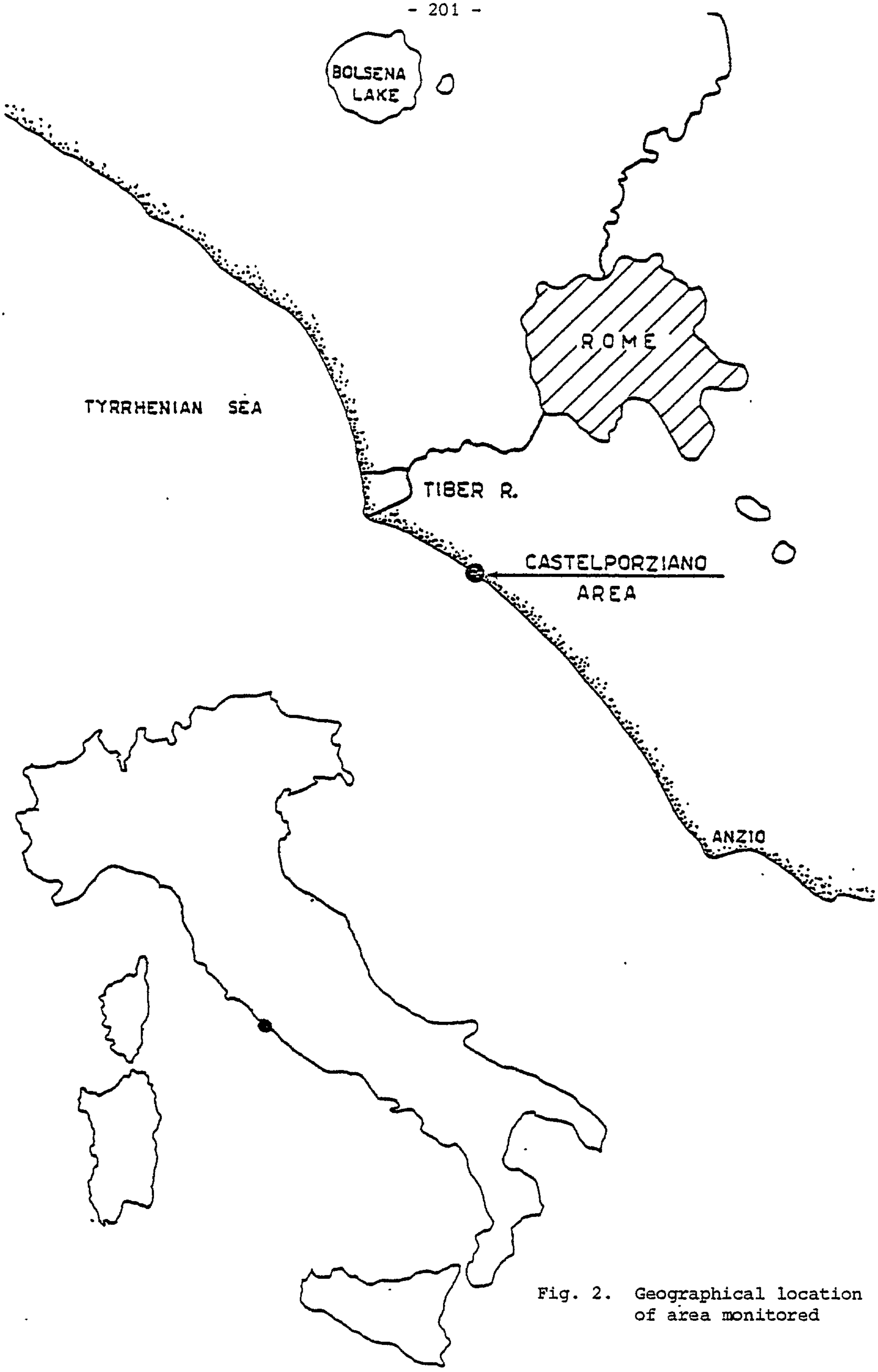

Fig. 2. Geographical location of area monitored

Table I

MONITORING AREA — CASTEL PORZIANO ($41^{\circ}41'$ N, $12^{\circ}31'$ E; $41^{\circ}40'$ N, $12^{\circ}32'$ E)

Date	28/4					12/6					10/7				
Sea conditions	2					2					3				
Current	Direction 320° Speed 5,0					Direction 300° Speed 3,0					Direction 270° Speed 2,0				
Wind	Direction 180° Speed 1,0					Direction 160° Speed 1,0					Direction 140° Speed 1,0				
Sampling points	2	3	4	5	6	2	3	4	5	6	2	3	4	5	6
Sampling time	10	10	10	11	12	11	12	12	12	13	11	11	11	12	12
Air temp. $^{\circ}C$	12,0	13,0	14,5	14,0	14,0	23,0	28,0	28,0	28,0	28,0	24,0	27,0	27,0	27,0	27,0
Water temp. $^{\circ}C$	11,0	11,5	11,5	11,5	11,5	21,0	20,5	20,5	22,0	22,4	23,5	25,0	25,0	25,0	25,0
Salinity	36,55	37,15	37,45	37,20	37,10	36,35	37,05	37,15	36,85	37,15	36,30	37,00	37,30	37,30	37,10
Oxygen mg/l	7,6	8,1	9,1	9,7	9,6	7,1	7,2	9,2	9,7	9,2	6,1	7,1	8,0	8,4	8,0
PO_4 -P mg/m^3	0,4	0,2	0,2	0,1	0,1	1,5	0,3	0,4	0,1	3,8	0,1	0,0	0,0	0,1	0,0
NH_3 -N mg/m^3	0,3	0,2	0,2	0,1	0,1	0,3	0,3	0,0	0,0	0,0	0,2	0,1	0,1	0,0	0,1
NO_2-N mg/m^3	0,2	0,2	0,1	0,0	0,0	0,2	0,2	0,0	0,0	0,0	0,2	0,1	0,0	0,0	0,0
F. C. n/100 ml	5	28	13	0	2	0	105	62	0	24	2	3	20	9	1
F. S. n/100 ml	39	56	22	71	21	36	79	154	300	30	0	0	0	0	0

Table II

MONITORING AREA CASTEL PORZIANO (41°41' N, 12°31' E; 41°40' N, 12°32' E)															
Date	24/7					31/8					10/9				
Sea conditions	3					2					2				
Current	direction 270° speed 4,0					direction 310° speed 3,5					direction 320° speed 3,0				
Wind	direction 130° speed 2,0					direction 160° speed 2,0					direction 160° speed 2,0				
Sampling points	2	3	4	5	6	2	3	4	5	6	2	3	4	5	6
Sampling time	10	11	11	11	12	11	11	11	12	12	11	11	11	12	12
Air temp. °C	26,5	27,0	28,0	28,5	28,0	24,0	22,3	23,5	24,0	24,0	25,0	25,0	25,5	26,5	26,5
Water temp. °C	27,5	27,0	27,5	27,5	27,0	26,0	25,5	25,5	25,5	26,0	18,0	18,5	18,5	18,5	19,0
Salinity	36,20	36,90	37,10	37,00	37,20	36,65	36,90	37,15	37,30	37,30	36,55	36,85	37,15	37,10	37,15
Oxygen mg/l	6,1	6,4	8,3	8,1	8,1	6,2	6,9	7,5	7,6	8,0	7,5	7,9	9,4	9,3	9,6
PO_4 - P mg/m^3	0,4	0,2	0,0	0,1	0,0	0,3	0,1	0,0	0,1	0,0	0,1	0,0	0,1	0,0	0,3
NH_3 - N mg/m^3	0,2	0,2	0,1	0,1	0,0	0,1	0,0	0,1	0,2	0,0	0,2	0,2	0,0	0,0	0,1
NO_2 - N mg/m^3	0,1	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,1	0,1	0,0	0,0	0,0
F. C. n/ 100ml	18	64	2	79	61	10	0	0	0	0	10	15	12	6	14
F. S. n/ 100ml	70	66	35	300	300	10	4	2	0	0	10	35	26	36	39

Table III. Results of Monitoring Sea-Water during the Period September 1979 to March 1981

Date	21.9.1979					19.10.1979					12.11.1979					29.1.1980					18.2.1980				
Sea conditions	3					2					3					3					1				
Current	direction 300° speed 3					direction 310° speed 1					direction 320° speed 2					direction 270° speed 4					direction 320° speed 1				
Wind	direction 130° speed 5					direction 160° speed 2					direction 120° speed 4.5					direction 130° speed 3					direction 240° speed 1.5				
Sampling points	2	3	4	5	6	2	3	4	5	6	2	3	4	5	6	2	3	4	5	6	2	3	4	5	6
Sampling time	10.40	11.00	11.20	11.30	11.40	10.00	10.15	10.30	10.45	11.00	10.30	10.45	11.00	11.15	11.30	10.30	10.45	11.15	11.30	12.00	10.15	10.30	10.45	11.00	12.00
Air temp. °C	24	24	24	24	24	20	20	21	21	21	20	20	20	20	20	9	9	9	9	9	17	17	17	17	17
Water temp. °C	22	22	22	22	22	18	18	18.5	18	18	18	18	18	18	18	9	9	9	9	9	13	11	11	11	11
Salinity	36.15	36.65	37.15	37.35	37.10	37.15	37.00	37.35	37.20	37.30	36.10	36.30	37.00	37.20	36.50	36.05	37.15	37.30	37.45	37.30	36.50	37.20	37.10	37.20	37.05
Oxygen mg/l	7.0	7.0	7.5	7.7	7.5	7.8	7.9	8.3	8.2	8.2	6.5	6.8	7.5	8.1	7.9	9.1	9.5	9.4	9.4	9.3	8.7	9.2	9.3	9.5	9.4
PO_4 - P mg/m^3	0.6	0.4	0.2	0.2	0.1	0.5	0.2	0.1	0.1	0.0	2.3	1.4	1.3	0.8	1.5	0.6	0.4	0.3	0.0	0.3	0.2	0.1	0.0	0.0	0.1
NH_3 - N mg/m^3	0.4	0.2	0.1	0.1	0.0	0.4	0.3	0.0	0.0	0.0	0.9	0.9	0.0	0.5	0.7	0.2	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0
NO_2 - N mg/m^3	0.2	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.4	0.3	0.3	0.2	0.3	0.3	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
F.C. n/100 ml	120	30	44	35	14	26	0	0	2	0	180	230	72	150	> 300	60	100	150	60	30	20	0	0	0	0
F.S. n/100 ml	60	25	58	27	46	38	0	2	3	0	>300	> 300	> 300	> 300	> 300	30	150	150	30	20	15	0	0	0	0
T.C. MPN/ 100 ml	240	75	64	93	75	20	3	14	< 3	< 3	93	>1100	210	460	>1100	150	120	240	14	75	93	23	< 3	< 3	< 3
F.C. MPN/ 100 ml	240	43	64	43	75	15	3	9	< 3	< 3	93	150	210	240	1100	75	75	210	9	43	23	< 3	< 3	< 3	< 3
last rain (days)	1					4					1					1					4				

Date	31.3.1980					13.6.1980					26.6.1980					11.7.1980					13.9.1980				
Sea conditions	1					3					3					3					3				
Current	direction 300° speed 1					direction 320° speed 2					direction 210° speed 2					direction 320° speed 3					direction 330° speed 3				
Wind	direction 220° speed 1					direction 140° speed 2.5					direction 130° speed 3					direction 140° speed 3					direction 120° speed 4				
Sampling points	2	3	4	5	6	2	3	4	5	6	2	3	4	5	6	2	3	4	5	6	2	3	4	5	6
Sampling time	10.[illegible]	10.45	11.00	11.30	12.00	11.00	11.10	11.20	11.30	12.00	10.30	10.45	12.5	13.05	13.10	10.00	10.10	10.20	10.30	10.4[illegible]	10.3[illegible]	[illegible]	10.50	11.00	11.30
Air temp. °C	22	22	22	22	22	25	25	25	25	25	27	27	27	27	27	26	26	26	26	26	24	24	24	24	21
Water temp. °C	16	16	16	16	16	20	20	20	20	20	24	24	21	24	24	22	22	22	22	22	23	23	23	23	23
Salinity	37.10	37.2[illegible]	37.15	37.20	37.10	36.80	37.10	37.00	37.20	37.15	36.00	37.05	37.10	37.30	37.25	37.30	37.25	37.30	37.[illegible]0	37.35	37.15	37.21	37.2	37.20	37.10
Oxygen mg/l	8.1	8.4	8.4	8.9	9.1	7.5	7.5	7.8	8.1	8.2	6.9	7.2	7.3	7.5	7.5	6.9	7.3	7.5	7.9	7.8	6.9	7.[illegible]	7.[illegible]	7.4	7.5
PO_4 - P mg/m^3	0.1	0.1	0.0	0.0	0.2	0.3	0.1	0.1	0.0	0.1	0.3	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.3	[illegible]	0.1	0.1	0.2
NH_3 - N mg/m^3	0.2	0.1	0.0	0.0	0.1	0.2	0.1	0.0	0.0	0.0	0.2	0.2	0.1	0.1	0.2	0.1	0.3	0.1	0.1	0.0	0.2	0.1	0.0	0.0	0.1
NO_2 - N mg/m^3	0.1	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1
F.C. n/100 ml	34	[illegible]	0	0	0	3	0	0	0	11	2[illegible]	0	0	[illegible]	0	9	0	0	0	0	10	[illegible]	0	1	0
F.S. n/100 ml	29	0	0	0	0	15	2	0	0	7	19	0	0	5	0	26	0	0	0	0	10	0	0	5	0
T.C. MPN/ 100 ml	39	< 3	< 3	< 3	< 3	28	3	3	7	21	64	< 3	< 3	< 3	< 3	39	< 3	< 3	11	< 3	15	< 3	11	28	3
F.C. MPN/ 100 ml	23	< 3	< 3	< 3	< 3	21	3	3	4	9	39	< 3	< 3	< 3	< 3	23	< 3	< 3	4	< 3	9	< 3	4	21	< 3
last rain (days)	4					4					4					4					4				

Table III continued. Results of Monitoring Sea-Water during the period September 1979 to March 1981

Date	22.9.1980				
Sea conditions	3				
Current	direction 300° speed 3				
Wind	direction 120° speed 4				
Sampling points	2	3	4	5	6
Sampling time	10.[illegible]	1030	1100	11.3[illegible]	12.[illegible]
Air temp. °C	23	23	23	23	23
Water temp. °C	21	21	21	21	21
Salinity	36.1	36[illegible]	37.[illegible]	37.10	37.[illegible]
Oxygen mg/l	7.0	7.5	7.5	7.5	7.5
PO_4 - P mg/m^3	0.6	0.4	0.5	0.2	0.2
NH_3 - N mg/m^3	0.2	0.2	0.0	0.0	0.0
NO_2 - N mg/m^3	0.2	0.1	0.1	0.0	0.0
F.C. n/100 ml	80	25	37	46	21
F.S. n/100 ml	35	40	32	50	0
T.C. MPN/ 100 ml	150	93	93	93	3
F.C. MPN/ 100 ml	150	93	43	3	< 3
last rain (days)	1				

Date	27.10.1980				
Sea conditions	3				
Current	direction 300° speed 2				
Wind	direction 160° speed 4				
Sampling points	2	3	4	5	6
Sampling time	10.3[illegible]	11.0[illegible]	11.3	12.[illegible]	12 3[illegible]
Air temp. °C	20	19	19	19	19
Water temp. °C	18	18	18	18	18
Salinity	36.5	37.0	37.30	3700	37.25
Oxygen mg/l	6.9	7.2	7.5	7.5	8.0
PO_4 - P mg/m^3	0.2	0.2	0.2	0.3	0.2
NH_3 - N mg/m^3	0.2	0.1	0.1	0.2	0.1
NO_2 - N mg/m^3	0.1	0.0	0.0	0.0	0.0
F.C. n/100 ml	19	0	2	3	3
F.S. n/100 ml	20	15	0	0	6
T.C. MPN/ 100 ml	93	3	3	3	3
F.C. MPN/ 100 ml	43	<3	<3	3	3
last rain (days)	3				

Date	10.11.1980				
Sea conditions	3				
Current	direction 270° speed 4				
Wind	direction 120° speed 3				
Sampling points	2	3	4	5	6
Sampling time	[illegible]	11.3[illegible]	12.[illegible]	12.3[illegible]	13.[illegible]
Air temp. °C	19	19	19	19	19
Water temp. °C	18	18	18	18	18
Salinity	37.0	37.0	37.10	37.10	37.0
Oxygen mg/l	7.5	7.6	7.9	8.2	8.2
PO_4 - P mg/m^3	0.2	0.2	0.0	0.0	0.0
NH_3 - N mg/m^3	0.2	0.1	0.0	0.0	0.0
NO_2 - N mg/m^3	0.1	0.1	0.0	0.0	0.0
F.C. n/100 ml	6	0	0	0	0
F.S. n/100 ml	27	15	31	0	0
T.C. MPN/ 100 ml	3	3	<3	<3	<3
F.C. MPN/ 100 ml	<3	<3	< 3	< 3	< 3
last rain (days)	4				

Date	21.1.1981				
Sea conditions	1				
Current	direction 320° speed 1				
Wind	direction 240° speed 2				
Sampling points	2	3	4	5	6
Sampling time	11.0[illegible]	11.3[illegible]	12.[illegible]	12.[illegible]	13.[illegible]
Air temp. °C	10	10	10	10	10
Water temp. °C	10	10	10	10	10
Salinity	36.0[illegible]	37.[illegible]	37.20	37.20	37.30
Oxygen mg/l	[illegible]	[illegible]	9.0	9.3	9.2
PO_4 - P mg/m^3	0.4	0.2	0.1	0.0	0.0
NH_3 - N mg/m^3	0.2	0.2	0.0	0.0	0.0
NO_2 - N mg/m^3	0.3	0.1	0.0	0.0	0.0
F.C. n/100 ml	5	0	0	0	0
F.S. n/100 ml	3	0	0	0	0
T.C. MPN/ 100 ml	15	< 3	< 3	< 3	< 3
F.C. MPN/ 100 ml	3	< 3	< 3	< 3	< 3
last rain (days)	4				

Date	25.3.1981				
Sea conditions	1				
Current	direction 320° speed 1				
Wind	direction 130° speed 2				
Sampling points	2	3	4	5	6
Sampling time	10.[illegible]	10.[illegible]	11.[illegible]	11.[illegible]	12.[illegible]
Air temp. °C	19	19	19	19	19
Water temp. °C	15	15	15	15	15
Salinity	36.[illegible]	37.[illegible]	37.3	3720	3720
Oxygen mg/l	[illegible]	6.2	[illegible]	[illegible]	6.2
PO_4 - P mg/m^3	0.1	0.0	0.0	0.0	0.0
NH_3 - N mg/m^3	0.1	0.0	0.0	0.0	0.0
NO_2 - N mg/m^3	0.[illegible]	0.0	0.0	0.0	0.0
F.C. n/100 ml	10	1	0	5	0
F.S. n/100 ml	15	5	5	0	0
T.C. MPN/ 100 ml	3	<3	<3	<3	<3
F.C. MPN/ 100 ml	3	<3	<3	<3	<3
last rain (days)	4				

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INTRODUCTION

In recent years a number of studies on the recovery and survival of pathogens in sea-waters have indicated the presence of salmonellae as well as enteric viruses in coastal waters, even when the coliform densities were low. The pathogens survived for long periods of time in waste-water and their concentration was usually higher in sediment than in sea-water. As the coliform bacteria (the indicators of pollution) are relatively sensitive to the marine environment, the question arose whether it would not be advisable to use a more suitable organism as an indicator of pollution in the marine environment.

Previous studies carried out in the laboratory showed that E. coli bacteriophages were more resistant than E. coli bacteria to marine environmental conditions. It was proposed therefore to study and compare the recovery of coliform bacteria, of salmonellae, E. coli B bacteriophages and human enteric viruses from various coastal waters and sediment samples.

It is well known that oysters found in polluted waters concentrate viruses (infectious hepatitis virus). Since fish living in polluted waters might concentrate bacteria and viruses from the water in their organs and muscles and may therefore, constitute public health hazards, it is important to study the recovery of enteric bacteria (indicator as well as pathogen), E. coli bacteriophages and human enteric viruses from various organs of fish grown in the vicinity of domestic waste-water outfalls into the sea.

AREA(S) STUDIED

Water and sediment: Study and comparison of the recovery of various indicators in coastal areas.

For this study three sampling points were chosen, all located in the Haifa Bay: one at the southern entrance to Haifa, in a residential area (location I) (see attached map, Figure 1), the second in the eastern part of the Bay in the centre of the industrial area (location II) and the third in an unpolluted area along the sea-shore.

Sampling point 1 (location I), at the Tirat Hacarmel outfall (population 10,000) where mainly treated domestic waste-water is discharged into the sea. The waste-water treatment consists of settling in an Imhoff Settling Tank, and collection into two oxidation ponds. The retention time in each of the ponds is four days. (A total of eight days). The flow rate of the effluent into the sea is 2,000 m^3/day. Frequently, when the quantity of the incoming waste-water is too large, it is made to by-pass the treatment plant and is reintroduced directly into the effluent channel which is discharged into the sea.

The area surrounding the outfall consists of consolidated sand dunes; the beach is sandy and smooth.

The currents at the sampling point flow in a south-easterly direction. The ground water in the area is in the form of a shallow aquifer.

Sampling point II (location II) is in the eastern part of the Haifa Bay, at the industrial area.

Feeding the Kishon River are: (1) secondary effluent of the Haifa Treatment Plant. The flow of the effluent is at a rate of 30,000 m^3/day (more than three times the original volume of the river, (2) wastes from a textile factory (mainly dyes), (3) wastes from petrochemical factories, (4) wastes from an oil refinery.

The surrounding land consists of sandy soil. The ground water is a shallow aquifer.

Being heavily polluted the Kishon River does not constitute a water resource. It flows into the sea and as a result the whole area is heavily polluted.

Sampling point III (location III) is an unpolluted sea-shore, situated north of the first sampling point. The surrounding area consists of consolidated sand dunes. The beach is sandy.

At location III a number of points have been sampled:

In the summer of 1978, contrary to usual custom, the effluent was used for the irrigation of cotton crops. As a result waste-water (or effluent) has not been discharged into the sea during the summer months. The discharge into the sea was resumed during the month of September. The samples examined at location I were collected therefore between the end of September and the end of December.

Monthly sampling at all points will continue throughout the year.

Before choosing location I as the sampling point, a number of additional locations were tested. They are all situated in the vicinity of Tirat Hacarmel (location I) and have very similar characteristics. The results obtained have been summarized in Table II.

Samples were collected as follows:

(a) From the waste-water discharge;

(b) 50 m. north of the outfall, and

(c) 50 m. south of the outfall into the sea.

At each point, water and sediment samples were collected. The samples were brought immediately to the laboratory and tested.

MATERIAL AND METHODS

Tests for recovery of the following organisms were performed on each sample:

1. Coliform bacteria

2. Faecal coliform bacteria

3. Salmonellae

4. Bacteria that grow on nutrient agar

5. *E. coli* bacteriophages

6. Human enteric viruses

On a number of samples the presence of *Vibrio parahaemolyticus* was also tested.

The tests for the recovery of coliforms and faecal bacteria included:

1. Filtration on membrane filters (growth on mFC medium with incubation at 35°C and 44.5°C).

2. MPN multiple tube fermentation (presumptive and confirmed) and growth of EC medium with incubation temperature at 44.5°C for faecal coliform bacteria.

3. Enrichment of tetrathionate and selenite medium for the recovery of Salmonellae.

4. Standard plate count on nutrient agar.

5. MPN-phage for the recovery of *E. coli* B bacteriophages.

6. Concentration of sea-water samples on membrane filters and elution with 3 per cent beef extract for the recovery of human enteric viruses.

7. Direct inoculation of waste-water samples for the recovery of human enteric viruses.

RESULTS AND THEIR INTERPRETATION

For the study: Study and comparison of the recovery of various indicators in coastal water and sediment.

The results obtained are summarized in Tables I and II; they show:

In the clean "control" point (location III) bacteria were recovered on the nutrient agar Petri dish. Their number was low (see Table I). Coliform bacteria were recovered in very small numbers. No faecal coliform bacteria, salmonellae or human enteric viruses were recovered. No *E. coli* bacteriophages were found.

In addition to the Tirat Hacarmel discharges (location I) two smaller waste-water outfalls at Shikmona and Bat-Galim were examined and the results obtained at all three points are summarized in Table II. Shikmona turned out to be the least polluted of the three sampling points. The number of coliform bacteria recovered from the sediment was higher than in the water above. The standard plate count was also higher in the sediment than in the sea-water (Table II). No salmonellae were recovered at this sampling point.

At the Bat Galim point the number of coliform bacteria increased with the distance from the discharging point. This may be due to the direction of the current, Salmonellae were recovered from the discharging waste-water and bacteriophages of E. coli B were recovered in all the samples.

At the Tirat Hacarmel sampling point the number of coliform bacteria in the discharging waste-water was high: 3.3 x 10^7/100 ml. The results obtained by membrane filtration were lower than by the MPN fermentation tube method. The number of E. coli bacteriophages were 3.3 x 10^6/100 ml, a concentration usually found in waste-water.

Salmonellae were isolated, and the strains recovered were: S. typhimurium, S. infantis, S. emek. The number of bacteria (SPC) and coliform bacteria was higher in the sediment than in the sea-water.

The number of E. coli bacteriophages was usually higher in the sediment than in the water above, and the ratio coliform bacteria-E. coli bacteriophages was smaller than in the waste-water. Salmonellae and viruses were recovered from all the waste-water samples tested. No salmonellae and no human enteric viruses were recovered from the water samples or sediment (Tables I and II). Additional data need to be collected during the warm months of the year to allow conclusions to be drawn.

In comparing the efficiency of recovery of coliform bacteria by the MPN method and membrane filtration method, no definite conclusions could be drawn (Figures 2 and 3). In some instances the recovery was higher by the filtration method especially in the sediment (samples 1, 9, 10); in others it was higher by the MPN method (samples 14, 15), the recovery of faecal coliform being generally higher by the MPN than by the filtration method. (Figures 4 and 5)

The concentration of coliform bacteria was higher in the sediment south of the outfall than in the water at the same sampling point. In the water, the concentration of coliform bacteria was higher north of the outfall.

Study on the recovery of indicators and pathogens from fish.

Some of the results obtained during this study are summarized below:

Fish not exposed to polluted water did not contain bacteria in their blood or muscles. A small number of bacteria were recovered from the liver, spleen and kidneys. Bacteria present in the water were recovered from the gills and the Digestive Tract Content (D.T.C.). Table III summarizes the results of a typical recovery of bacteria from clean fish. Fish grown in experimental ponds containing coliform bacteria in concentrations of 10^2/100 ml and 10^3/100 ml were tested at the end of the growing for the presence of coliform and faecal coliform bacteria, E. coli bacteriophages total bacterial counts, enterococci and human enteric viruses. The results obtained are summarized in Tables IV, V and Figure 6, and they show that when the concentration of coliforms in the water was 10^2/100 ml and above, and the total bacterial count was 1.4 x 10^5/ml, coliform bacteria were recovered from all the organs including muscles. The bacterial concentration in the organs was higher than in the water in which the fish were grown.

In one instance human enteric viruses have been recovered from kidneys of fish grown in these ponds.

The recommended parameter in judging the bacterial quality of bathing water is E. coli. Water containing on the average during the bathing season up to 200

E. coli may be considered as quite safe. Water containing 200 to 1000 E. coli/ml shows evidence of sewage pollution and caution should be exercised by the responsible health authority in permitting bathing.

In view of the correlation between the concentration of bacteria in water and the recovery of bacteria from fish organs, the question arises whether fish grown in the recommended concentrations of faecal coliforms might not constitute a public health hazard.

Research in this area is highly recommended.

A similar situation might occur in the vicinity of the waste-water outfall into the sea and therefore fish growing in the area might constitute a public health hazard both to fish and man.

It is planned therefore to test fish found in the vicinity of the sampling points and determine the concentration of coliform bacteria, salmonellae, E. coli bacteriophages and human enteric viruses in their various organs.

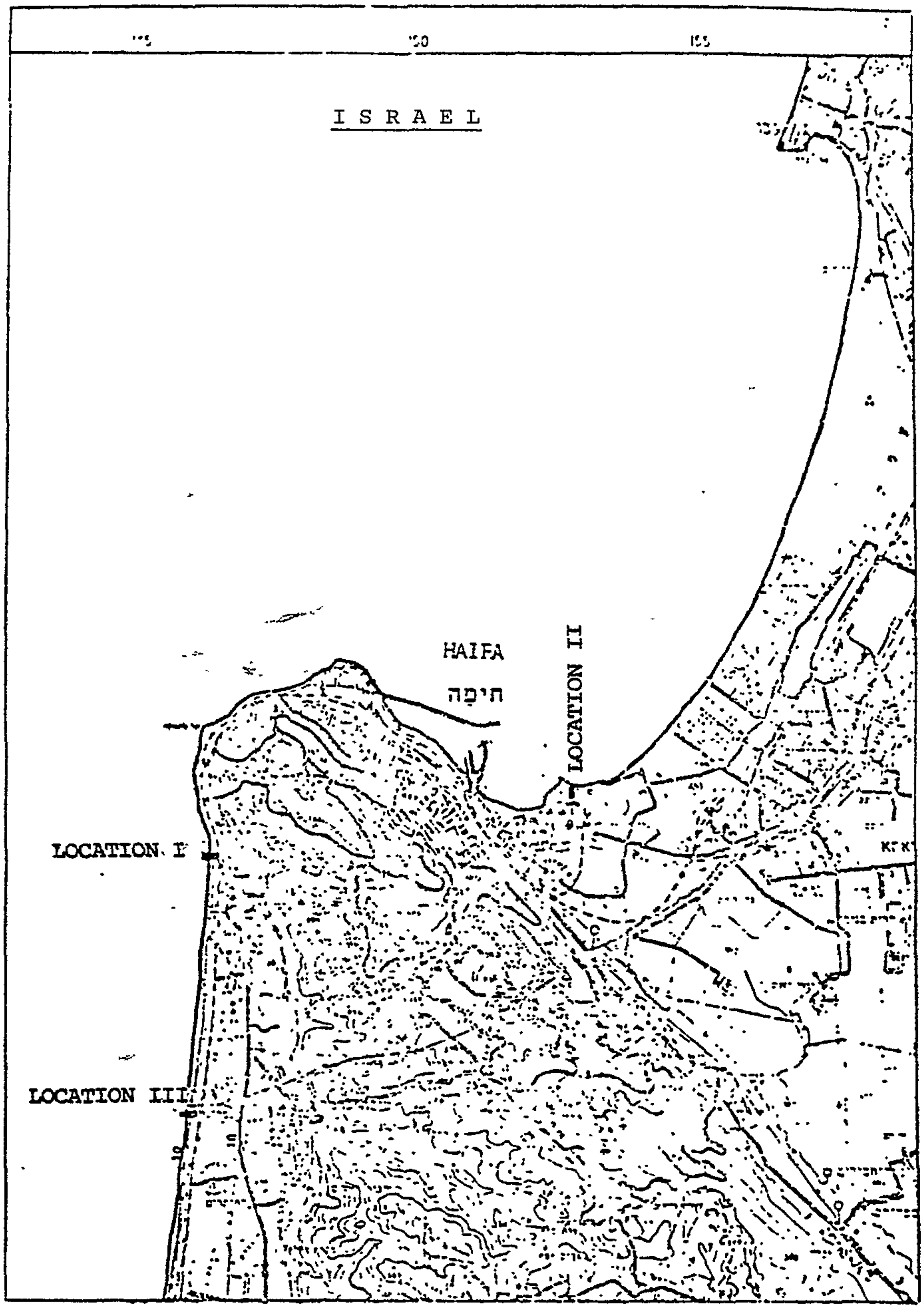


Fig. 1. Area studied

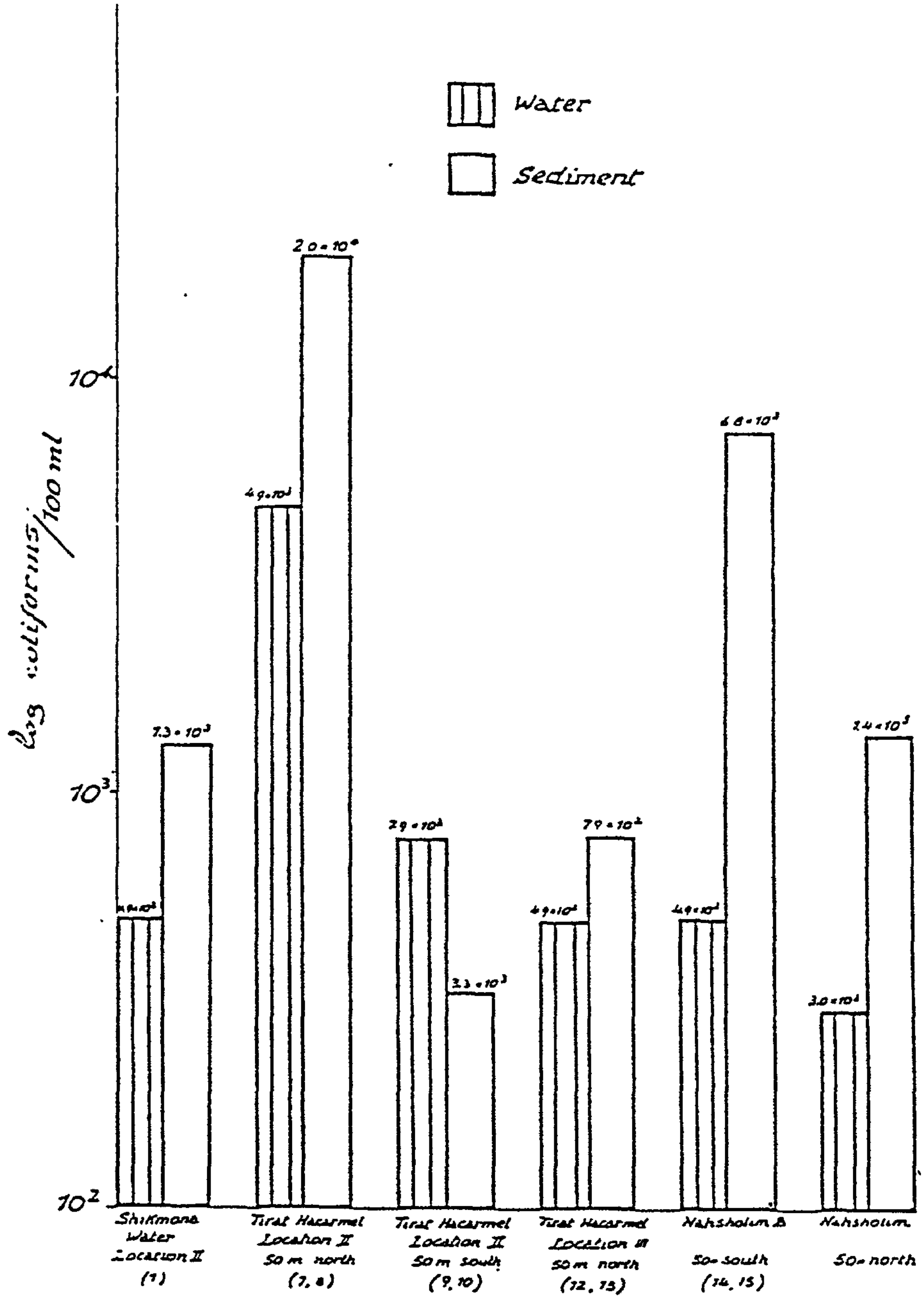


Fig. 2. Recovery of coliforms from sea-water and sediment in the vicinity of wastewater outfall (MPN)

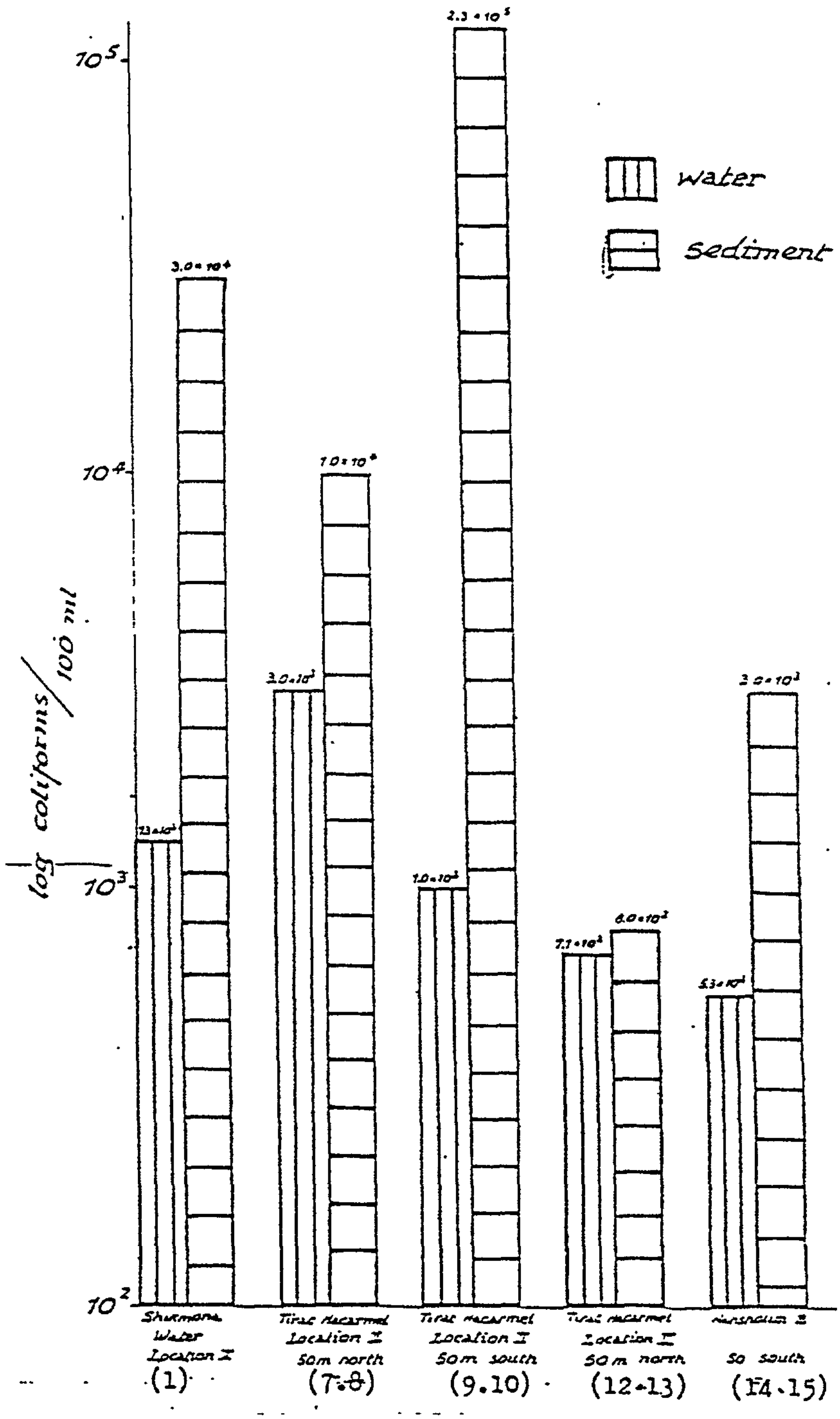


Fig. 3. Recovery of coliforms (Membrane Filtration) from sea-water and sediment in the vicinity of wastewater outfall

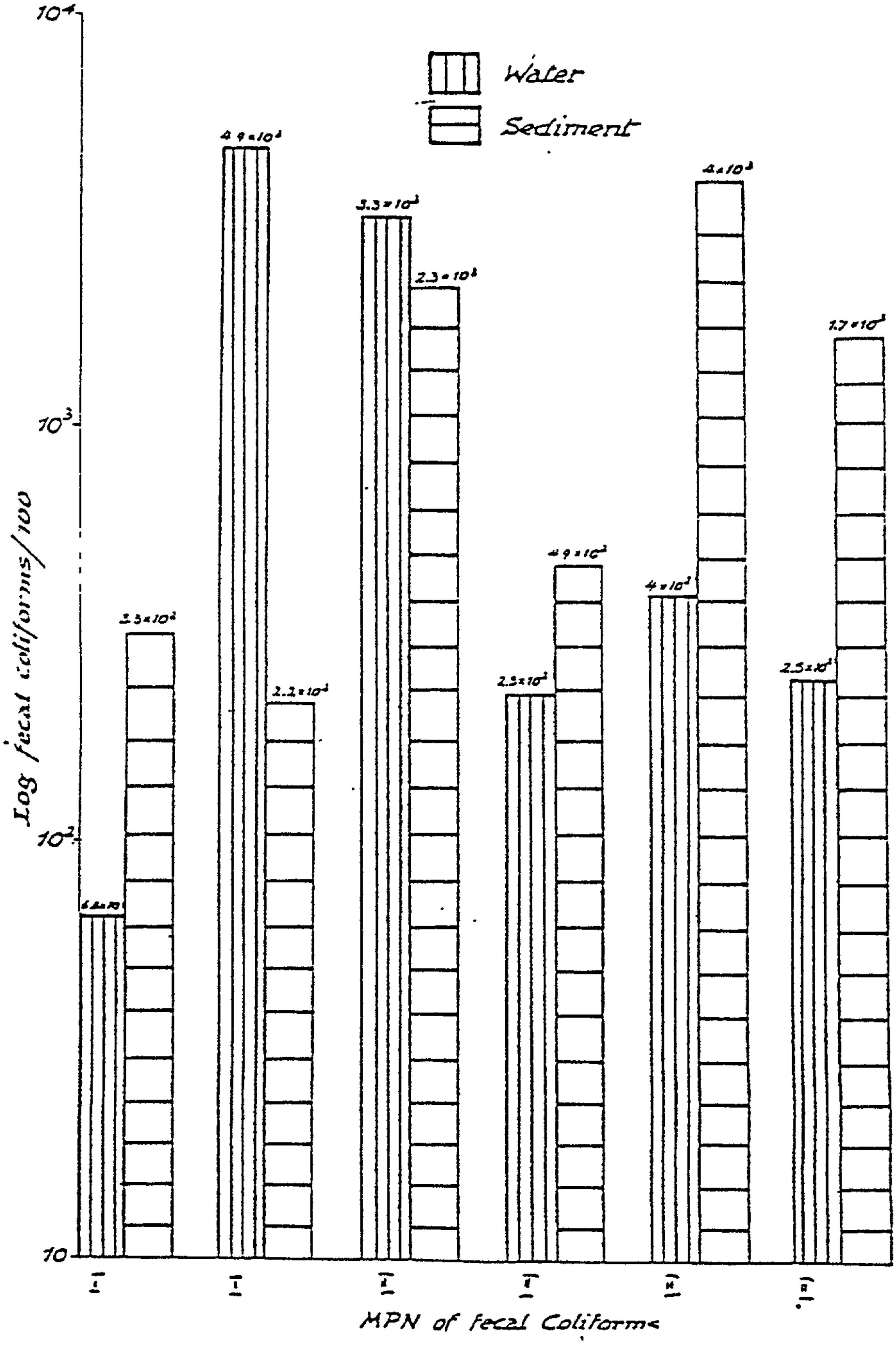


Fig. 4. Recovery of fàecal coliform from sea-water and sediment in the vicinity of wastewater outfall

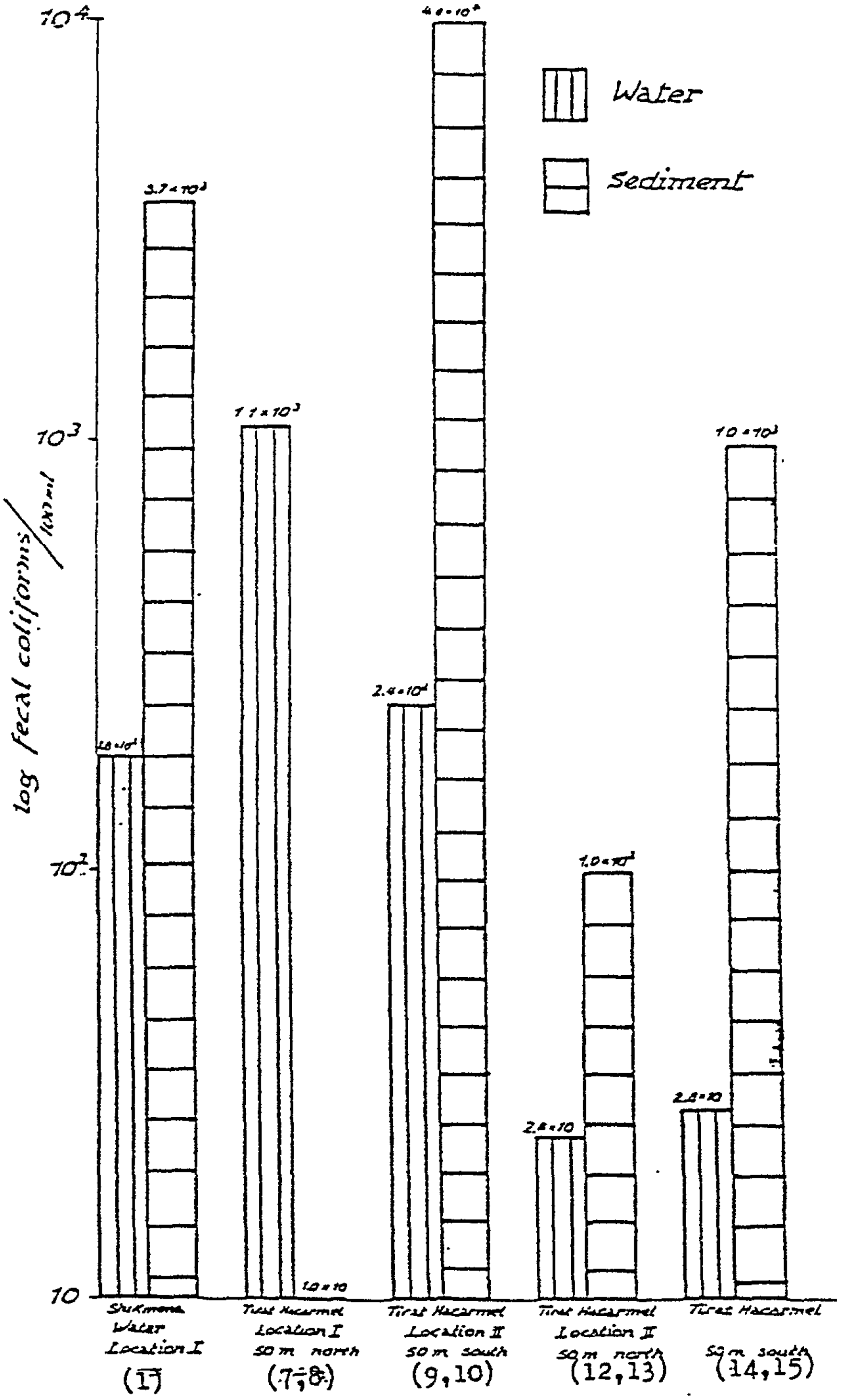


Fig. 5. Recovery of faecal coliforms (Membrane Filtration) from sea-water and sediment in the vicinity of wastewater outfall

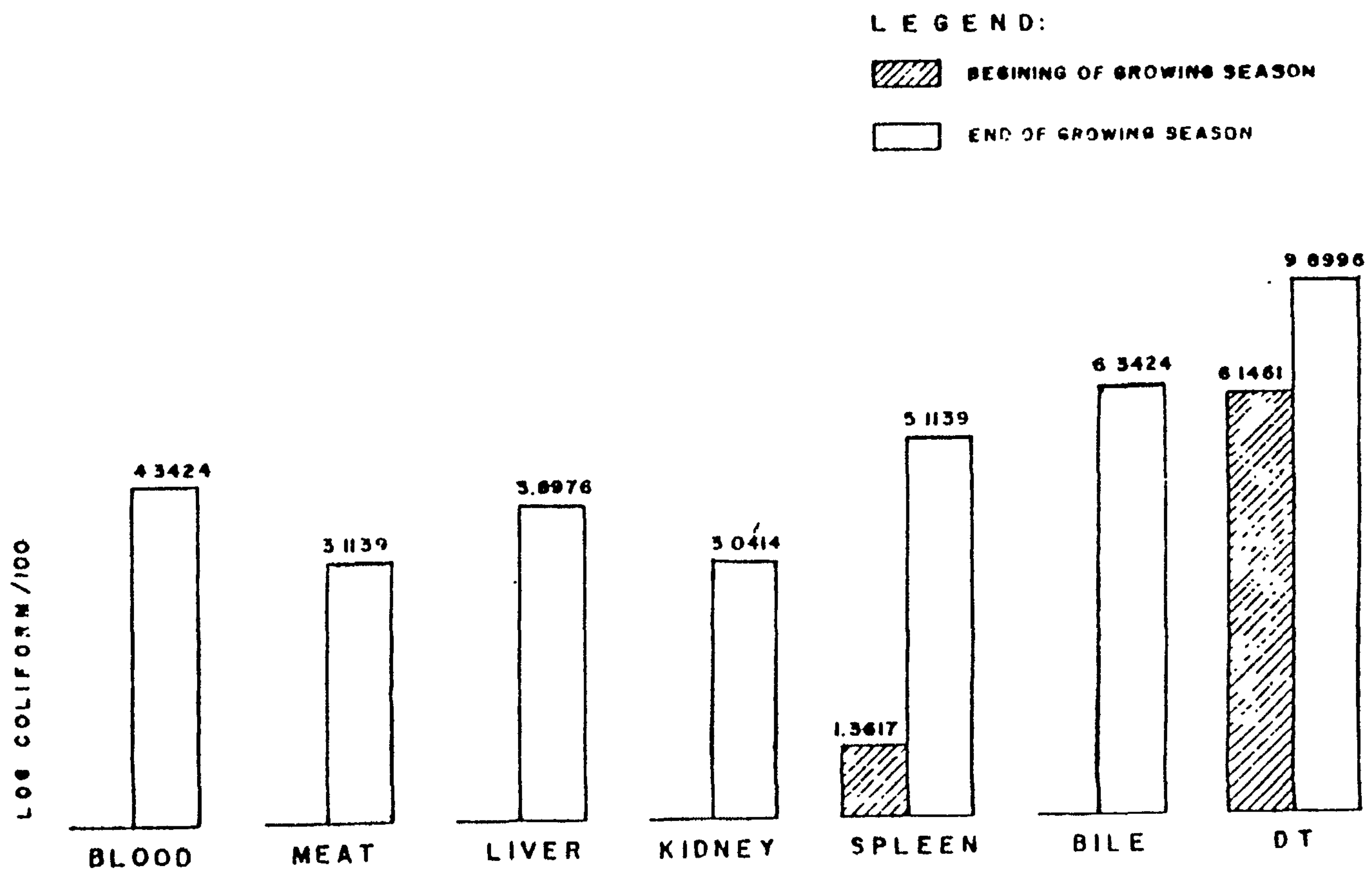


Fig. 6. Comparison between coliform concentration in various organs

Table I Recovery of bacteria, E. coli bacteriophages and human enteric viruses from clean sea-water and sediment samples

Shikmona Location III	MPN/100 ml		Membrane Filtration /100ml			Standard plate count /ml	Salmonella	Human enteric viruses
	Coliform	Faecal coliform	Coliform	Faecal coliform	E. coli B phage			
1. Water	0	0	0	0	0	12	0	0
Sediment	2	0	1	0	0	95	0	0
2. Water	2	0	2	0	0	60	0	0
Sediment	4	0	5	0	0	106	0	0
3. Water	2	0	2	1	0	55	0	0
Sediment	4	0	6	3	0	100	0	0

Table II Recovery of bacteria, E. coli bacteriophages and human enteric viruses from sea-water and sediment in the vicinity of a wastewater outfall

Location	MPN/100ml		Membrane filtration/100ml			Standard plate count /ml	Salmonella	Human enteric viruses
	Coliform	Faecal coliform	Coliform	Faecal coliform	E. coli B phage			
1. Shikmona Water	$4.9x10^2$	6.8x10	$1.3x10^3$	$1.8x10^2$	11	$4.0x10^2$	0	
LocationIII Sediment	$1.3x10^3$	$3.3x10^2$	$3.0x10^4$	$3.7x10^3$	10	$4.5x10^4$	0	
2. Bat Galim Wastewater outlet	$1.6x10^5$	$1.0x10^4$	$9.5x10^4$	$9.0x10^4$	$2.4x10^4$	$1.7x10^6$	++	+
3. Bat Galim South 25m. from sewage outlet	$5.4x10^2$	$1.0x10^2$	$3.0x10^2$	$1.0x10^2$	70	$5.0x10^3$		
4. Bat Galim South 50m. from wastewater discharge	$2.4x10^4$	$1.5x10^3$	$2.5x10^4$	$2.0x10^4$	110	$7.0x10^3$		

Table II continued

Location		MPN/100ml		Membrane filtration/100ml			Standard plate count /ml	*Salmonella*	Human enteric viruses
		Coliform	Faecal coliform	Coliform	Faecal coliform	*E. coli* B phage			
5. Bat Galim 100m. south of wastewater discharge		$3.3x10^4$	$2.9x10^3$	$3.0x10^4$	$2.5x10^3$	27	$5.8x10^3$		
6. Tirat Hacarmel Location II Wastewater discharge		$3.3x10^7$	$1.7x10^7$	$4.0x10^5$	$3.9x10^3$	$3.3x10^6$	$2.2x10^6$	+++	
7. Tirat Hacarmel Location II 50m. north	water	$4.9x10^3$	$4.9x10^3$	$3.0x10^3$	$1.1x10^3$	$4.9x10^2$	$5.9x10^3$		
8.	Sediment	$2.0x10^4$	$2.0x10^2$	$1.0x10^4$	1.0x10	$1.1x10^3$	$3.0x10^3$		
9. Tirat Hacarmel Location II 50m. south	Water	$7.9x10^3$	$3.3x10^3$	$1.0x10^3$	$2.4x10^2$	$4.0x10^2$	$3.5x10^2$		
10.	Sediment	$3.3x10^3$	$2.3x10^3$	$2.3x10^5$	$4.8x10^4$	$7.9x10^3$	$1.5x10^5$		
11. Tirat Hacarmel Location II Wastewater discharge	Water	$6.8x10^6$	$4.0x10^6$	$2.5x10^7$	$7.6x10^5$	$2.2x10^5$	$2.9x10^6$	+++	+
12. Tirat Hacarmel Location II 50m. north	Water	$4.9x10^2$	$2.3x10^2$	$7.1x10^2$	24	68	$1.5x10^3$		
13. Tirat Hacarmel Location II	Sediment	$7.9x10^2$	$4.9x10^2$	$8.0x10^2$	$1.0x10^2$	$2.4x10^2$	$3.0x10^3$		
14. Nahsholim B 50m south	Water	$4.9x10^2$	$4.0x10^2$	$5.3x10^2$	2.8x10	$1.3x10^2$	$4.0x10^3$		
15. Nahsholim B	Sediment	$6.8x10^3$	$4.0x10^3$	$3.0x10^3$	$1.0x10^3$	$7.9x10^2$	$1.5x10^4$		

Table III

Organ	Coliform MPN/100 gr	Faecal Coliform MPN/100 gr	*E. coli* phages MPN/100 gr	Salmonella
Blood	0	0	0	No Salmonella were found
Meat	0	0	0	
Liver	0	0	0	
Kidney	2	0	0	
Spleen	2	0	0	
DTC	1.4×10^6	0	0	
Bile	0	0	0	

TABLE IV

Recovery of bacteria and E. coli B phages from fish grown in polluted water ponds containing 10^2/100 ml coliform bacteria:-

	Coliform MPN/100 ml	Faecal Coliform MPB/100 ml	E. coli phages MPN/100 ml	Salmonella	SPC/ml
Water	6.5×10^2	3.3×10^2	6.9×10^3	+	1.4×10^5
Fish					
Blood	2.2×10^4	7.0×10^3	0		3.5×10^5
Meat	1.3×10^3	790	0	Not	1.0×10^5
Liver	7.9×10^3	4.9×10^3	0		1.5×10^5
Kidney	1.1×10^3	1.3×10^3	0		7.5×10^4
Spleen	1.3×10^5	3.3×10^4			3.5×10^6
Bile	2.2×10^6	1.7×10^4	0	found	2.3×10^4
DTC	7.9×10^9	2.2×10^9	2.3×10^3		6.2×10^8

TABLE V

Recovery of bacteria and E. coli B phages from fish grown in polluted water ponds containing $10^3$100 ml coliform bacterial:-

	Coliform MPN/100 ml	Faecal Coliform MPB/100 ml	E. coli phages MPN/100 ml	Enterococci/ ml	SPC/ml
Water	2.1×10^3	2.1×10^3	1.7×10^2		6.0×10^3
Fish					
Gills	8.0×10^5	5.5×10^5	0	2.3×10^3	3.3×10^6
Liver	2.2×10^5	1.8×10^5	0	3.5×10^2	3.0×10^6
Spleen	4.0×10^3	8.0×10^2		4.0×10^3	1.2×10^5
DTC	8.6×10^6	6.8×10^6	1.5×10^2	1.7×10^4	4.7×10^7

Research Centre: Public Health Laboratory
Public Health Department
HAIFA
Israel

Principal Investigator: R. SELIGMANN

INTRODUCTION

Before the participation in the pilot project MED POL VII, approximately 20 bathing beaches were monitored monthly during the summer using the following parameters:

1967-1977	:	total and faecal coliforms
1967-1977	:	total heterotrophic bacteria
1970, 1973	:	Salmonellae
1971, 1974, 1977	:	V. parahaemolyticus and V. alginolyticus
3 winter months and 6 summer months 1977	:	faecal streptococci

In May 1978 this laboratory joined the pilot project.

AREA(S) STUDIED

The northern part of Israel comprises "North District" and "Haifa District". The area studied is on the approximately 90 km long shoreline from Rosh Hanikra, the most northerly sampling point in the north District, to Givat Olga, the most southerly point in the Haifa District.

Description of the coast: north District - at Rosh Hanikra Control Station (C 1) and the bathing beaches Shave Zion (Nos. 1, 2) small rock formations reach the coast. Haifa District - the bathing sites at Hof Hacarmel (Nos. 3 & 4), Givat Olga (Nos. 5 & 6), and the Control Station at Caesarea (C 2) are on flat, sandy beaches.

In October 1979 a control sampling point at Rosh Hanikra (C 1N), 250 m north of C 1 (see map) was added. Point C 1 is now referred to as C 1S and the norther sampling point as C 1N.

MATERIAL AND METHODS

Total and faecal coliforms:

(a) MED VII reference methods

(b) Membrane filter procedure, M-endo broth, according to Standard Methods for the Examination of Water and Wastewater, APHA 1975, subculture of up to 5 colonies in EC broth, incubation at 44°C/24 hours. In 1979 M-endo agar was used instead of broth.

(c) Multiple tube technique (MPN) according to APHA.(1975)

Faecal streptococci:

Membrane filter procedure according to APHA;(1975) colonies were often confirmed by biochemical tests.

Salmonellae and shigella:

(a) Tetrathionate broth incubated at 35°C/24 hours and 48 hours, subculture on BG-agar and SS-agar, incubated at 35°C/24 hours and 48 hours, isolation of suspicious colonies for biochemical and serological examinations.

(b) Dulcitol-Selenite broth incubated at 41.5°C/24 hours and 48 hours, subculture on MacConkey and SS-agar, after incubation at 35°C/24 hours and 48 hours isolation of suspicious colonies for further tests.

V. parahaemolyticus and *V. cholerae*:

(a) Membrane filter procedure, filter transferred to TCBS medium, incubated at 35°C/24 hours isolation of suspicious colonies for biochemical tests.

(b) Sediment after centrifugation spread to TCBS-agar, further examination as (a). Due to manpower shortage, this procedure was omitted in 1979.

BOD_5:

Dissolved oxygen was measured by Azide modification of Iodometric method (APHA - 1975).

Settleable matter:

Determined in Imhoff cone and reported as ml/l (APHA - 1975).

Total suspended matter:

APHA - 1975.

Additional parameters measured during October 1978 to September 1979: (See Table IV)

pH: PHA 1975, measured by Metrohm Precision Potentiometer E 353 B

COD: APHA 1975

Turbidity: APHA 1975. Measured by Hach Turbidimeter Model 2100 A

Conductivity: APHA 1975. Measured by Metrohm Conductometer E. 382.

RESULTS AND THEIR INTERPRETATION

Total and faecal coliforms:

Period up to October 1978:

Measured by 3 methods, all samples conformed to the requirements for bathing waters (Council of the European Communities). Total faecal coliforms/100 ml numbered less than 100 in 95 per cent of the samples.

Period October 1978 to September 1979 (See Tables I, II and III).

Winter (October 1978 to March 1979):

In 93% of the samples total coliform numbered less than 100/100 ml. Cultures of 7% showed 100 - 250 total coliforms/100 ml, (median 175).

Only one sample (C N1) contained more than 100 faecal coliforms/100 ml, (200 organisms were calculated).

Summer (April-September 1979):

Numbered less than 100/100 ml in all samples except one (collected at C 2) which contained 120 total coliforms/100 ml.

Period October 1979 to March 1980:

As during the winter months, October 1978 - March 1979, bacterial counts of the three mandatory parameters were higher than during the summer. Retarded growth rate of bacteria at lower temperature has to be considered, inter alia, a causative factor for this finding. Still, the quality of the coastal water at our bathing beaches proved, as in previous years, satisfactory. Tables V, VI and VII detail mean values, in log and antilog, of the three parameters for each sampling point.

A summary of the results demonstrates that for total and faecal coliforms, 95% of the samples contained less than 100 organisms/100 ml. (Sampling points Nos. 3 and 4 are excluded; these will be dealt with in the next paragraph).

Specific observation at Hof Hacarmel north and south (Nos. 3 and 4): an unexpected rise of total coliforms (1,140/100 ml at No. 3 and 966/100 ml at No. 4) and of faecal coliforms (177/100 ml and 290/100 ml, respectively) were encountered in January 1980.

Repeated examination confirmed these results by similar findings. Although the absolute numbers of total and faecal coliforms may not seem remarkable, they differed enormously from our usual observations. Furthermore, the correlation between the three pollution parameters proved almost perfect in both sampling points - TC : FC r = .96 (No. 3); .994 (No. 4), TC : FS r =.98 (Nos. 3 and 4); FC : FS r = .995 (No. 3), .996 (No. 4) (see Table VIII). Obviously, recent contamination by sewage had to be concluded. Sanitary investigation at the site revealed a slight leak from a sewage pipe, approximately 1 km south of the approved beach. After repairs, less than 100 organisms/100 ml were found for the three parameters. (These measurements were done during the first days of April and are not included in this report).

Faecal streptococci:

Period up to October 1978:

The Council of the European Communities allows 100/faecal streptococci/ 100 ml. 95 per cent of the samples contained less than 50 enterococci/100 ml. Two samples exceeded the approved limit: 120 enterococci/100 ml were isolated from one sample in June (Control Station C.1) and 130 enterococci/ 100 ml from the other in August (Station 4).

Period October 1978 to September, 1979:

Winter (October 1978 to March 1979):

In 73% of the samples less than 50 faecal streptococci/100 ml were computed. Eleven per cent of the samples exceeded the approved limit of 100 streptococci/100 ml. They contained 120-250 organisms/100 ml (median 150).

Summer (April 1979 to September 1979):

95% of the samples contained less than 50 Enterococci/100 ml. Two samples exceed the CEC limit: one from No. 3 (Hof Hacarmel north), the other from No.4 (Hof Hacarmel south). Sampled on the same day (within one hour approx.), 144 faecal Streptococci/100 ml were isolated from No.3 and 320 Streptococci/100 ml from No. 4.

Period October 1979 to March 1980:

In 89% of the samples less than 100 organisms/100 ml were counted, 11% contained 120-200 streptococci per 100 ml, Median 165.

During the unexpected rise of total coliforms and faecal coliforms at Hof Hacarmel in January 1980 mentioned above, the numbers of faecal streptococci remained steady.

Pathogenic organisms:

During the period up to October 1978, salmonella, shigella and cholera were negative in all cultures. V. parahaemolyticus were isolated from 5 bathing beaches (nos. 2, 3, 4, 5 and 6) and from one of the control stations (C2). Sampling points polluted by V. parahaemolyticus yielded positive cultures on 3-5 sampling days, most of the strains being Kanagawa positive.

In 1979, salmonella, shigella and V. cholera were negative in all cultures. From two samples, collected within one hour from No. 1 and No. 2 (Shave Zion north and south), Aeromonas hydrophila were isolated.

V. parahaemolyticus were isolated from bathing beaches No. 3 (May 28), No. 5 (May 21), and No. 6 (August 14), control points C 1S (July 18) and C 2 (August 14). The dates indicate only one positive culture from each point.

Period October 1979 to March 1980:

V. parahaemoliticus cultures were discontinued during November 1979. The organism was not isolated during the preceding six weeks.

Salmonella, shigella and V. cholera were negative in all cultures.

Quality of rivers and effluents:

During the period up to October 1978 the following data were measured:

(a) Naaman River

BOD_5	:	20 - 25 mg/l O_2
T.S.M.	:	140-276 mg/l
Settleable matter	:	0 ml/l.

(b) Kishon effluents

BOD_5	:	317 - 408 mg/l O_2
T.S.M.	:	86 - 228 mg/l
Settleable matter	:	0 ml/l

In our experience, the two mandatory parameters, BOD_5 and settleable solids, although most informative, are insufficient for the assessment of the pollution in rivers and effluents. We propose the measurement of three more parameters: pH, COD and total suspended matter.

The proposed additional parameters were introduced in the measurement made during the period May to September 1979.

The results are as follows:

(a) Naaman River

pH	:	7.74 - 8.70
BOD_5	:	7 - 25 mg/l O_2
COD	:	56 - 320 mg/l O_2
T.S.M.	:	66 - 158 mg/l
Settleable matter	:	0 ml/l

(b) Kishon effluents

pH	:	1.30 - 6.20 (1.30; 2.10; 3.20; 4.00, 4.40, 6.20)
BOD_5	:	198 - 390 mg/l O_2
COD	:	3840 - 9680 mg/l O_2
T.S.M.	:	136 - 320 mg/l
Settleable matter	:	0 ml/l

Wind direction:

On most sampling days westerly or south-westerly winds were predominant. During the winter 1979-1980 south-easterly and easterly winds were more often recorded than during the winter of 1978-1979.

Still no association with bacteriological results could be detected, either with direction or with velocity. For a reliable study of the subject data of many more sampling days for each sampling point should be analysed.

Analysis of data:

This analysis is refered to the data collected during the period October 1978 to September 1979.

Tables I, II, and III summarize the results of the organisms monitored at all sampling points. They list geometric mean, standard deviation, sample variance and correlation between total coliforms versus faecal coliforms and faecal coliforms versus faecal streptococci. Log transformed data were used.

Ratio between mean values and deviation factors:

The deviation factor appears higher than the mean value of total and faecal coliforms and faecal streptocci at most sampling points during the summer. For interpretation of this unusual result, histograms (Figures 1, 2, and 3) were prepared. They clearly expose the few positive cultures amongst the majority of negative samples for all locations.

In winter, similar results were computed for faecal coliforms only. The mean variation ratio was more typical for the populations of total coliforms and faecal streptococci.

Correlation:

Total coliforms versus faecal coliforms:

Summer - good or fair correlation was computed for three stations: No. 3 (Hof Hacarmel north) r = 0.97; C 2 (control station Caesarea) r = 0.98; No.5 (Givat Olga north) r = 0.85. At the other sampling points r ranged between 0.65 to -0.27.

Winter - r = 0.88 was calculated in No. 3 only (in summer, r was 0.97, see last paragraph), elsewhere r ranged between 0.77 to -0.62.

Lack of correlation between total and faecal coliforms need not astonish us. Many organisms classified in the total coliform group are non-viable at 44.5°CC and consequently, they do not correspond to the definition of faecal coliforms (some of these were identified as Klebsiella spec.).

Although it would be of interest to know more about the predominant organisms in the total coliforms group on our coast, lack of manpower prevented us from studying the subject.

For the period October 1979 to March 1980 the Tables V, VI and VII give the relevant means, deviation factors and variance for coastal water, and Table VIII gives the correlation factor (r) between the mandatory parameters.

DISCUSSION OF RESULTS

Quality of coastal waters:

As in previous years, the quality of recreational waters at our approved bathing beaches proved highly satisfactory during the summer as well as during winter.

More samples for bacteriological and chemical examinations should be collected. It is hoped that additional parameters could be introduced and monitored (salinity and others) during summer as well as during winter.

Notwithstanding budgetary difficulties, the present surveillance programme should continue without curtailment.

Methodology:

Assessment of total coliforms by m-FC 36°C.

The reference method of MED POL VII was introduced into our laboratory in 1978.

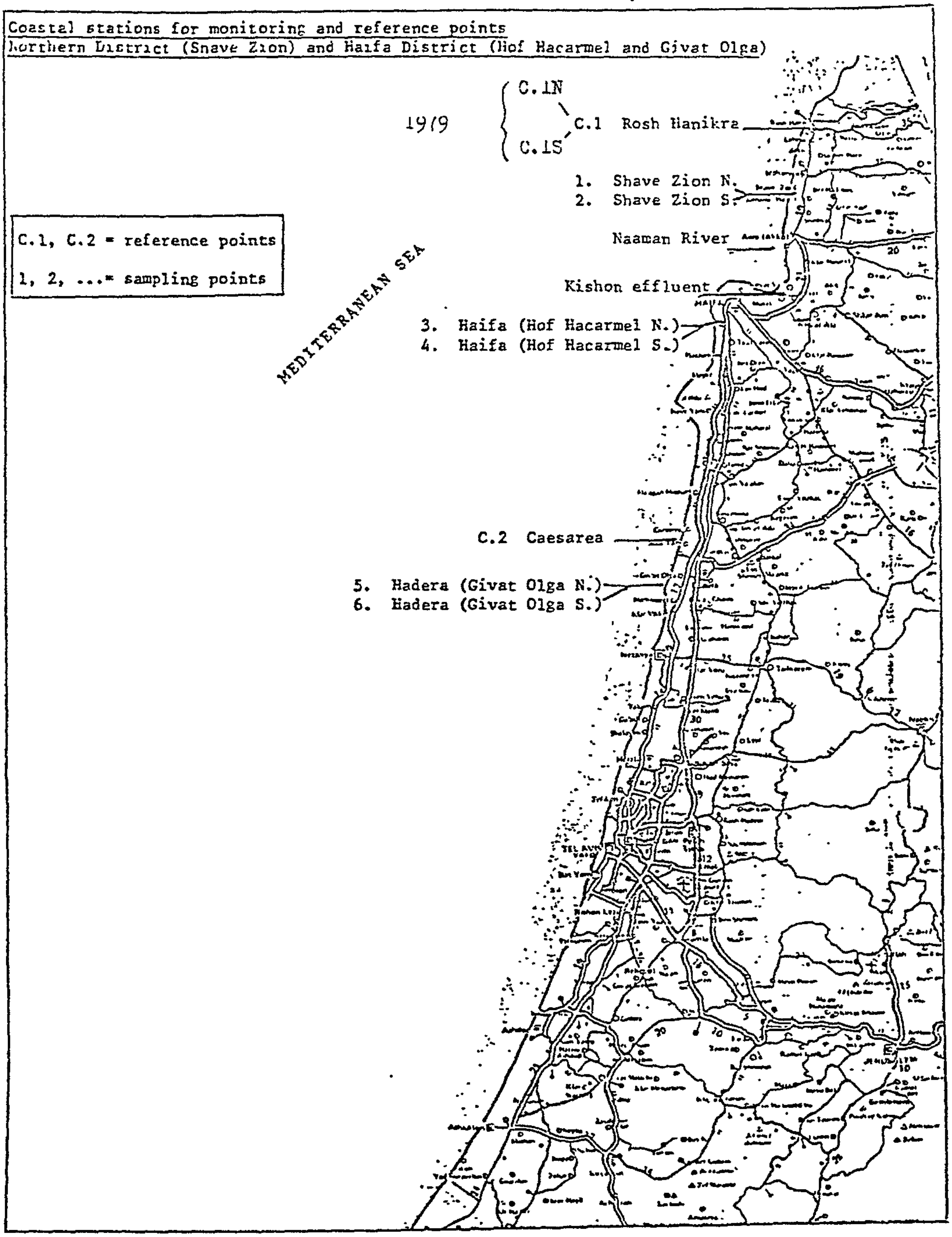
The methods employed in Israel were (and still are) based on "Standard Methods for the Examination of Water and Waste-water", APHA, latest edition. For total coliforms we performed the MPN procedure or used m-endo broth, later this was substituted by m-endo agar. Likewise, faecal coliforms were tested by MPN or m-FC 44.5°C. This was done during 1978 - 1979.

To evaluate the MED VII reference method and eventually be able to suggest our method of choice, we made parallel examinations for total coliforms by three procedures: (a) MPN, (b) m-endo agar, and (c) m-FC 36°C. Faecal coliforms were examined by two methods: (a) MPN, and (b) m-FC 44.5°C.

Comparison of the results and calculation of the differences by the Student's t-test indicated the following: Total coliforms values obtained by MPN and m-endo agar did not differ beyond chance occurrence, $t = 1.19$, $p = 0.2$. Contrary to this measured by MPN and m-FC 36°C, a highly significant difference was established, $t = 6.44$, p 0.001. Faecal coliforms - results obtained by MPN and m-FC 44.5°C did not differ significantly: $t = 1.63$, $p = 0.1$ (Table IX).

The choice between MPN and m-endo agar for total coliforms and between MPN and m-FC 44.5°C for faecal coliforms remains valid, according to Student's t-test of our material. m-FC 36°C appeared unsuitable for the determination of total coliforms. Taking into consideration the cost of media, equipment and, last but not least, of labour we suggest the use of m-endo agar for total and m-FC 44.5°C for faecal coliforms.

All samples collected during the summer, including those pertaining to MED POL VII and 180 samples from 15 other bathing beaches, were examined for the determination of total and faecal coliforms by three methods (see above). For an optimal evaluation of the results obtained by other methods, in addition to the compulsory methods of MED POL VII, applied in our, and other institutes, we suggest that appropriate recording sheets be prepared. The data on these additional sheets should be studied as part of the information recorded on the relevant MED POL VII data forms or, if from samples not within the framework of MED POL VII, they should be analysed independently.



Map showing reference and sampling points

<u>Table I</u> Means, deviation factors and sample variances - total coliforms for each sampling point (summer and winter).

		S U M M E R *			W I N T E R **			
Sampling point No.	No. of samples	Mean	Deviation	Variance	No. of samples	Mean	Deviation	Variance
1	10	1.31	2.35	1.33	8	19.88	5.39	2.94
2	10	2.08	3.41	1.80	8	10.96	4.79	2.56
3	10	1.83	3.84	2.03	5	9.77	2.77	6.74
4	10	1.84	3.66	1.93	5	10.96	5.50	7.42
5	8	1.99	3.67	1.90	6	3.98	3.16	1.60
6	8	1.33	2.26	1.29	6	3.16	2.51	1.35
C 1N	9	2.09	3.12	1.65	8	18.62	3.98	2.07
C 1S	9	1.29	2.15	1.26	8	17.38	3.25	1.70
C 2	7	7.58	7.42	4.46	6	9.55	3.47	1.75

* April-September 1979.

** October 1978 - March 1979.

Table II Means, deviation factors and sample variances - faecal coliforms, correlation between total and faecal coliforms for each sampling point (summer and winter).

	SUMMER *					WINTER **				
Sampling point No.	No. of samples	Mean	Deviation	Variance	r TC : FC	No. of samples	Mean	Deviation	Variance	r TC : FC
1	10	2.57	3.98	2.11	0.52	8	4.38	4.91	2.63	0.33
2	10	2.25	4.78	2.60	0.27	8	4.37	5.25	2.84	0.48
3	10	1.62	2.53	1.40	0.97	5	3.02	5.62	2.82	0.88
4	10	2.39	4.64	2.51	0.65	5	2.29	6.31	3.21	0.77
5	8	1.73	3.07	1.33	0.85	6	1.70	2.40	1.32	0.76
6	8	1.77	2.41	1.34	-0.28	6	1.48	2.57	1.38	-0.62
C 1N	9	1.49	3.07	1.63	0.14	8	6.17	9.12	6.46	0.67
C 1S	9	2.27	3.17	1.67	-0.27	8	4.37	6.17	3.54	0.39
C 2	7	5.32	5.57	3.02	0.98	6	2.40	2.75	1.46	0.53

* April - September 1979

** October 1978 - March 1979

Table III Means, deviation factors and sample variances - faecal streptococci, correlation between faecal coliforms and faecal streptococci for each sampling point (summer and winter).

		SUMMER *				WINTER **				
Sampling point No.	No. of samples	Mean	Deviation	Variance	r FC : FS	No. of samples	Mean	Deviation	Variance	r FC : FS
1	10	1.73	2.48	1.38	0.38	8	23.99	4.37	2.30	0.00
2	10	2.08	3.65	1.93	0.52	8	19.47	4.48	2.35	0.28
3	10	4.69	9.55	7.32	0.34	5	14.13	7.94	4.46	0.33
4	10	3.58	6.13	3.62	0.00	5	10.23	13.68	10.79	0.64
5	8	1.91	3.03	1.60	-0.28	6	8.71	6.03	3.22	0.64
6	8	1.77	2.41	1.34	-0.05	6	10.00	6.46	3.53	0.51
C 1N	9	2.21	3.06	1.62	0.45	8	20.89	6.76	3.96	0.83
C 1S	9	1.99	3.92	2.06	0.70	8	16.60	4.79	2.54	0.54
C 2	7	2.56	3.45	1.78	-0.51	6	6.03	5.13	2,62	0.55

<   >

* April - September 1979

** October 1978 - March 1979

Table IV Results of pH, turbidity, conductivity and water temperatures for each sampling point (May-September 1979).

Sampling point No.	No. of samples	pH	Turbidity N.T.U.	Conductivity mhos/cm	Temperature °C Range	Median
1	8	7.80 - 8.00	0.35 - 0.65	51.4 - 57.5	26-29	27
2	8	7.80 - 8.00	0.35 - 1.40	54.3 - 57.5	26-29	27
3	7	7.50 - 8.00	0.50 - 1.60	49.3 - 60.6	22-28	27
4	7	7.50 - 8.10	0.58 - 2.70	49.3 - 60.6	22-29	27
5	7	7.80 - 8.00	0.16 - 0.63	51.7 - 64.0	25-28	27
6	7	7.80 - 8.00	0.16 - 0.57	51.7 - 60.4	26-28	26
C 1N	8	7.80 - 8.00	0.18 - 2.20	53.7 - 60.4	26-29	28
C 1S	8	7.80 - 8.00	0.18 - 0.70	53.7 - 60.4	26-29	28
C 2	6	7.80 - 8.00	0.15 - 0.52	50.3 - 63.1	25-28	26

Table V. Total coliforms/100 ml- means, deviation factors and sample variances-coastal water, North and Haifa District, October 1979 - March 1980.

Sampling Point	No. of Samples	Mean (log)	Deviation (log)	Variance (log)	Mean & Deviation (antilog)
1. Shave Zion N.	7	1.70	0.79	0.54	51 ± 6
2. Shave Zion S.	8	1.35	1.01	0.89	22 ± 10
3. Hof Hacarmel N.	3	2.05	1.22	0.99	112 ± 16
4. Hof Hacarmel S.	3	1.81	1.59	1.69	65 ± 39
5. Givat Olga N.	5	1.05	0.7	0.39	11 ± 5
6. Givat Olga S.	5	1.34	0.85	0.58	22 ± 7
C 1N Rosh Hanikra N.	8	1.33	0.83	0.6	22 ± 7
C 1S Rosh Hanikra S.	7	1.66	0.67	0.38	45 ± 5
C 2 Caesarea aquaduct	5	1.23	0.81	0.52	17 ± 6

Table VI Fecal coliforms/100 ml- means, deviation factors and sample variances-coastal water, North and Haifa District, October 1979 - March 1980.

Sampling Point	No. of Samples	Mean (log)	Deviation (log)	Variance (log)	Mean & Deviation (antilog)
1. Shave Zion N.	7	1.27	0.75	0.48	19 ± 6
2. Shave Zion S.	8	1.1	0.9	0.71	13 ± 8
3. Hof Hacarmel N.	3	1.71	0.96	0.61	51 ± 9
4. Hof Hacermel S.	3	1.59	1.38	1.26	39 ± 24
5. Givat Olga N.	5	0.69	0.82	0.54	5 ± 7
6. Givat Olga S.	5	1.31	0.4	0.13	20 ± 3
C 1N Rosh Hanikra N.	8	0.96	0.83	0.6	9 ± 7
C 1S Rosh Hanikra S.	7	1.15	0.83	0.6	14 ± 7
C 2 Caesarea aquaduct	5	1.14	0.56	0.25	14 ± 4

Table VII Fecal streptococci/100 ml - means, deviation factors and sample variances-coastal water, North and Haifa District, October 1979 - March 1980.

Sampling Point	No. of Samples	Mean (log)	Deviation (log)	Variance (log)	Mean & Deviation (antilog)
1. Shave Zion N.	8	0.93	0.68	0.4	9 ± 5
2. Shave Zion S.	8	0.98	0.52	0.24	9 ± 4
3. Hof Hacarmel N.	3	1.09	0.95	0.6	12 ± 9
4. Hof Hacarmel S.	3	1.02	0.89	0.52	11 ± 8
5. Givat Olga N.	6	1.11	0.95	0.76	13 ± 9
6. Givat Olga S.	6	1.24	0.92	0.71	17 ± 8
C 1N Rosh Hanikra N.	8	0.87	0.57	0.29	7 ± 4
C 1S Rosh Hanikra S.	8	1.06	0.55	0.27	11 ± 4
C 2 Caesarea aquaduct	6	1.15	1.05	0.91	14 ± 11

Table VIII Correlation factor (r) between the mandatory parameters - total coliforms (TC), fecal coliforms (FC), fecal streptococci (FS).

Sampling Point	No. of Samples	TC : FC	TC : FS	FC : FS
1. Shave Zion N.	7	.84	.62	.46
2. Shave Zion S.	8	.91	.2	.08
3. Hof Hacarmel N.	3	.96	.98	.995
4. Hof Hacarmel S.	3	.994	.98	.996
5. Givat Olga N.	5	.38	.72	.88
6. Givat Olga S.	5	.82	.8	.34
C 1N Rosh Hanikra N.	8	.91	.44	.41
C 1S Rosh Hanikra S.	7	.6	.09	.66
C 2 Caesarea aquaduct	5	.87	.95	.87

Table IX Student's t-test, results obtained for total coliforms by a) MPN and mFC 36°C; b) MPN and m-endo agar 36°C, for fecal coliforms by MPN and mFC 44.5°C

	Mean (log)	Deviation (log)	Mean & Deviation (antilog)
Total Coliforms			
(a) MPN	1.28	0.86	19 ± 7
mFC 36°C	1.02	0.82	10 ± 7
n = 113		t = 6.44	$p < 0.001$
(b) MPN	1.38	0.92	24 ± 8
m-endo agar	1.34	0.87	22 ± 7
n = 165		t = 1.19	p = 0.2
Fecal Coliforms			
MPN	0.98	0.84	10 ± 7
mFC 44.5°C	0.94	0.73	9 ± 5
n = 316		t = 1.63	p = 0.1

Table X Results of pH, turbidity and conductivity for each sampling point (October 1979 - March 1980)

Sampling Point	No. of Samples	pH	Turbidity N.T.U.	Conductivity mhos/cm
1. Shave Zion N.	5	7.7 - 8.08	0.6 - 1.0	47.1 - 49.5
2. Shave Zion S.	5	7.64 - 8.06	0.51 - 1.6	48.3 - 49.5
3. Hof Hacarmel N.	3	7.9 - 8.05	1.4 - 2.3	43.9 - 54.3
4. Hof Hacarmel S.	3	7.8 - 7.98	1.8 - 3.0	38.5 - 56.8
5. Givat Olga N.	5	7.9 - 8.04	0.95 - 1.8	46.0 - 49.5
6. Givat Olga S.	5	7.9 - 8.07	1.4 - 2.1	48.3
C 1N Rosh Hanikra N.	7	7.8 - 8.22	0.58 - 0.96	48.3
C 1S Rosh Hanikra S.	7	7.8 - 8.32	0.48 - 0.9	43.9 - 48.3
C 2 Caesarea aquaduct	4	7.9 - 7.92	1.4 - 2.2	48.3 - 49.5

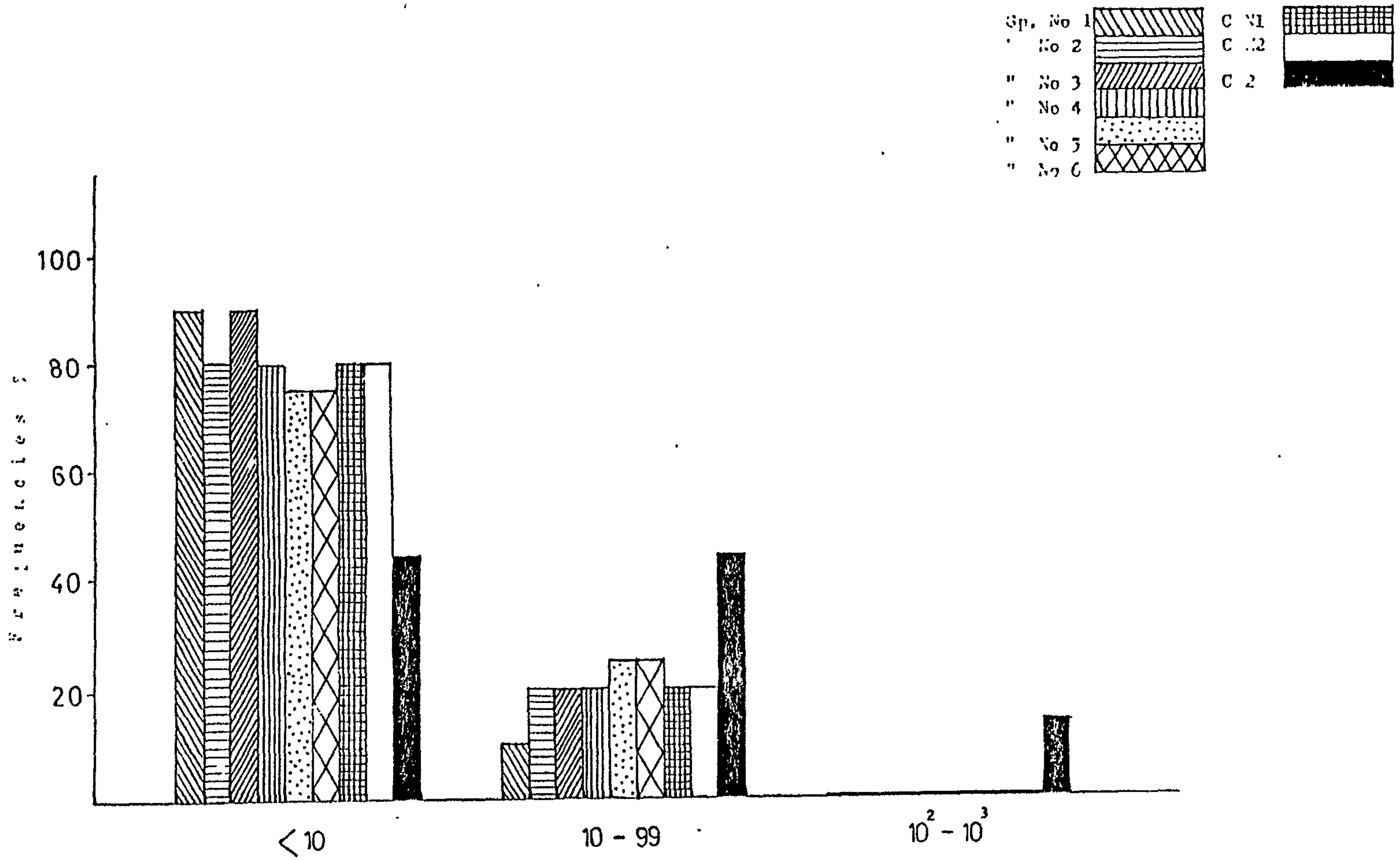


Fig. 1. Total coliforms/100 ml

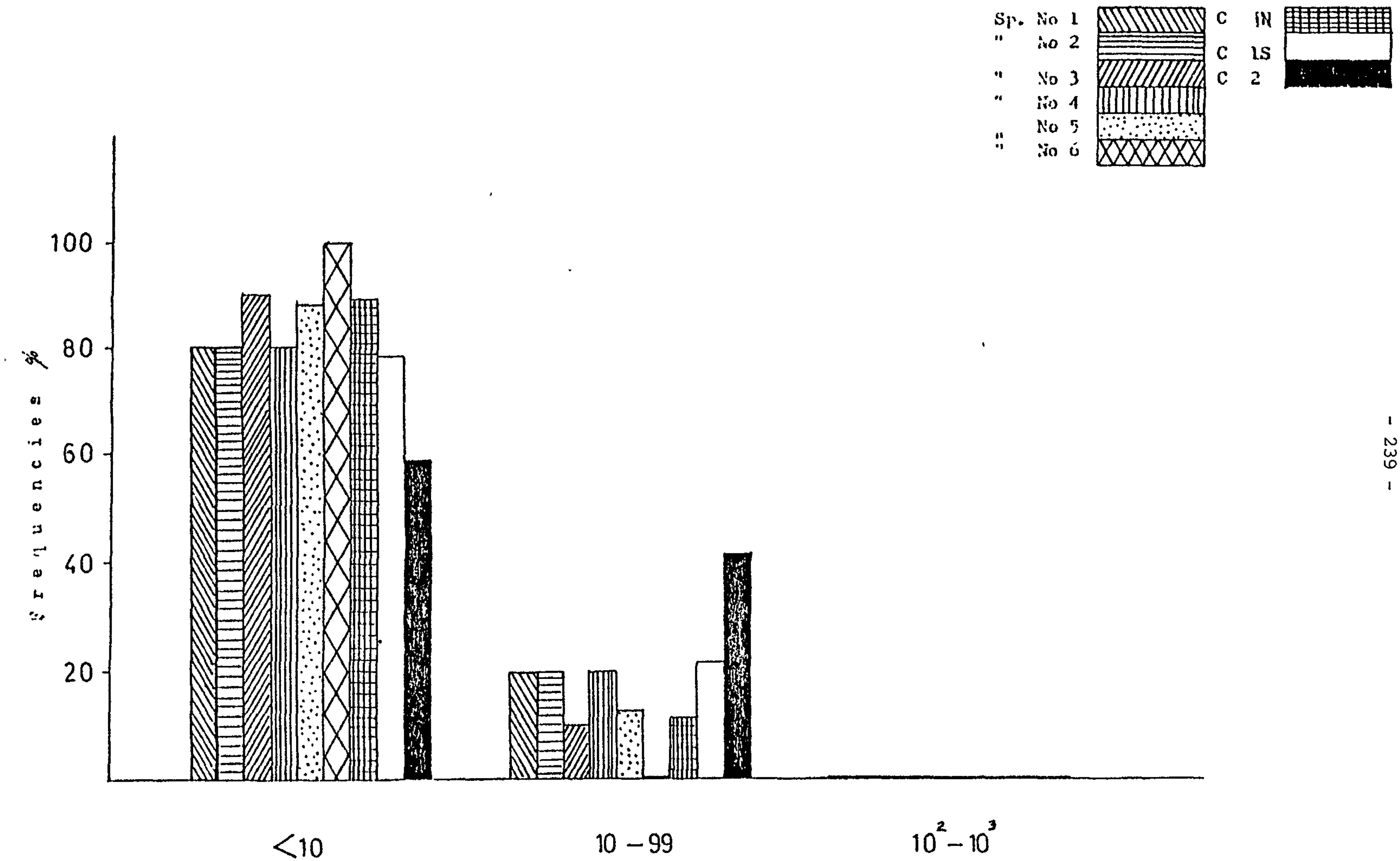


Fig. 2. Faecal coliforms/100 ml

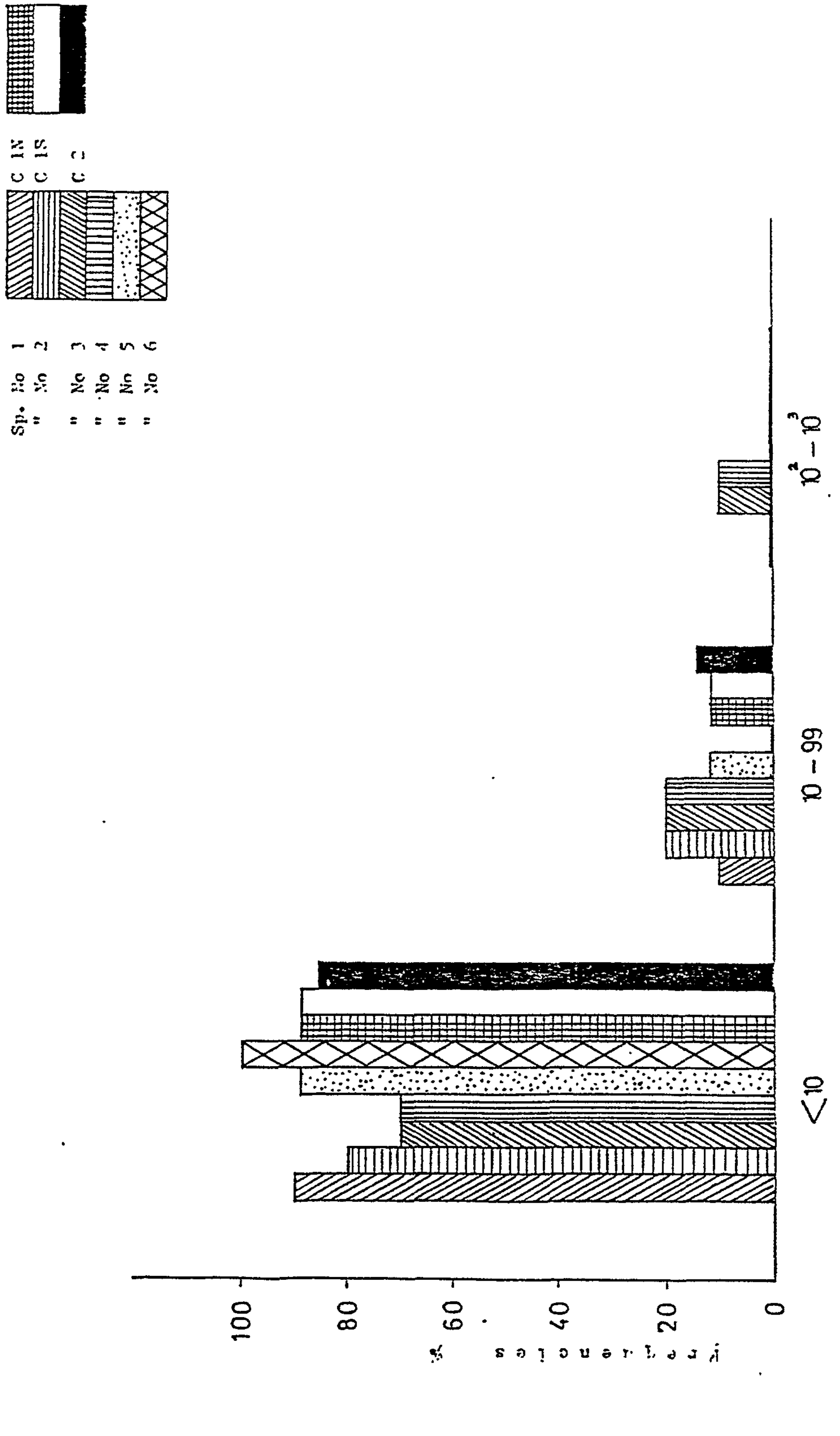


Fig. 3. Faecal streptococci/100 ml

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INTRODUCTION

Pathogenic bacteria and viruses are discharged in large numbers into the sea through sewage outfalls, posing a potential health risk to consumers of shellfish bred in adjacent waters or to bathers at contaminated beaches. Although enteric bacterial concentration is rapidly reduced in the sea as a result of dilution and other factors, it has been demonstrated that the pathogens can survive long enough in sufficiently high concentration to lead to disease transmission via bathers swimming at contaminated beaches.

The introduction of uniform standards and test procedures is an essential aspect of marine pollution control. This uniformity has recently been achieved through the UNEP/WHO Mediterranean pollution monitoring and control programme, in which the Environmental Health Laboratory in Israel is an active participant.

In the last five years, the Environmental Health Laboratory has initiated the following projects:

(a) Analysis of coastal water quality data in the Tel Aviv region during 1963-76. This included bacteriological testing and statistical analysis in co-operation with the Felix Public Health Laboratory of the Ministry of Health, Tel Aviv.

(b) Field and laboratory studies on the die-away kinetics of coliforms and enteric viruses in coastal waters.

(c) Development of sensitive methods for enteric virus detection in large volumes of sea-water.

The purpose of this research project is to study the die-away kinetics of coliforms and enteric viruses in coastal waters and to test the concentration of the total coliforms, faecal coliforms and faecal streptococci to determine if there is a correlation with concentrations of enteroviruses at three Mediterranean beaches off the coast of Tel Aviv near one of its sewage outfalls.

AREA(S) STUDIED

In accordance with the MED POL VII plan, during the study period routine bacteriological tests were made on samples taken at three (3) main beaches designated as sampling stations. All were in Tel Aviv. About 50 per cent of the samples were also examined for enteroviral content. In addition, occasionally, samples were taken from most of the other Tel Aviv area beaches for purposes of comparison of bacteriological and viral content. (See map).

At a point about 880 metres out to sea, the untreated sewage of Tel Aviv is discharged into the sea through a pipe. The closest beaches are the Tel Baruch beach, No. 6, just north of the Reading power plant sewage outfall and Nachshon, No. 8a, and Hilton, No. 8b, beaches which are in the south. (The results from Stations 8a and 8b were unified under one heading. These two stations were combined for data collection purposes because they are very close to each other and provided few samples). Station No. 5, which is further north of the sewage outfall, was selected as a control station. It should be noted that there are other points at which sewage enters the sea. One major source is the Yarkon River, into which cities situated further inland, release their sewage. Another smaller outlet is at Feingold Street, No. 13b, and near Bassa, No. 14a, both of which are to be closed down.

Data on wind velocity and direction, temperature and conductivity were collected for the above-mentioned beaches. The mean wind velocity was 10m/second and the wind direction generally was from south to north. The temperatures of the sea-water studied are tabulated in Table I. This table shows the range as 15° - 29°C, with the summer-time mean as 25°C. The mean for the remaining months of the year was 19°C. For the purposes of this study the summer-time was defined as the months of May to October, inclusive. The conductivity for these stations is presented in Table II. The mean for the entire period was 47 millimho. However, it should be noted that the summer-time mean was slightly higher (49 millimho).

MATERIAL AND METHODS

For the measurement of all the parameters, the methods used were those recommended by the project in "Guidelines for Health Related Monitoring of Coastal Water Quality", WHO Copenhagen, 1977). The organic flocculation method was used for concentrating and testing viruses from sea-water (Katzenelson, et al., 1976, Katzenelson, 1977) These tests yielded a mean virus recovery of 65% with seeded polio virus in 35 litre samples of sea-water.

Tables III-VII summarize the data for total coliforms, faecal coliforms, faecal streptococci and enteroviruses at three beaches. From these tables the following can be seen:

1. The mean value of the coliform count is lower in the summer than in the remaining months of the year (presented as "Others" in the tables).

2. The percentage of positive enterovirus samples in the summer was 44% in contrast to 56% in the remaining months. This trend was also seen for coliforms.

3. In Table VII, an interesting finding can be seen. About 78% of the positive enterovirus samples were found at beaches for which the bacterial pollution level was considered within the acceptable range (less than 1000 per/100 ml faecal coliform).

4. From Tables VI and VII we see that the percentage of samples positive for enteroviruses was found to be lower in the summer than in the remaining months of the year.

The correlation analysis between the various bacteria and the enteroviruses are presented in Figures 1-3, with the details of the regression lines. The presentation in these figures is based on data additional to the information in Tables III-VI. A significant correlation was found between total coliform vs. faecal coli, total coliform vs. faecal streptococci and faecal coli vs. faecal streptococci.

The mean ratio of positive enteric virus samples vs. other samples found positive was as follows:

(a) enteric viruses vs. total coliforms = 1: 3.0 x 10

(b) enteric viruses vs. faecal coliforms = 1: 1.8 x 10

(c) enteric viruses vs. faecal streptococci = 1: 4.3 x 10

A total of 15 different enteroviruses was identified, including types of poliovirus, echovirus and coxsackie (Fig. 4). These findings concur with those of Goyal, et al., 1978. In the sea, total coliforms and faecal streptococci were shown to have more rapid die-away rates than enteroviruses. The die-away rate of the faecal streptococci more closely paralleled that of the enteroviruses. (Fig. 5).

The UNEP/WHO Interim Guideline for bathing water quality has established that acceptable beaches should have no more than 10% of the samples test showing an E. coli count greater than 1000/100ml. Based on these guidelines all three of the beaches studied met these criteria during the official summer bathing season, (no samples greater than 1000/100ml), and one (6) had one sample out of 11 greater than 1000/100ml. However, based on high total coliform counts, the Israel Health Authorities have declared the beach as unsafe for swimming for a number of seasons.

The finding that coliform counts are higher in winter than in summer has been noted by us for some time and in an effort to elucidate this question several hundred coliform tests at the Country Club Beach between 1963 and 1974 were analysed as shown in Fig. 6 (Shuval et al 1978). There is a very strong negative correlation between mean monthly log coliform count and mean monthly duration of sunshine (r= -0.93). From these data it can be seen that coliform counts in the sea were almost two log cycles higher during winter periods of low sunshine duration as compared to summer months of maximum sunshine duration.

Studies by others (Gameson & Gould, 1975) have shown that light plays a major role in coliform die-away rates in sea-water, which might provide a reasonable explanation for the significantly lower coliform counts during the summer at beaches in the vicinity of outfalls. It should be noted, however, that most beach monitoring tests in Israel and many other Mediterranean countries are carried out during the official summer bathing season.

This could lead to approval of beaches which might not meet the criteria during the winter "off season" period. However, many of these Mediterranean beaches are frequented in the winter, particularly by tourists from northern European countries who find swimming in 18°C sea-water quite acceptable. An operative conclusion from these findings might be to require bacteriological monitoring of such tourist beaches on a year-round basis with decisions as to acceptability based both on winter and summer test results.

CONCLUSIONS

1. In general, enteric bacteria are reduced in the sea relatively more rapidly than enteroviruses.

2. Faecal streptococci displayed a die-away rate similar to that of enteroviruses. It may serve as a useful indicator of the degree of viral contamination in the sea.

3. A wide range of enteroviruses can be detected in the sea at a distance of up to five (5) kilometres from the sewage discharge point in the sea-water.

4. The microbial concentration level in the sea was low in the summer as compared with the remaining months of the year. Apparently, this is due to increased summer-time daylight and solar radiation which affects the micro-organism die-away rate.

5. In the light of our finding that enteroviruses were detected at all three (3) beaches, even when coliform levels were acceptable, health authorities should not ignore the possible risk of bathing in sea-water slightly contaminated with sewage. This finding emphasized the importance of implementing the proposed epidemiological study on disease rates among bathers and non-bathers at beaches of varying levels of bacterial pollution (Cabelli, et al., 1975). It also suggests that there might be a need in the future to develop a virus standard for bathing beaches.

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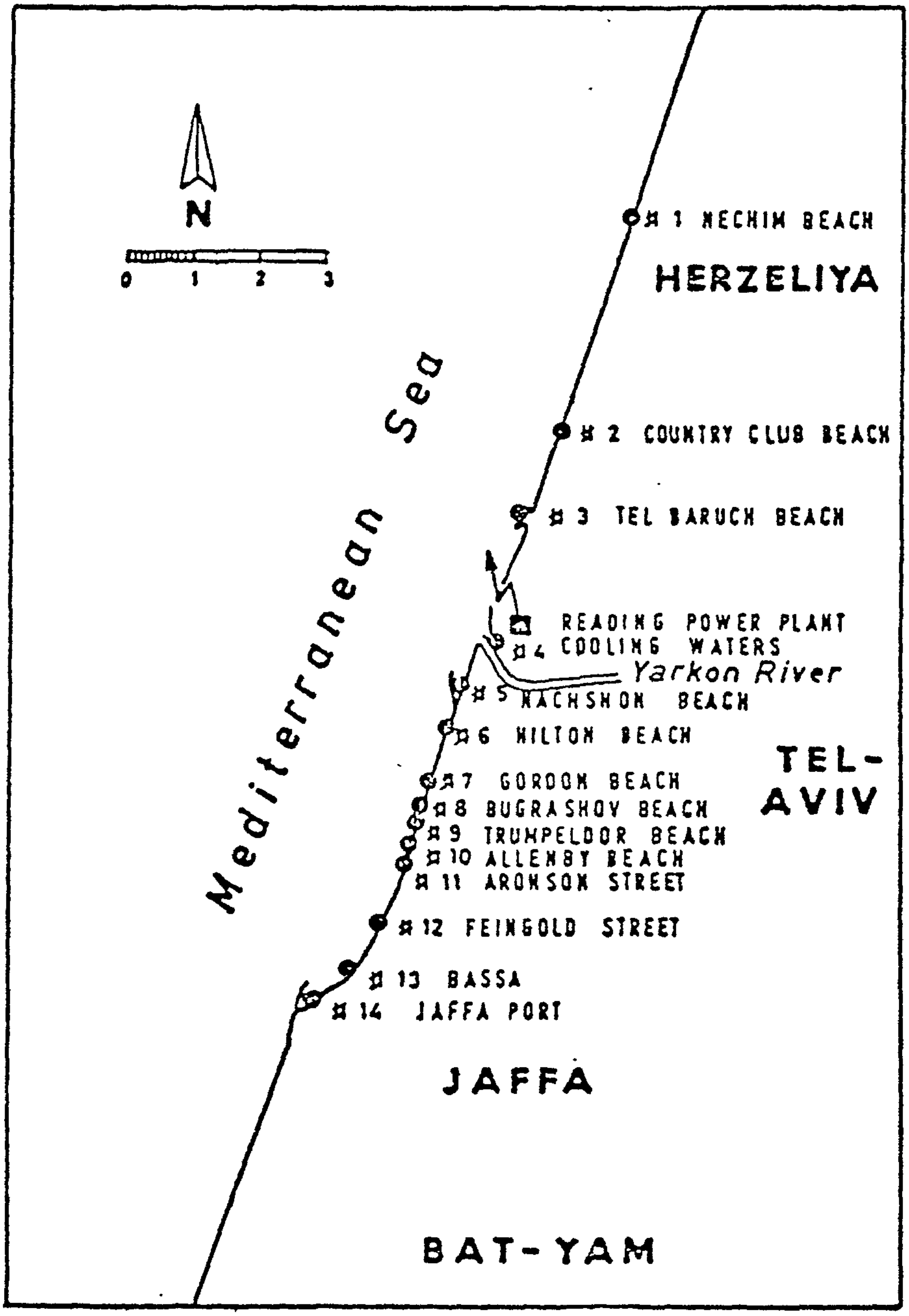

Tel Aviv's Coastal Region in which samples were taken

Table I

SEA TEMPERATURE IN SITU - SURFACE (°C)

SAMPLING POINT	Country Club 5	Tel Baruch 6	Hilton & Nachshon 8	All Points
SAMPLE VALUES				
Date				
26.10.77	—	23.0	23.0	23.0
02.11.77	25.0	—	—	25.0
23.11.77	—	—	22.2	22.2
22.01.78	18.0	18.0	—	18.0
02.02.78	—	17.5	16.5	17.0
14.02.78	—	—	17.0	17.0
15.03.78	18.0	18.0	—	18.0
03.04.78	—	21.0	19.5	20.3
11.04.78	—	—	20.0	20.0
02.05.78	20.0	—	—	20.0
29.05.78	—	22.0	24.0	23.0
21.06.78	25.0	25.0	25.0	25.0
28.07.78	27.0	27.0	27.0	27.0
16.08.78	27.0	27.0	27.0	27.0
03.09.78	27.0	27.0	27.0	27.0
16.01.80	15.0	15.0	19.0	16.3
14.04.80	19.0	19.8	20.0	19.6
26.05.80	22.0	22.0	26.0	23.3
01.07.80	29.0	28.5	28.0	28.5
Mean Values				
Summer	25.28	25.18	25.87	24.87
Others	19.00	18.21	19.17	19.34
Total	22.66	22.20	22.74	22.96
St. Deviations				
Summer	2.96	2.39	1.61	2.57
Others	3.28	1.88	1.79	2.55
Total	4.38	4.08	3.75	3.76

Table II

CONDUCTIVITY - SURFACE (Millimho)

SAMPLING POINT	Country Club 5	Tel Baruch 6	Hilton & Nachshon 8	All Points
SAMPLE VALUES				
Date				
22.01.78	47.0	47.5	—	47.3
02.02.78	—	44.9	44.5	44.7
14.02.78	—	—	44.3	44.3
15.03.78	44.9	45.0	—	45.0
03.04.78	—	42.5	47.5	45.0
11.04.78	—	—	49.0	49.0
02.05.78	48.2	—	—	48.2
29.05.78	—	52.5	52.8	52.7
28.07.78	48.0	47.0	47.0	47.3
16.08.78	47.5	48.0	48.0	47.8
Mean values				
Summer	47.9	49.2	49.3	49.0
Others	45.9	45.0	46.3	45.9
Total	47.1	46.8	47.6	47.1
St. Deviations				
Summer	0.4	2.9	3.1	2.5
Others	1.5	2.0	2.3	1.9
Total	1.3	3.2	2.9	2.6

Table III

TOTAL COLIFORMS - SURFACE (NO./100 ML)

SAMPLING POINT

SAMPLE VALUES Date	Country Club 5	Tal Baruch 6	Hilton & Nachshon 8	All Points
26.10.77	--	10	8	3.2
02.11.77	60	--	--	60.0
23.11.77	--	--	10	10.0
22.01.78	20	380	--	85.1
02.02.78	--	6.0×10^4	40	1.5×10^3
14.02.78	--	--	10	10.0
15.03.78	8.9×10^3	980	--	2.8×10^3
03.04.78	--	7.4×10^3	250	1.3×10^3
11.04.78	--	--	500	500.0
02.05.78	5	--	--	5.0
29.05.78	--	200	150	147.9
21.06.78	120	1.7×10^3	500	457.1
28.07.78	70	4.3×10^3	24	190.5
16.08.78	360	1.1×10^3	250	457.1
03.09.78	42	420	10	54.9
21.07.79	25	40	80	42.7
18.09.79	59	84	23	48.2
16.10.79	50	50	23	38.0
16.01.80	3.2×10^3	1.0×10^3	4.1×10^3	2.3×10^3
14.04.80	1.4×10^3	1.8×10^3	210	794.3
26.05.80	47	24	8	20.4
01.07.80	4	400	130	58.9
Log mean values				
Summer	38.0	186.2	36.3	51.3
Others	537.0	2511.9	120.2	269.2
Total	91.2	467.7	58.9	109.6
St. Deviations				
Summer	3.5	6.2	5.5	4.4
Others	10.2	5.2	7.6	7.8
Total	8.1	8.5	6.8	6.9

Distribution	Country Club 5	PC	Tal Baruch 6	PC	Hilton & Nachshon 8	PC	All Points	PC
0 - 100	10	67	5	29	10	56	25	50
101 - 1000	2	13	5	29	7	39	14	28
+ 1000	3	20	7	42	1	5	11	22

Table IV

FECAL COLIFORMS - SURFACE (NO./ML)

SAMPLING POINT

SAMPLE VALUES Date	Country Club 5	Tel Baruch 6	Hilton & Nachshon 8	All Points
26.10.77	—	0	0	0
23.11.77	—	—	0	0
22.01.78	20	—	—	20.0
02.02.78	—	$5.2x10^4$	10	537.0
14.02.78	—	—	0	0
15.03.78	$4.6x10^3$	530	—	$1.5x10^3$
03.04.78	—	$5.1x10^3$	40	446.7
11.04.78	—	—	150	150.0
02.05.78	5	—	—	5.0
29.05.78	—	90	80	83.2
21.06.78	80	700	30	117.5
28.07.78	70	$1.7x10^3$	20	131.8
16.08.78	210	750	130	263.0
03.09.78	33	330	10	46.8
21.07.79	50	550	40	92.6
18.09.79	22	46	14	19.9
16.10.79	1	1	0	1.0
16.01.80	$1.1x10^3$	100	$1.5x10^3$	501.1
14.04.80	$2.6x10^3$	$3.1x10^3$	155	794.3
26.05.80	91	23	157	58.4
01.07.80	6	60	0	6.9
Log mean values				
Summer	25.1	79.4	14.2	24.5
Others	207.9	2089.3	27.5	89.1
Total	65.4	218.8	18.2	42.7
St. Deviations				
Summer	4.7	11.2	6.2	6.2
Others	8.3	8.1	12.3	14.1
Total	9.8	15.8	8.5	10.0

Distribution	Country Club	PC	Tel Baruch	PC	Hilton & Nachshon	PC	All Points	PC
0 - 100	10	71	7	44	13	72	30	62
101 - 1000	1	7	5	31	4	22	10	21
+ 1000	3	22	4	25	1	6	8	17

Table V

FECAL STREPTOCOCCI - SURFACE (NO./100 ML)

SAMPLING POINT SAMPLE VALUES Date	Country Club 5	Tel Baruch 6	Hilton & Nachshon 8	All Points
02.02.78	—	$2.5x10^{4}$	0	158.4
14.02.78	—	—	0	0
15.03.78	$1.2x10^{3}$	130	—	389.0
03.04.78	—	$1.2x10^{3}$	20	154.8
11.04.78	—	—	80	80.0
02.05.78	13	—	—	13.0
29.05.78	—	330	130	208.9
21.06.78	40	190	50	72.4
16.08.78	120	38	20	44.7
03.09.78	18	180	6	26.9
21.07.79	5	220	70	42.0
18.09.79	68	24	9	24.4
16.10.79	8	8	15	9.8
16.01.80	200	120	200	167.2
14.04.80	880	450	65	292.9
26.05.80	116	90	70	89.1
01.07.80	600	190	60	186.2
Log mean values				
Summer	38.0	85.1	30.9	44.7
Others	588.8	707.9	16.2	85.1
Total	75.9	182.0	24.0	57.5
St. Deviations				
Summer	4.2	3.2	2.7	2.6
Others	2.1	7.1	7.9	4.3
Total	5.8	6.0	4.7	4.3
Distribution	PC	PC	PC	PC
0 - 100	6 50	4 28	13 86	23 56
101 - 1000	5 42	8 58	2 14	15 37
+ 1000	1 8	2 14	0 0	3 7

Table VI

ENTEROVIRUS - SURFACE (PFU/L)

SAMPLING POINT

SAMPLE VALUES Date	Country Club 5	PC	Tel Baruch 6	PC	Hilton & Nachshon 8	PC	All Points	PC
26.10.77	--		--		2/70			
02.11.77	0/85		--		--			
23.11.77	--		--		0/85			
22.01.78	1/50		4/70		--			
02.02.78	--		--		0/85			
14.02.78	--		--		1/85			
15.03.78	7/85		8/50		--			
03.04.78	--		7/80		7/80			
02.05.78	0/85		--		--			
29.05.78	--		0/85		0/85			
18.09.79	0/68		0/68		2/34			
16.10.79	1/80		0/80		4/70			
14.04.80	28/50		40/65		36/65			
26.05.80	--		--		5/75			
01.07.80	13/78		5/80		4/78			
No. of Positive	5	63	5	63	8	73	18	67
No. of Negative	3	37	3	37	3	27	9	33

Table VII

Comparison of the concentration of total coliforms (T.C.), faecal coliform (F.C.) and faecal streptococci (F.S.) in bathing water samples found positive in enterovirus

Date	Enterovirus Pfu/L	T.C. (No./100 ml)	F.C. (No./100 ml)	F.S. (No./100 ml)	Name of Beach
26.10.77	2/70	0	0	--	Hilton & Nachshon
22.01.78	1/50	20	20	--	Country Club
22.01.78	4/70	380	--	--	Tel Baruch
14.02.78	1/85	10	0	0	Hilton & Nachshon
15.03.78	7/85	$8.9x10^3$	$4.6x10^3$	$1.2x10^3$	Country Club
"	8/50	980	530	130	Tel Baruch
03.04.78	7/80	$7.4x10^3$	$5.1x10^3$	$1.2x10^3$	Tel Baruch
"	7/80	250	40	20	Hilton & Nachshon
18.09.79	2/34	23	14	9	Hilton & Nachshon
16.10.79	1/80	50	1	8	Country Club
"	4/70	23	0	15	Hilton & Nachshon
14.04.80	28/50	$1.4x10^3$	$2.6x10^3$	880	Country Club
"	40/65	$1.8x10^3$	$3.1x10^3$	450	Tel Baruch
"	36/65	210	155	65	Hilton & Nachshon
26.05.80	5/75	24	23	70	Hilton & Nachshon
01.07.80	13/78	4	6	600	Country Club
"	5/80	400	60	190	Tel Baruch
"	4/78	130	0	60	Hilton & Nachshon

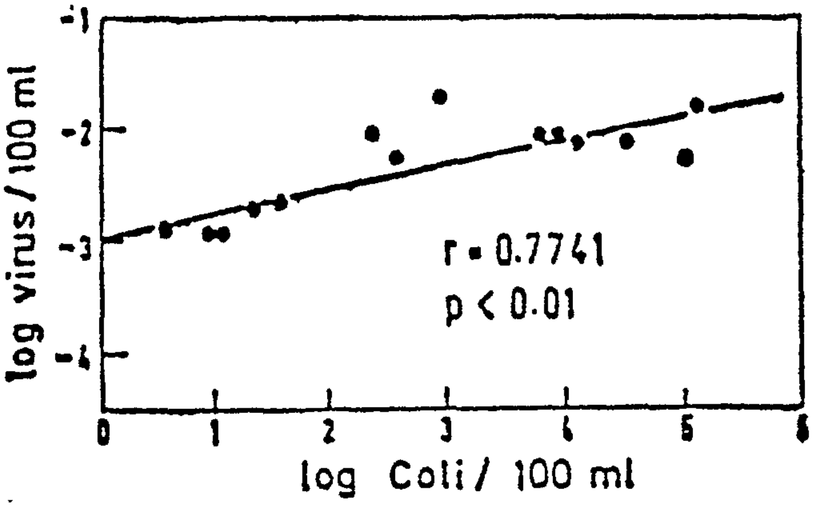

Fig. 1. Correlation between coliforms and viruses found at beaches

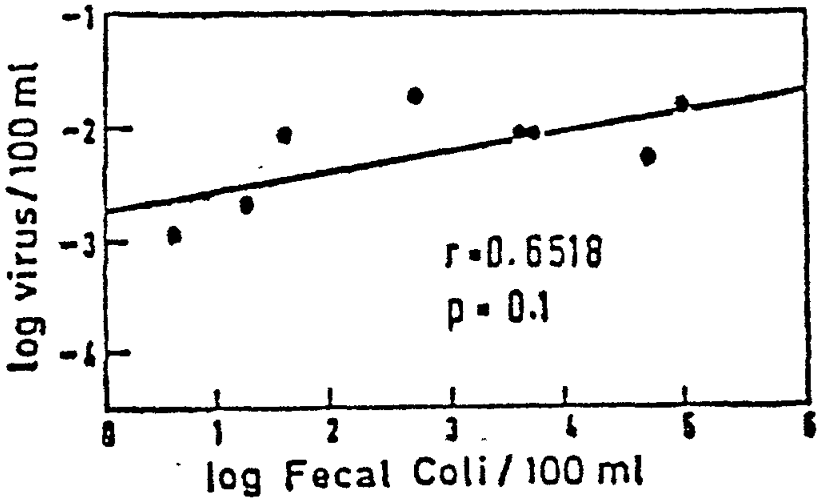

Fig. 2. Correlation between faecal coliforms and viruses found at beaches

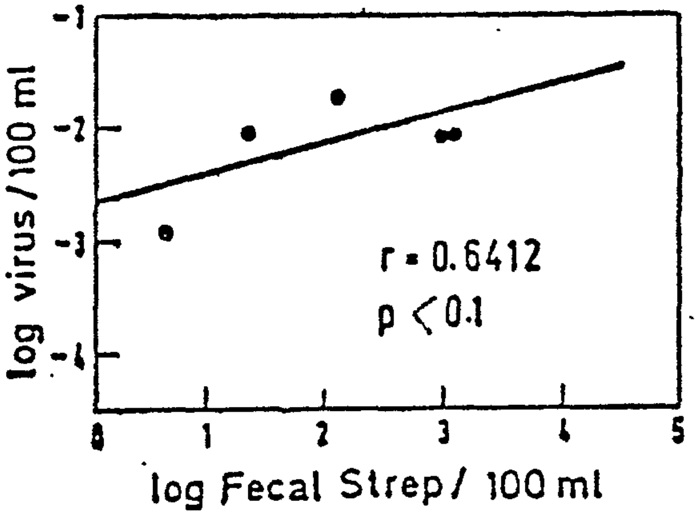

Fig. 3. Correlation between faecal streptococci and viruses found at beaches

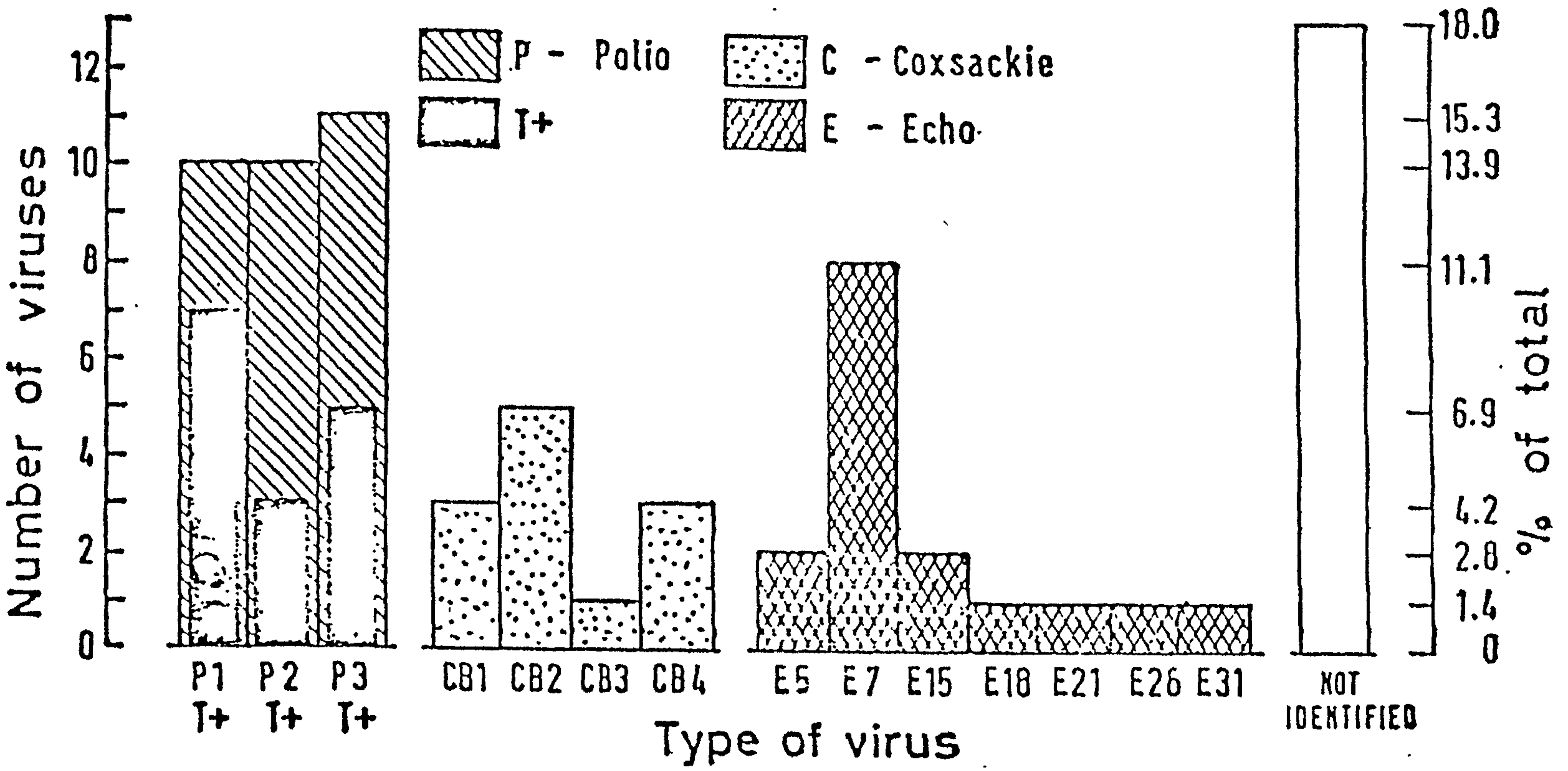

Fig. 4. Types of viruses found at beaches

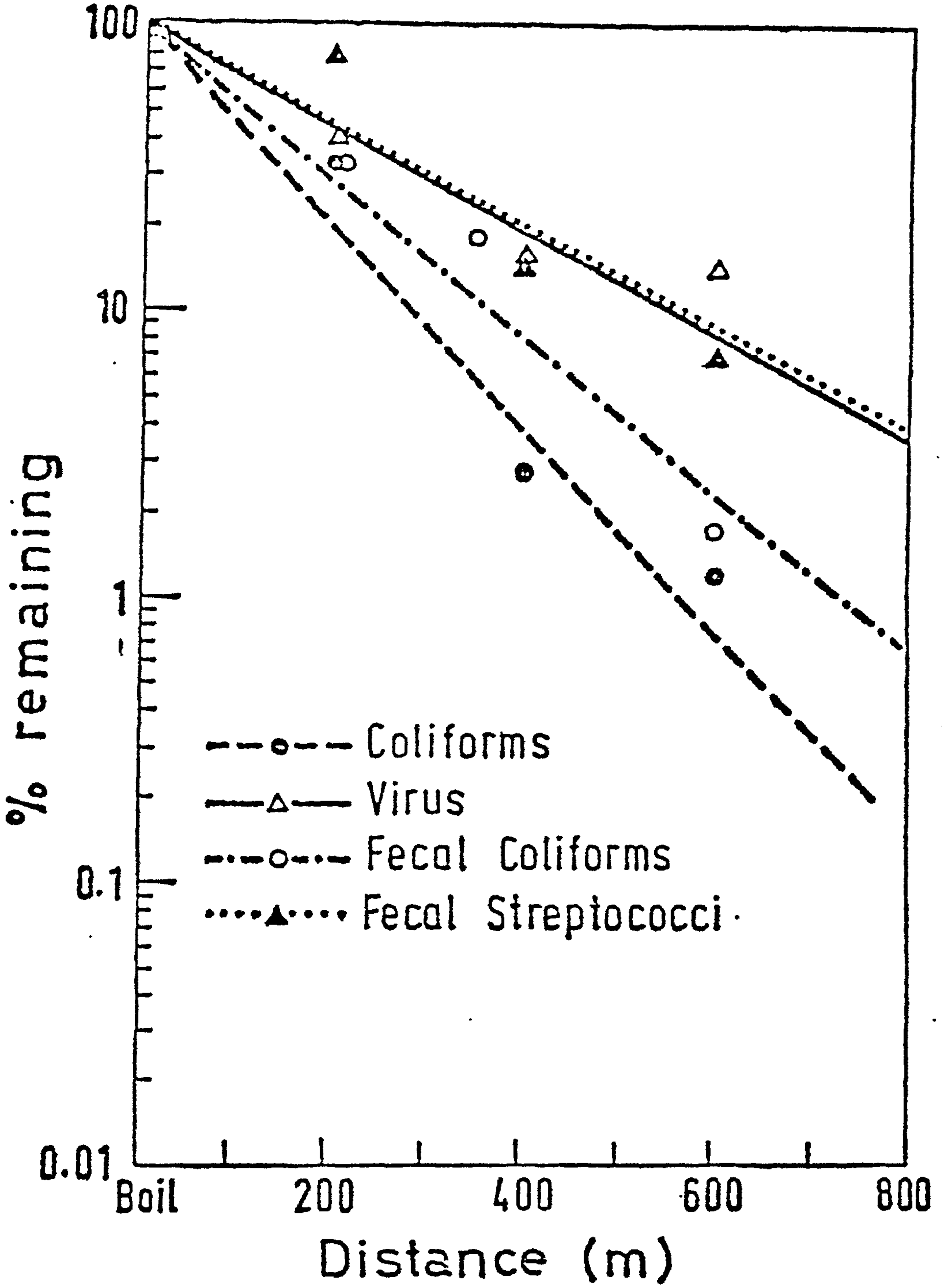

Fig. 5. Disappearance of enteric microorganisms at various distances from the point of discharge

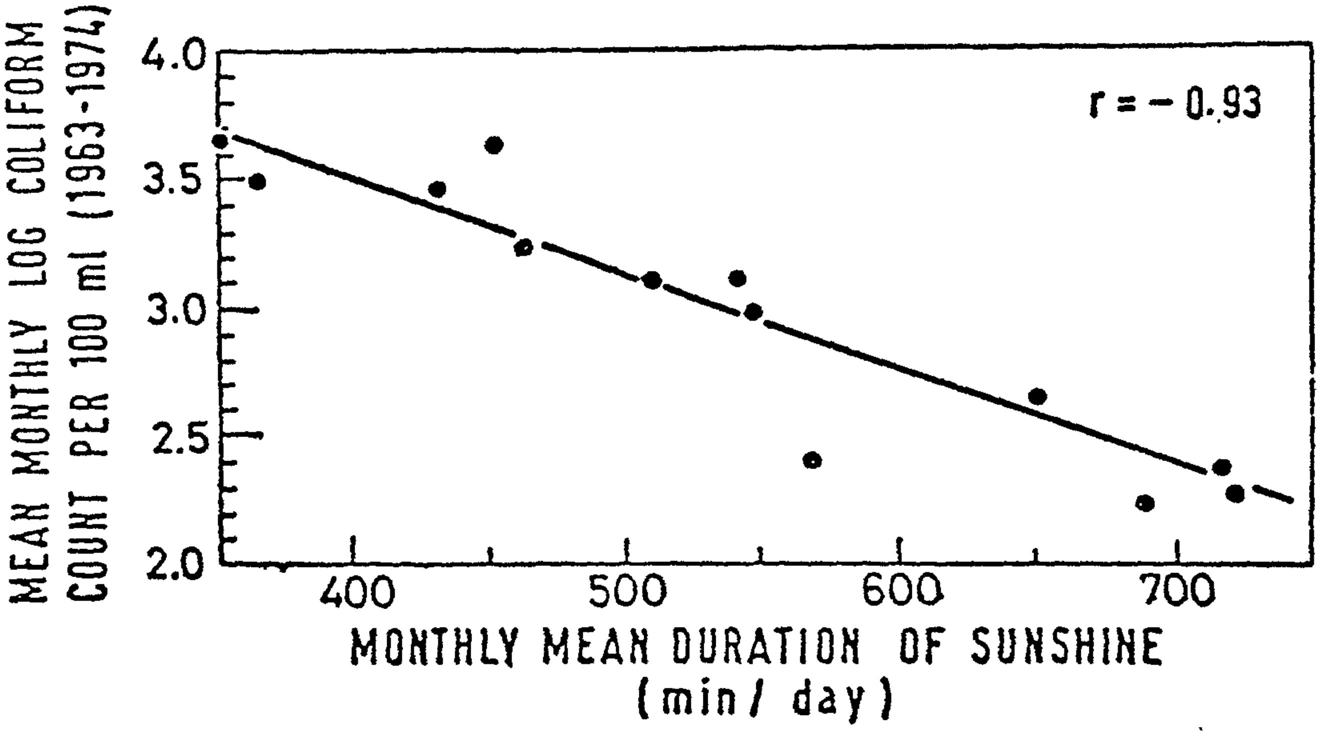

Fig. 6. Relationship between duration of sunshine and coliform count at the Tel-Aviv Country Club beach, 1963-1974

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INTRODUCTION

The official bathing season in Israel is May 15 to October 15, but in practice it starts earlier and extends far beyond that date, depending on the weather. Monitoring in the summer was therefore done from the beginning of May till the end of October, except in 1978, when we joined the project and started monitoring at the end of June.

We have been monitoring total coliforms in the Tel-Aviv beaches since 1963 and since 1975 faecal coliforms as well, employing the fermentation tube procedure (MPN) for both (1). In the last five years monitoring was extended to other beaches along the shore of central and southern Israel, comprising about 30 beaches. During a study of coastal pollution problems around the sewage outfall north of Tel Aviv, total coliforms were also monitored by membrane filtration with M-endo broth.

The mandatory bacteriological parameters to be monitored for the MED POL VII project were total coliforms (TC), faecal coliforms (FC) and faecal streptococci (FS) and the method stipulated for monitoring was membrane filtration (MF) with m-FC medium for the coliforms (incubation temperature 36°C ± 1°C for the total and 44°C ± 0.2°C for the faecal) and M-Enterococcus agar for the faecal streptocci. As our previous experience indicated that the MPN procedure gave considerably higher counts of coliforms than the MF in about 50% of samples (2) and the filters on m-FC medium at 35°C were often very difficult to read due to many interfering colonies, it was felt that monitoring by the MPN technique should be continued, parallel with the mandatory MF technique, and membrane filtration with m-Endo agar for the total coliforms should also be included. The comparative results are presented and discussed here.

The optional part of our programme included examinations for the presence of salmonellae and <u>Vibrio parahaemolyticus</u>.

AREA(S) STUDIED

The coastline under surveillance of our laboratory is about 90 km long and the three beaches selected for the project, namely Nathania, Tel Aviv and Ashquelon, are in the most populated areas. The land near the beaches is mainly sandy and surface or ground water reaches them only on rainy days in the winter. There is a sewage outfall about 4 km north of the Tel Aviv beach and none near the others.

MATERIALS AND METHODS

Sampling - there were 2 sampling points in each beach, about 250 m apart (sp 1-6) and two control points, one in the north near Nathania (cp1) and one in the south near Ashquelon (cp2). In the summer, water samples were collected every fortnight and in the winter, every six weeks. All samples were collected in the morning and brought to the laboratory within 1-2 hours.

Total coliforms:

MF with m-FC agar and LES Endo agar incubated at 36°C ± 1°C for 22 h. MPN with lactose broth confirmed by plating for isolated colonies on MacConkey agar.

Faecal streptococci:

MF with M-Enterococcus agar incubated at 44.5°C ± 0.2°C.

Faecal coliforms:

MF with M-FC medium incubated at 44.5°C and MPN method by inoculating the positive tubes of the total coliform test into E.C. broth incubating at 44.5°C and observing for gas production in 24 hours.

Salmonellae:

MF of 500 ml water, membranes immersed in selenite-cystine-broth incubated at 41°C ± 0.5°C; plating after 24 and 48 h on brilliant green agar incubated at 37°C. Suspicious colonies were picked and identified biochemically and serologically. The final identification of serotypes was done in the National Salmonella Center in the Central Laboratories in Jerusalem.

Vibrio parahaemolyticus:

In the first season enrichment in salt broth (3% NaCl) plated on TCBS agar; later, only MF with TCBS agar incubated at 41°C ± 0.5°C. Suspicious colonies were picked and examined biochemically.

RESULTS

Winds: The prevailing wind direction was south-westerly and occasionally south. Results were therefore analysed according to season only (3 summers and 2 winters). The results of the three mandatory parameters are presented in Tables I - III.

In Table I data for total coliforms, obtained by MF with two media and MPN, are compared. They indicate that MF with m-FC agar and LES Endo agar gave similar results, while those obtained by the MPN procedure were considerably higher, particularly in the winter, when the number of organisms was elevated by all methods. A similar pattern was observed for faecal coliforms (Table II).

When MF counts of faecal coliforms were related to the 95% confidence limits of the MPN, in all 300 samples monitored, 64.7% were within the limits, 3.6% were above and 31.7% were below them. However, when compared on a numerical basis, since for evaluating beach quality the number stated for the MPN is employed rather than the confidence limits, 32% of the results were equal, 9.3% were higher by MF and 58.7% were higher by the MPN procedure. The relations between MF and MPN in the individual sampling points are presented in Tables IV - VI.

Correlation between the 3 mandatory parameters is given in Table VII.

There is a fairly good correlation between total and faecal coliforms in both seasons; no correlation between any of them and faecal streptococci in the summer, but a fairly good one between faecal coliforms and faecal streptococci in the winter.

V. parahaemolyticus was not detected but two strains of salmonella were isolated in 1980, one in February (S. anatum) from the southern point in Nathania, the other in March (S. Dublin) from the southern point in Ashquelon.

Salinity - ranged between 34.13°/oo to 38.80°/oo.

Dissolved oxygen - 4.9 to 7.8 mg/l

Temperature - in the winter the water temperature was 8°C-12°C and in the summer it was 17°C-27°C.

DISCUSSION OF RESULTS

During the bathing seasons, all points complied with the quality criteria of "100 E. coli per 100 ml" by both methods employed for monitoring and by MF in the winter as well (Table II). The results of the MF procedure also complied with "no more than 10% of 10 consecutive samples collected during the bathing season should exceed 1000 E. coli per 100 ml". However, had the quality been assessed by the MPN results, two points would have been disqualified in the summer of 1979, since 3 out of 10 samples in one point and 2 out of 12 in the other exceeded 1000 faecal coliforms. It seems, therefore, that quality criteria should also define the method of monitoring and set the standards accordingly.

The data presented here confirm two of our previous observations: (a) the number of organisms was much higher in the winter than in the summer, and (b) results obtained by the one-step MF procedure were below the 95% confidence limits of the MPN in a considerable part of the samples - about 32% in the present study and 46-50% in the previous one (2).

The elevated number of organisms in the winter can be attributed to two factors: (a) stormwater run-off contaminated by faecal material from animals, as suggested by Geldreich (3), which occurs in Israel only in the winter, as there is no rain in the summer, and (b) stirring up of organisms that have settled to the bottom by the stormy sea. The latter is borne out by the fact that in clean beaches like Ashquelon (Sp.5,6 and cp2) the number of organisms remained low in the winter.

The MPN procedure was more efficient in recovering total and faecal coliforms, presumably by affording better conditions for recovery of stressed organisms that are undoubtedly present in the marine environment. In chlorinated waste-water effluents, where stressed bacteria are present, the MPN procedure was also more efficient in recovering faecal coliforms (4). Stevens, et al., (5) who examined 200 samples of sea-water for faecal coliforms, found that only 10% of organisms measured by the MPN technique were enumerated by the current MF procedure and the stress imposed by the elevated temperature (44.5°C) on the individual faecal coliform cells during the initial 15 minutes of exposure was lethal to the majority of faecal strains filtered from sea-water. This may account for the greater discrepancy between the MPN and MF data in the winter, when the water temperature was much lower.

A two layer medium proposed by Rose, et al., (6), which includes 2 hours pre-incubation at 35°C recovered 3.8 to 7 times more faecal coliform colonies from marine water than the direct MFC procedure. It is felt that the MPN method is more suitable for monitoring faecal coliforms in marine water and if the MF procedure is to be employed it should be modified to improve recovery efficiency. Further investigation is desirable before a standard procedure for enumerating faecal coliforms in the marine environment can be recommended.

The number of faecal streptococci was usually quite low and even in the winter, in points with high faecal coliform counts, they did not exceed a few hundred per 100 ml. In our previous work (2) the ratio between TC:FS and FC:FS was 95:1 and 38:1 respectively in heavily contaminated water, while in lightly contaminated water it was 19:1 and 3:1 respectively. The density of faecal streptococci in our coastal water is apparently not high enough to make them a good parameter for assessing faecal contamination. Geldreich and Kenner (7) maintain that faecal streptococci are of limited sanitary significance, since the group contains varieties that are ubiquitous or rarely found in warm-blooded animals. When used alone or in conjunction with total coliforms in recreational waters they may yield misleading indications of faecal pollution. Only parallel examinations with faecal coliforms would confirm validity of faecal streptococci. It should be mentioned that in an epidemiological study conducted by Cabelli (8) in two New York beaches the density of faecal streptococci was found to be sufficient to index the rates of gastrointestinal symptoms observed. A similar epidemiological survey in our country, where sea bathing is very popular and the season extends over 7 - 8 months of the year, would certainly contribute to establishing quality criteria for this region.

Many strains of salmonella were previously isolated from coastal water up to 2 km from a sewage outfall (9), but in the present work they were found in water of fairly clean beaches, where even on the days of salmonella isolation the number of indicator organisms was not too excessive (in Nathania - FC 83 per 100 ml by MF and 1100 per 100 ml by MPN, and FS 33/100 ml; in Ashquelon - FC 320/100 ml by MF and 460/100 ml by MPN and FS 400/100 ml). The presence of salmonellae in moderately polluted or clean water is well documented in the literature (10, 11 and 12).

According to the quarterly report of the National Salmonella Center for January - March, 1980, the two serotypes that we isolated belonged to the five most common serotypes from non-human sources in that period. S. Dublin was isolated only from animals, (including one bird), from meat and a few strains from man. As there are no sewage outfalls near these beaches it is assumed that contamination was from animals or birds, directly or through stormwater run-off from the land.

Since one of the objectives of this collaborative pilot project was to establish efficient methods for monitoring quality control parameters in the marine environment, based on experience gained through this work as well as the literature, it is felt that a few comments have to be made concerning the "agreed" methodology stated on Page 8 in the report of the last meeting of principal investigators (Rome, 20-23 November 1979).

1. There are two deviations from the methodology given in the guidelines (13) which we followed for the first two years of the project, that I cannot accept:

   (i) It is emphasized that "liquid m-FC as opposed to agar" should be used. In our experience on solid medium with agar the colonies were larger and more typical and Geldrich (14) states that recent quality control testing has demonstrated a significant reduction in colony counts and colony size associated with the use of absorbant pad substrate in comparison to the same medium prepared in a 1.5% agar base. In addition to avoiding toxicity of some absorbant pads used for the liquid medium the agar medium has a technical advantage that the plates can be prepared beforehand and stored in the refrigerator for a couple of days.

(ii) The incubation temperature for faecal streptococci was changed from 44°C ± 0.2°C in the guidelines to 35°C ± 0.5°C. One of the definitions of faecal streptococci which differentiates them from other streptococci is the ability to grow at 45°C. Incubation at 35°C will enable other streptococci to grow, giving erroneously higher results.

2. According to our experience an incubation temperature of 35°C ± 0.5°C is not suitable for total coliforms on MFC. There was overgrowth of other organisms on the filter (many pink colonies of non-lactose fermenters), which made the counts of the filters inaccurate and sometimes unreadable. Raising the incubation temperature to 37°C improved their quality enormously making them quite readable. This observation, though, referred to earlier in the report was disregarded in the recommended procedure.

Reconsideration of methodology before the Long-Term Quality Control Programme commences seems desirable.

CONCLUSIONS

The data presented here lead to the following conclusions:

(a) The MPN procedure is apparently more suitable than the one-step MF for monitoring total and faecal coliforms in marine water. If the MF technique is to be used it should be modified to improve recovery efficiency.

(b) As there is a considerable variance in results obtained by different methods for monitoring quality parameters, the criteria should also define the method of monitoring (as is done in certain clincial tests) and set the standard accordingly.

(c) The density of faecal streptococci in our coastal water is apparently not high enough to make them a good parameter for assessing faecal contamination.

(d) Salmonellae can occasionally be isloated from fairly clean beaches with no sewage outfall in the vicinity. Their source is probably animals or birds.

(e) An epidemiological study in our country, where sea-bathing is very popular and the bathing season extends over 7 - 8 months of the year, may contribute to establishing quality criteria for this region.

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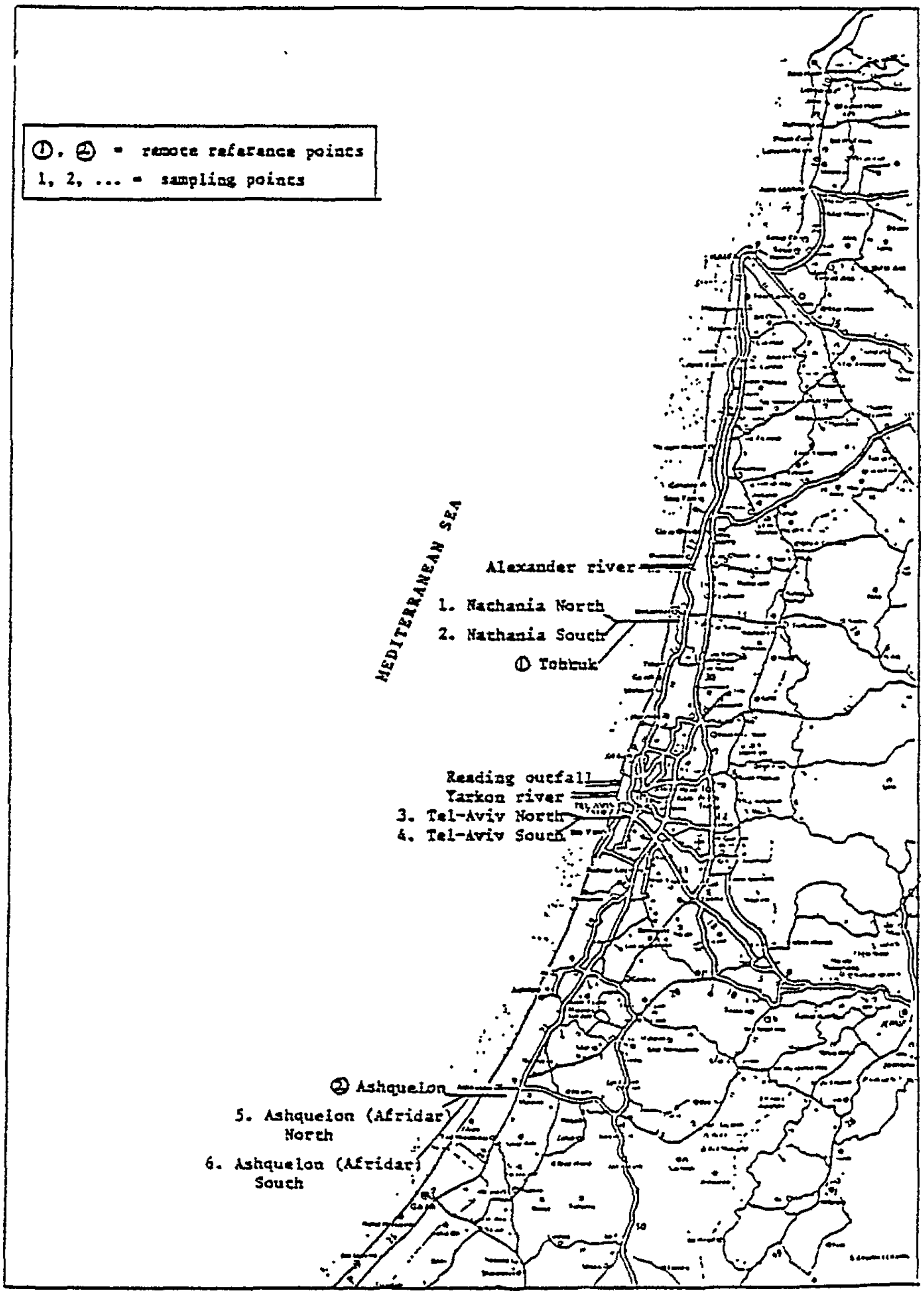

Fig. 1. Coastal stations for monitoring and reference points, Nathania, Tel-Aviv and Ashquelon

Table I: Medians and deviation factors of total coliforms per 100 ml in coastal water of central and southern Israel during three summers and two winters (1978 - 1980)

Sampling point No.	summer							winter						
	No. of Samples	m-FC		m-Endo		MPN		No. of Samples	m-FC		m-Endo		MPN	
		Mean	Dev	Mean	Dev	Mean	Dev		Mean	Dev	Mean	Dev	Mean	Dev
1	32	22	6	19	5	40	7	7	243	5	208	5	1714*	23
2	32	16	6	18	6	48	7	7	291	5	217	5	1840*	9
3	29	53	8	57	10	165	20	7	191	3	167	4	2544	4
4	29	38	5	27	5	122	8	7	230	5	190	4	9780	44
5	32	10	13	10	9	32	30	7	18	10	26	18	141	14
6	32	12	8	11	9	23	26	6	8	18	17	8	41	11
cp 1	32	13	5	11	6	13	12	6	222	7	190	6	1270	8
cp 2	32	4	7	6	6	8	14	7	22	10	21	10	52	8

* only 6 samples.

Table II Means and deviation factors of faecal coliforms per 100 ml in coastal water of central and southern Israel during three summers and two winters (1978 - 1980)

Sampling point No.	summer					winter				
	No. of	m-FC		MPN		No. of	m-FC		MPN	
	Samples	Mean	Dev	Mean	Dev	Samples	Mean	Dev	Mean	Dev
1	32	10	5	19	10	7	58	7	785*	20
2	32	7	6	18	8	7	52	10	1115*	9
3	29	21	8	83	13	7	51	4	1107	7
4	29	15	5	58	8	7	91	9	1705	108
5	32	5	9	20	19	7	5	13	30	42
6	32	5	8	10	20	6	4	11	16	13
cp1	32	4	6	9	9	6	56	8	904	11
cp2	32	3	6	4	7	7	7	11	13	14

* only 6 samples.

Table III Mean and deviation factors of faecal sheptococci per 100 ml in coastal water of central and southern Israel during three summers and two winters (1978 - 1980)

Sampling point No.	summer			winter		
	No. of samples	Mean	Dev	No. of samples	Mean	Dev
1	32	6	5	7	19	4
2	32	8	5	7	33	2
3	29	13	6	7	57	3
4	29	13	6	7	100	4
5	32	5	7	7	14	8
6	32	5	6	6	13	11
7	32	8	6	6	18	4
8	32	5	7	7	11	7

Table IV Distribution of MF counts of total coliforms in relation to MPN 95% confidence limits

Sampling point No.	No. of samples	% within limits	% above limits	% below limits
1	38	79	3	18
2	38	59	3	38
3	35	48	6	46
4	35	66	3	31
5	39	67	0	33
6	38	76	3	21
cp1	38	66	8	26
cp2	39	73	3	24
total	300	av. 66.7	av. 3.7	av. 29.6

Table V Distribution of MF counts of faecal coliforms in relation to MPN 95% confidence limits

Sampling point No.	No. of samples	% within limits	% above limits	% below limits
1	38	63	5	32
2	38	58	5	37
3	35	46	0	54
4	35	54	3	43
5	39	67	0	33
6	38	79	5	16
cp 1	38	71	5	24
cp 2	39	80	5	15
total	300	av. 64.7	av. 3.7	av. 31.7

Table VI Comparison of MF counts of faecal coliforms to MPN an a numerical basis

Sampling point No.	summer No. of Samples	% equal	% higer by MF	% higer by MPN	winter No. of Samples	% equal	% higer by MF	% higer by MPN
1	32	22	16	62	6	0	0	100
2	32	25	13	62	6	0	0	100
3	28	14	14	72	7	0	0	100
4	28	7	11	82	7	0	14	86
5	32	44	3	53	7	29	0	71
6	32	50	6	44	6	33	0	67
cp 1	32	59	6	35	6	0	0	100
cp 2	32	59	16	25	7	43	14	43
total	248	av 36	av 10	av 54	52	av 13	av 4	av 83

Table VII Correlation between the indicator organisms

Sampling point No.	summer TC : FC	TC : FS	FC : FS	winter TC : FC	TC: FS	FC : FS
1	0.922	0.075	0.054	0.867	0.656	0.918
2	0.669	0.019	0.039	0.879	0.613	0.911
3	0.898	0.684	0.804	0.993	0.594	0.581
4	0.975	0.399	0.672	0.971	0.860	0.901
5	0.890	0.827	0.968	0.995	0.983	0.964
6	0.976	0.616	0.628	0.999	0.938	0.935
7	0.986	0.287	0.237	0.944	0.612	0.768
8	0.983	0.575	0.692	0.964	0.986	0.912

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INTRODUCTION

Work along MED POL VII lines has been conducted in Lebanon for the past decade, however very few of the findings have been published. Among those published, we generally observe a lack of systematic approach, and a general absence of comparability basically due to different methodologies used.

Systematic sampling was initiated in September 1977 and has continued intermittently up to now. Occasional stopages were mainly due to the political situation in the country. In total there have been 11 sampling periods up to September 1979.

AREA(S) STUDIED

The area studied falls within the following co-ordinates: 35°38'E, 34°01'N (Maameltein-north of Beirut) and 35°28'E, 33°50'N (Khalde-south of Beirut).

Off the coast of Lebanon the major currents fall within the current pattern of the Eastern Mediterranean. The current in our area has a value which varies between 0.2 and 1.4 knots. Figure 1 gives all the important aspects of this current and is based on unpublished data supplied by T. Goedicke. Figure 2, which is also partially based on Goedicke's work, gives information about rivers and other major outfalls which fall within the general area of study.

A total of about 41 stations are sampled for bacteriological analyses. These are divided as follows: three control stations, seven under the influence of discharge points, and 31 regular.

MATERIAL AND METHODS

Initially, due to the lack of instrumentation and peripheral facilities at the Centre as well as local difficulties, the analyses were not carried out using the MF method. Following the receipt of some basic equipment and material it has been possible to apply the MF method, with the collaboration of a private public health laboratory. The micrological parameters studied were: total coliforms, faecal coliforms, faeacal streptococci, vibrio and clostridium.

The applied basic methodology is based on the Guidelines prepared by WHO/UNEP for this purpose.

Of the other relevant parameters, the following are regularly observed: air temperature, water temperature, salinity, PH, waves, wind, visual observation of floating pollutants and pollutants on the coast.

RESULTS AND THEIR INTERPRETATION

Based on the results obtained for our station during the sampling period, these are some of the very general observations:

pH range: 7.03 - 8.32

water temperature: 16°C - 29°C

salinity: 31.77- 41.50°/oo

These are the extreme values and are not indicative of the general mean. They compare favourably with past records. Water temperature was generally colder during 1977. Normally temperatures do not fall below 15°C.

As far as wind and drift are concerned, they tend to concentrate floating material on the coast particularly to the north of Beirut.

Table I gives some bacteriological results. They concern a selected few (three) stations representative of the area studied. They are also compared with three control stations and one station which is known to be influenced by a nearby sewer. It is apparent that all values are below international standards and are under the interim standard set by MED POL VII for the Mediterranean. It must be noted that almost all sampling operations were conducted after storms and heavy seas. Similarly, we wish to report that so far no vibrios have been isolated from our samples. Additional samples collected during 1979 and 1980 generally confirm the above-mentioned patterns.

Table II gives average values for all the sampling stations for the period September 1977 to September 1979. They are also indicative of the general pattern experienced from the results given in Table I. However, stations under the influence of direct discharge of liquid wastes should be excluded. They present relatively higher bacterial counts and practically no recreational activity takes place in their vicinity.

No pathogenic organism has been isolated, and at no time during our sampling were unacceptable bacterial counts observed.

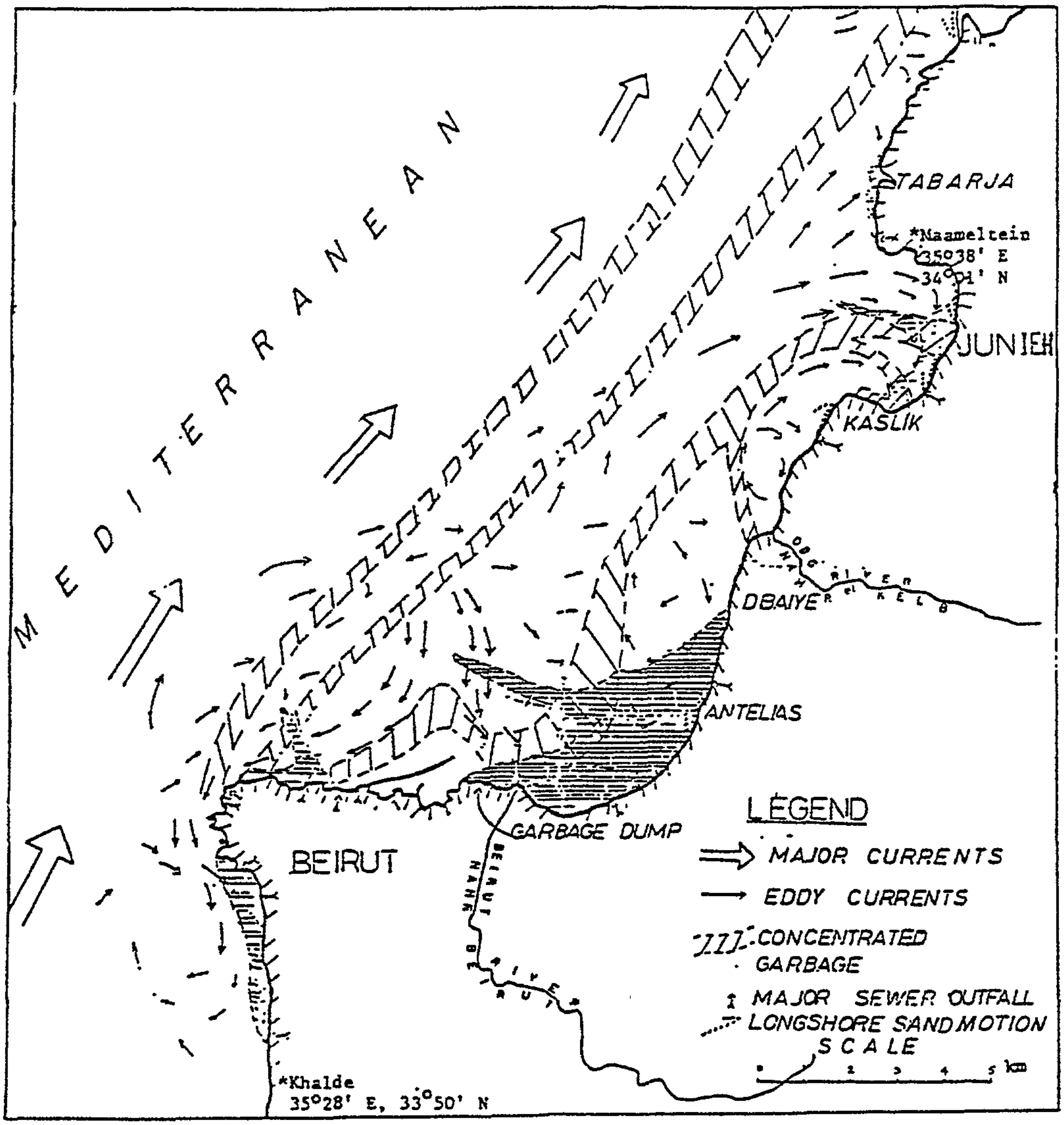


Fig. 1. Current pattern of the Eastern Mediterranean

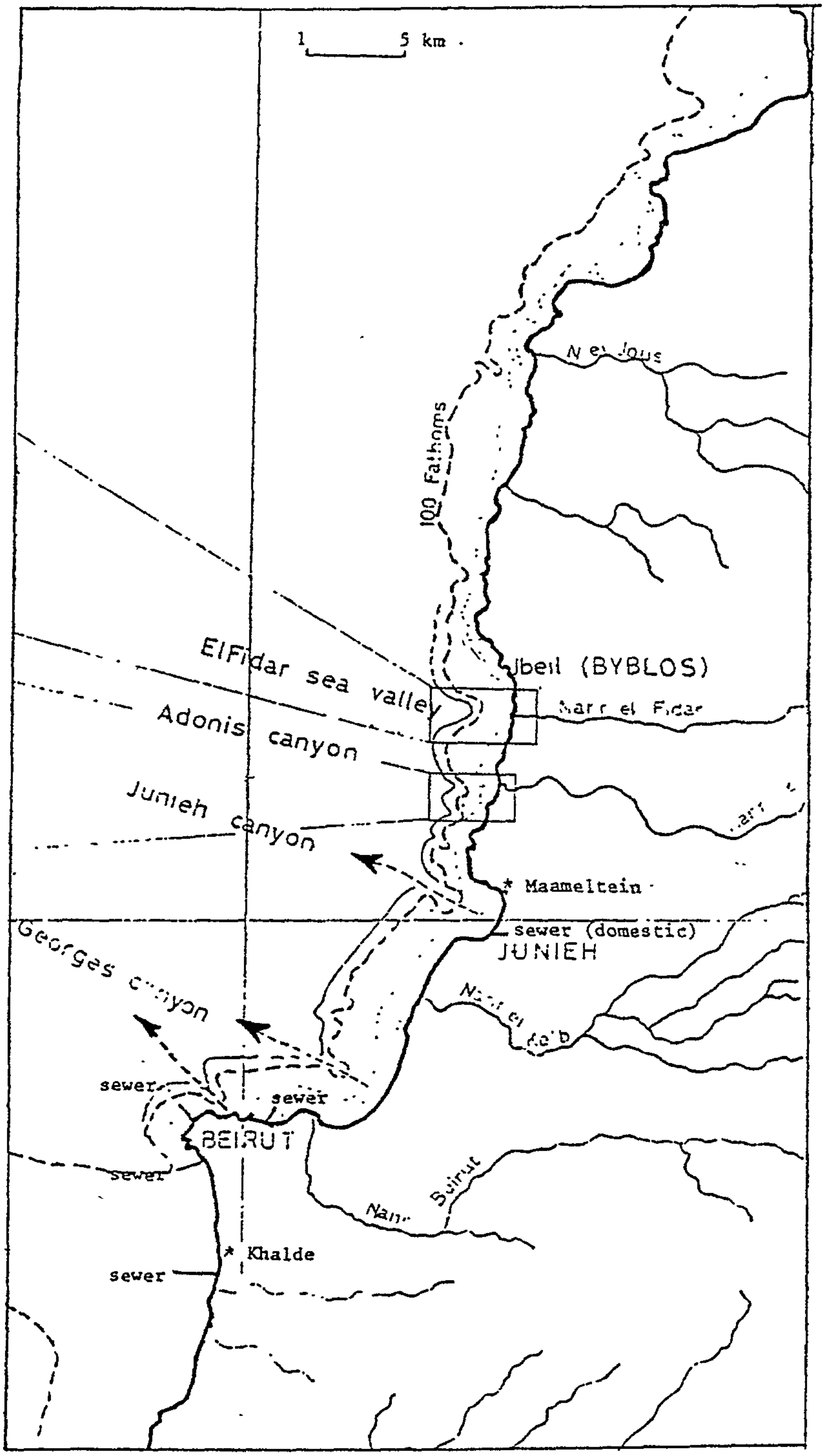


Fig. 2. Rivers and other major outfalls

Table 1

Station no.	Water temp. (°C)	Salinity (‰)	pH	*E. coli*	Total coli	*Strep. faecalis*
39	18.0 ± 5.0	38.41 ± 0.17	8.13 ± 1.70	20 ± 31	337 ± 113	I
40	20.7 ± 2.0	38.45 ± 0.27	8.14 ± 0.04	I	158 ± 90	37 ± 23
41	21.1 ± 2.6	39.08 ± 0.60	8.18 ± 1.79	12 ± 5	224 ± 106	57 ± 26
11	21.1 ± 1.5	39.21 ± 0.28	8.18 ± 0.02	21 ± 8	360 ± 78	38 ± 14
29	20.8 ± 2.0	39.45 ± 0.36	8.14 ± 1.50	3 ± 2	163 ± 50	52 ± 29
37	20.8 ± 2.0	38.42 ± 0.16	8.11 ± 0.28	69 ± 58	732 ± 311	40 ± 22
17	21.1 ± 1.48	35.37 ± 4.28	7.78 ± 0.12	50 ± 30	515 ± 235	67 ± 36

N.B.
- stations 39, 40 and 41 are control stations
- stations 11, 29 and 37 are normal stations
- station 17 is under the influence of a domestic sewer
- the standard error of each number is also given in the table
- I = insignificant
- all bacterial counts are per 100 ml of sea-water

TABLE II

point of sampling No.	Faecal Coliforms: number of sampling	period of sampling	average	variance	confidence limit	wind	current	remarks	Total Coliforms: number of sampling	period of sampling	average	variance	confidence limit	wind	current	remarks	Faecal streptococci: number of sampling	period of sampling	average	variance	confidence limit	wind	current	remarks
1	11	September 1977 - September 1979	0.71	1.6	±0.77				11	September 1977 - September 1979	1.5	1.2	±0.65				11	September 1977 - September 1979	0.9	1.2	±0.65			
2	11		1.1	1.3	±0.67				11		2.0	0.6	±0.48				11		1.3	1.6	0.75			
3	11		1.0	1.3	±0.68				11		1.9	1.0	±0.59				11		1.5	1.1	0.62			
4	11		0.5	1.1	±1.64				11		1.2	1.5	±0.71				11		1.3	1.8	0.81			
5	11		0.6	1.3	±0.68				11		1.5	1.9	±0.83				11		1.4	1.5	0.76			
6	11		0.5	1.7	±0.64				11		1.6	1.4	±0.69				11		1.1	1.8	0.80			
7	11		1.1	1.2	±0.65				11		1.8	1.5	±0.71				11		1.4	1.3	0.67			
8	11		0.9	1.1	±0.63				11		1.7	1.5	±0.71				11		1.3	1.8	0.80			
9	11		0.9	1.2	±0.66				11		2.1	1.3	±0.67				11		1.6	1.3	0.67			
10	11		0.9	1.4	±0.70				11		1.7	1.8	±0.81				11		1.2	1.7	0.77			
11	11		1.2	1.6	±0.75				11		2.2	1.0	±0.58				11		1.4	1.2	0.65			
12	11		1.5	1.7	±0.78				11		2.2	0.8	±0.55				11		1.6	1.1	0.62			
13	11		1.4	1.6	±0.75				11		2.2	0.8	±0.54				11		1.3	1.0	0.59			
14	11		0.9	1.6	±0.76				11		2.1	1.6	±0.74				11		1.2	1.9	0.83			

Variance s^2 of a sample of n determinations $s^2 = \frac{\Sigma_i (X_i - \bar{X})^2}{n-1}$ Confidence limit 95 % $\bar{X} \pm \frac{1.96 \times std.Dev.}{\sqrt{n}}$

TABLE II (cont.)

point of sampling No.	Faecal Coliforms: number of sampling	Faecal Coliforms: period of sampling	Faecal Coliforms: average	Faecal Coliforms: variance	Faecal Coliforms: confidence limit	Faecal Coliforms: wind	Faecal Coliforms: current	Faecal Coliforms: remarks	Total Coliforms: number of samplings	Total Coliforms: period of sampling	Total Coliforms: average	Total Coliforms: variance	Total Coliforms: confidence limit	Total Coliforms: wind	Total Coliforms: current	Total Coliforms: remarks	Faecal streptococci: number of sampling	Faecal streptococci: period of sampling	Faecal streptococci: average	Faecal streptococci: variance	Faecal streptococci: confidence limit	Faecal streptococci: wind	Faecal streptococci: current	Faecal streptococci: remarks
15	11	September 1977 - September 1979	1.3	1.9	±1.02				11	September 1977 - September 1979	2.3	0.4	±0.38				11	September 1977 -- September 1979	1.4	1.6	0.75			
16	11		1.6	1.9	±0.83				11		2.6	1.4	±0.71				11		1.5	1.6	0.75			
17	11		1.7	1.7	±0.77				11		2.8	0.5	±0.42				11		2.0	1.4	0.71			
18	11		1.0	1.3	±0.68				11		2.0	1.6	±0.77				11		2.0	1.4	0.71			
19	11		1.3	1.3	±0.69				11		2.1	0.8	±0.52				11		1.6	1.6	0.75			
20	11		1.4	1.4	±0.71				11		2.6	0.9	±0.57				11		1.7	1.5	0.74			
21	11		1.4	1.5	±0.73				11		2.0	1.8	±0.80				11		1.7	1.1	±0.64			
22	11		1.0	1.7	0.77				11		2.2	0.9	0.57				11		1.7	1.2	0.65			
23	11		0.8	1.7	0.77				11		2.3	1.0	0.59				11		1.6	1.4	0.71			
24	11		1.3	2.4	0.89				11		2.0	2.3	0.90				11		1.5	1.8	0.79			
25	9		1.2	1.6	0.85				9		1.9	0.9	0.61				9		1.5	1.6	0.82			
26	9		1.1	2.0	0.91				9		2.2	0.9	0.61				9		1.6	2.1	0.94			
27	9		1.2	2.3	0.98				9		2.2	0.9	0.60				9		1.7	1.9	0.90			
28	9		1.4	1.3	0.72				9		2.3	1.1	0.68				9		1.5	1.3	0.76			

TABLE II (cont.)

point of sampling No.	Faecal Coliforms								Total Coliforms								Faecal streptococci							
	number of sampling	period of sampling	average	variance	confidence limit	wind	current	remarks	number of sampling	period of sampling	average	variance	confidence limit	wind	current	remarks	number of sampling	period of sampling	average	variance	confidence limit	wind	current	remarks
29	9	September 1977 - September 1979	0.8	1.5	0.85				9	September 1977 - September 1979	2.2	1.1	0.69				9	September 1977 - September 1979	1.6	2.2	0.96			
30	9		1.4	1.8	0.85				9		2.5	1.1	0.70				9		1.9	1.2	0.71			
31	9		1.4	2.3	0.98				9		2.8	0.2	0.32				9		2.0	1.5	0.81			
32	9		1.5	2.3	0.98				9		2.5	1.8	0.88				9		2.0	1.4	0.78			
33	9		1.3	1.7	0.85				9		2.3	1.1	0.70				9		1.6	1.9	0.90			
34	9		1.6	2.1	0.98				9		3.0	0.4	0.40				9		2.1	1.8	0.88			
35	8		1.2	1.9	0.98				8		2.8	0.3	0.41				8		1.4	2.0	0.99			
36	9		1.3	1.9	0.91				9		2.3	1.3	0.74				9		1.7	1.7	0.86			
37	8		1.6	1.6	0.91				8		2.9	0.3	0.40				8		1.7	1.5	0.87			
38	8		1.5	1.4	0.84				8		2.7	0.5	0.48				8		1.9	1.1	0.74			
39	9		0.8	1.6	0.85				9		1.9	1.4	0.78				9		0.3	0.5	0.45			
40	9		0.4	1.2	0.72				9		0.8	1.2	0.71				9		0.8	0.7	0.56			
41	11		0.7	0.8	0.53				11		1.3	1.7	0.76				11		0.9	0.9	0.55			

Centre de Recherche : Centre Scientifique de Monaco
MONTE CARLO
Principauté de Monaco

Chercheur Principal: R. VAISSIERE

INTRODUCTION

Le Laboratoire de Microbiologie et d'Etudes des Pollution Marines a été créé en 1966. Il se compose de scientifiques de formation différente qui se sont spécialisés dans la surveillance des polluants en milieu marin et dans l'étude de leurs effets sur les écosystèmes côtiers.

Les prélèvements d'eau de mer, comme la mesure des composants physiques, chimiques et biologiques de ce milieu, sont devenus des activités de routine du laboratoire qui a, en outre, étudié les conditions hydrologiques de la région et la diffusion des eaux polluées par utilisation des traceurs (Rhodamine, photographies aériennes). Une méthode automatique d'analyses des détergents anioniques a également été mise au point.

ZONE(S) ETUDIEE(S)

Depuis 1967, et par conséquent pendant les trois années du projet MED POL VII, la totalité des eaux côtières de la Principauté est soumise à surveillance. Trois kilomètres de côte à vocation balnéaire ou portuaire sont contrôlés à partir de l'analyse d'échantillons d'eau de mer prélevés régulièrement tout au long de l'année en douze stations fixes (Fig. 1).

MATERIEL ET METHODES

Les méthodes d'analyse utilisées pour cette surveillance sont identiques à celles décrites par l'OMS, les analyses bactériologiques étant conduites par filtration sur membrane. La filtration est effectuée à bord du bateau immédiatement après le prélèvement.

Le programme d'analyses obligatoire est complété par les paramètres facultatifs suivants : nitrites, nitrates, phosphates et salmonelles.

RESULTATS ET LEUR INTERPRETATION

Les eaux usées de Monaco et des agglomérations voisines sont rassemblées depuis juillet 1971 dans un collecteur principal qui débouche en un point situé provisoirement à 450 m de la côte et 47 m de profondeur. Quatre petites rivières traversent la Principauté. Deux d'entre-elles débouchent directement en mer, l'une dans le coin nord du port, l'autre à la frontière est. Les deux autres ont été canalisées et se déversent dans le réseau d'assainissement. Afin de décharger ce réseau des crues passagères, un déversoir d'orage a été placé à proximité du raccordement de ces cours d'eau avec le réseau, il débouche à 30 m de profondeur à 500 m de la côte.

Les conditions hydrologiques diffèrent suivant que l'on s'intéresse aux masses d'eaux superficielles ou de fond.

En surface règne un régime complexe résultant des effets de trois composants essentiels :

(i) la topographie côtière : son effet sur la circulation générale des eaux de la mer Ligure conduit à des courants anticycloniques côtiers;

(ii) le vent dont l'action devient prépondérante lorsque celui-ci est bien établi;

(iii) les petits accidents côtiers : pointes digues, terre-plein, entrée de Port qui peuvent protéger certaines zones, ou provoquer des dépressions et conduire ainsi à l'accumulation de polluants et à des mouvements d'eau particuliers d'ampleur limitée.

Au fond, le courant montre une tendance à se déplacer en sens inverse de la couche d'eau superficielle soumise à l'action du vent mais n'atteint jamais l'orientation opposée comme cela est nettement observé dans les circulations océaniques. Un décalage plus ou moins important existe entre ces deux directions; il résulte de la topographie du fond et de la côte.

Enfin, les eaux marines de Monaco sont caractérisées entre la fin avril et la fin octobre par une thermocline saisonnière. L'isotherme de valeur la plus élevée qui la délimite se situe au-dessus de 50 mètres de profondeur alors que l'isotherme 15°C peut atteindre le niveau 75 mètres.

Les quatre tableaux saisonniers, (Fig. 2, 3, 4 et 5), rassemblent de façon synthétique les résultats obtenus durant le projet MED POL VII.

Afin d'augmenter le nombre d'observations, toutes les analyses effectuées entre 1975 et 1978 (soit environ 7100) ont été prises en compte dans l'élaboration de ce tableau.

Les résultats ont été séparés en sept groupes répondant aux conditions de vent le jour du prélèvement et ordonnés en classes définies suivant une croissance logarithmique :

Classes	Valeurs	Classes	Valeurs
1	<2	5	55 à 167
2	2 à 6	6	167 à 500
3	6 à 19	7	>500
4	19 à 55		

Les tableaux regroupent la fréquence des différentes classes en fonction de la station et de la direction du vent.

DISCUSSION DES RESULTATS

On constate que les résultats acquis au cours du projet MED POL VII ne diffèrent pas de ceux obtenus depuis juillet 1972 (date de l'immersion du collecteur principal).

L'analyse de six ans de contrôle de la qualité des eaux marines de Monaco (cf. Boisson, M., Vaissière, R., Schommers, E., Séméria, J.) a montré que l'immersion du collecteur principal a créé dans les eaux superficielles un cycle annuel des polluants. Ce cycle se compose d'une phase hivernale (octobre à avril) et d'une phase estivale (mai à septembre).

En hiver, la concentration des polluants en surface s'explique par les conditions hydrologiques du jour du prélèvement, l'éloignement du point de rejet ayant l'effet prépondérant par rapport au gradient thermique.

En été, l'amélioration de la qualité des eaux côtières provient principalement de l'existence de la thermocline saisonnière au-dessus de l'orifice du collecteur principal. Cependant des variations accidentelles des conditions météorologiques et les modifications thermiques des masses d'eau qui en résultent, peuvent conduire à des concentrations de polluants en surface selon un schéma analogue à celui de la phase hivernale.

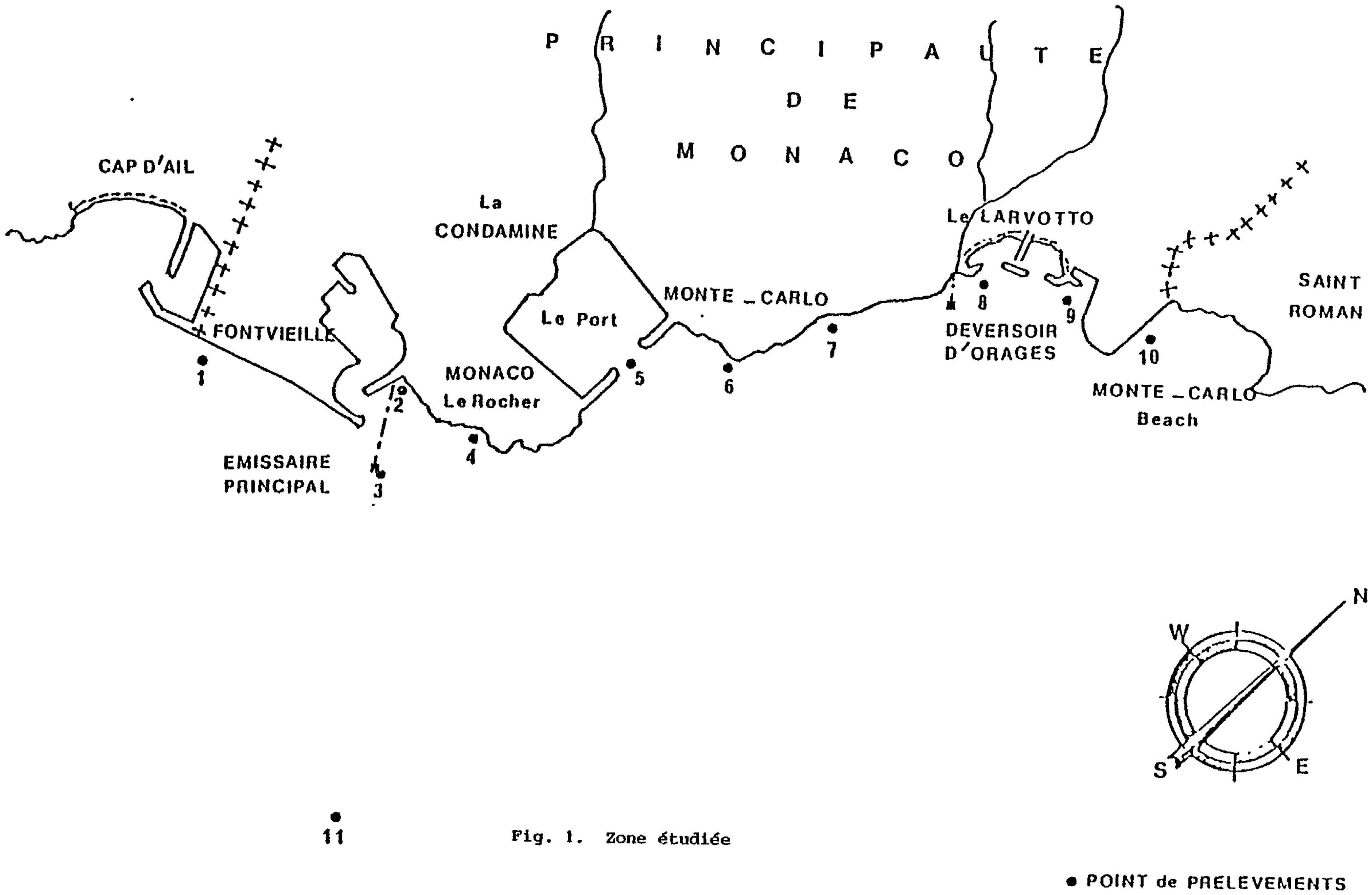


Fig. 1. Zone étudiée

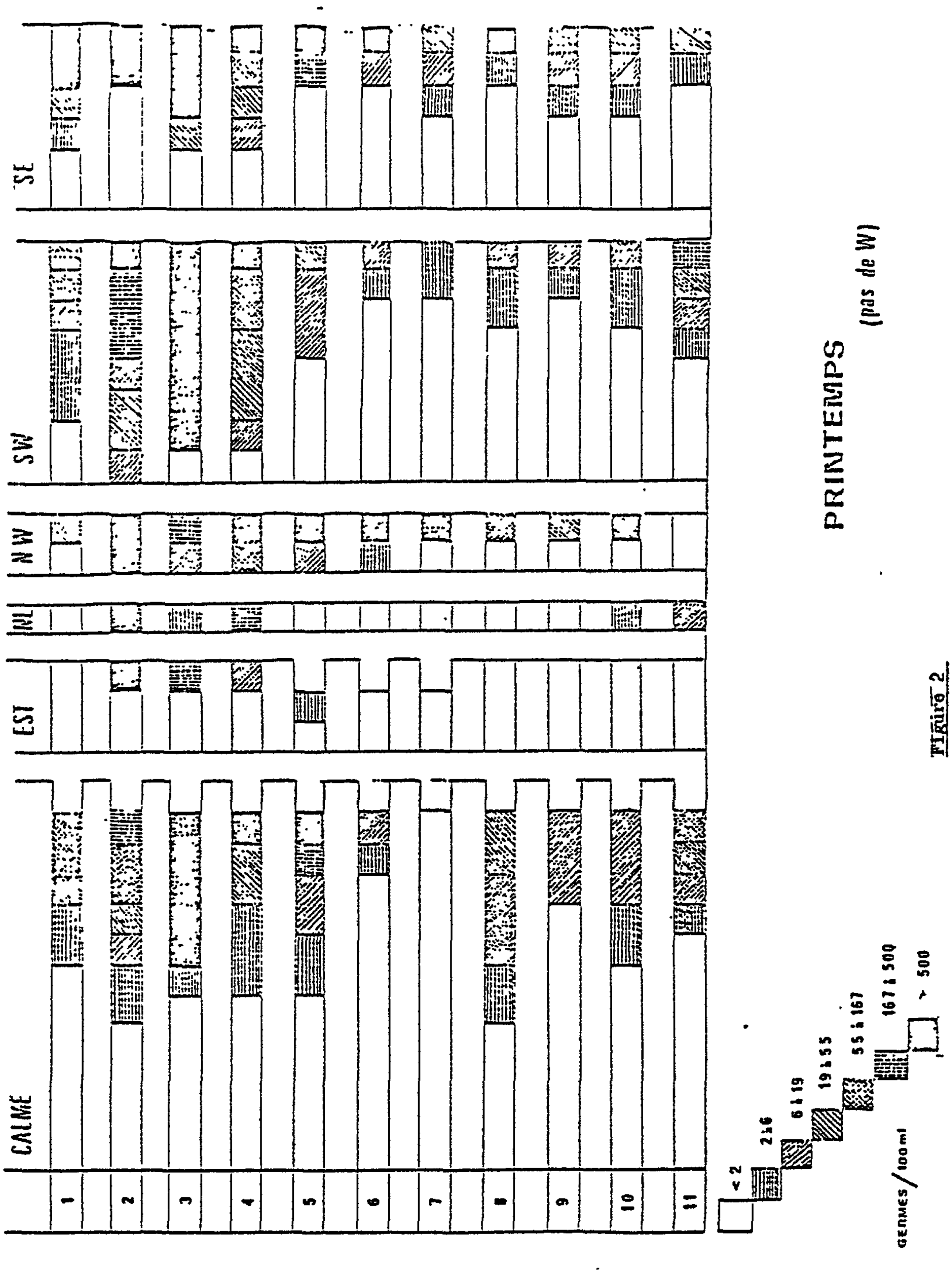
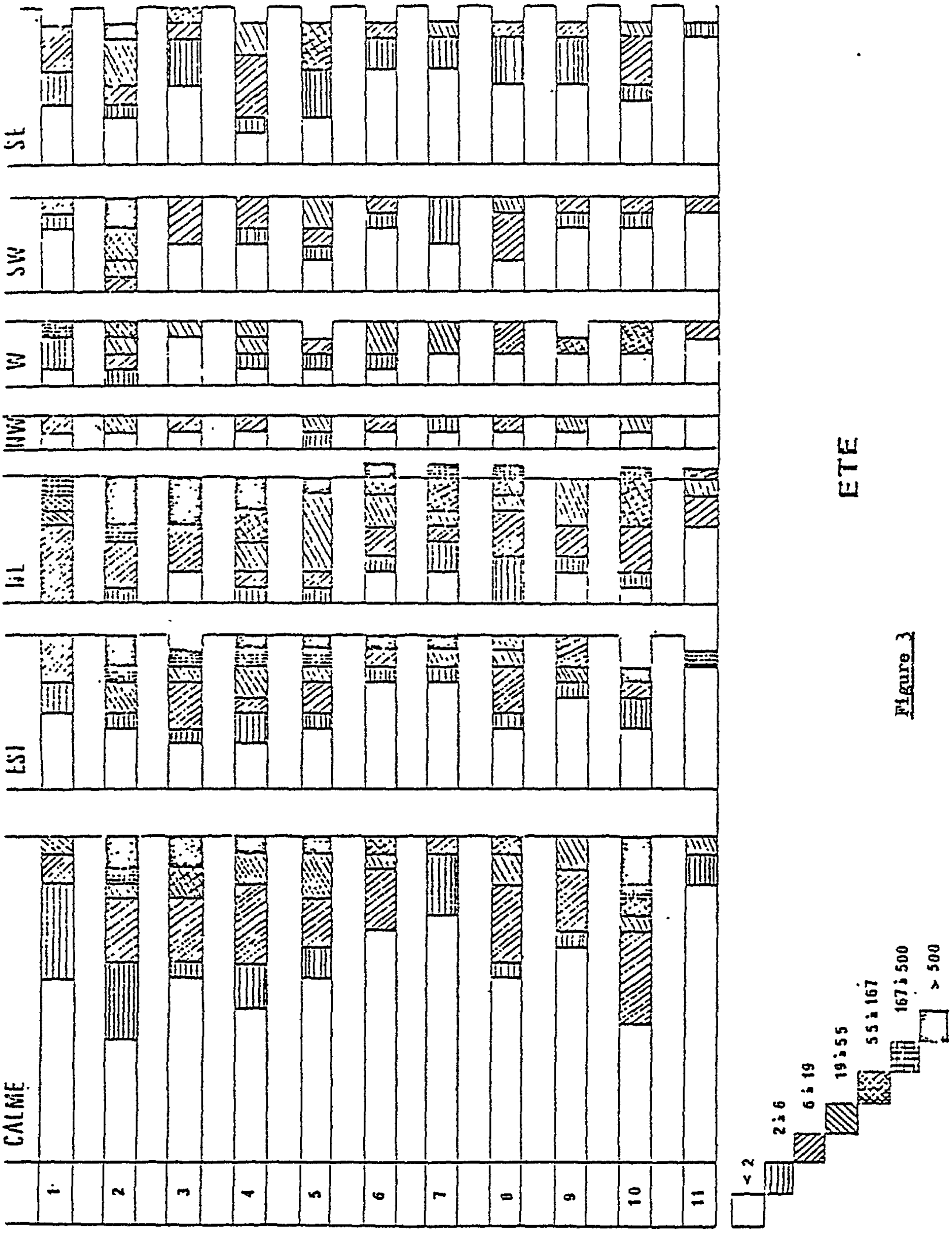

CALME
EST
NL
NW
SW
SE
1
2
3
4
5
6
7
8
9
10
11
< 2
2 à 6
6 à 19
19 à 55
55 à 167
167 à 500
> 500
GERMES/100ml
PRINTEMPS
(pas de W)

Figure 2


CALME
EST
NE
NW
W
SW
SE
1
2
3
4
5
6
7
8
9
10
11
< 2
2 à 6
6 à 19
19 à 55
55 à 167
167 à 500
> 500

ETE

Figure 3

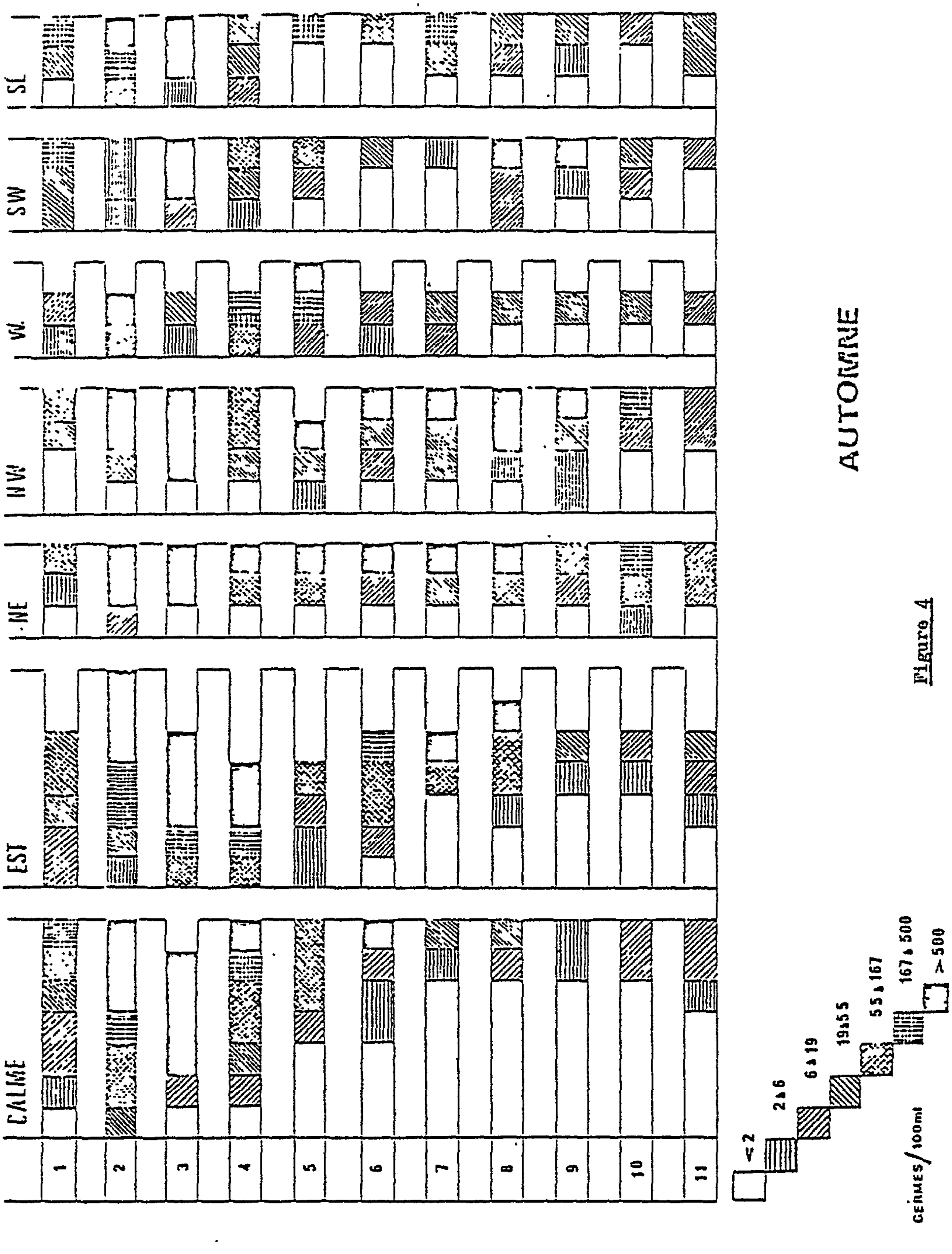
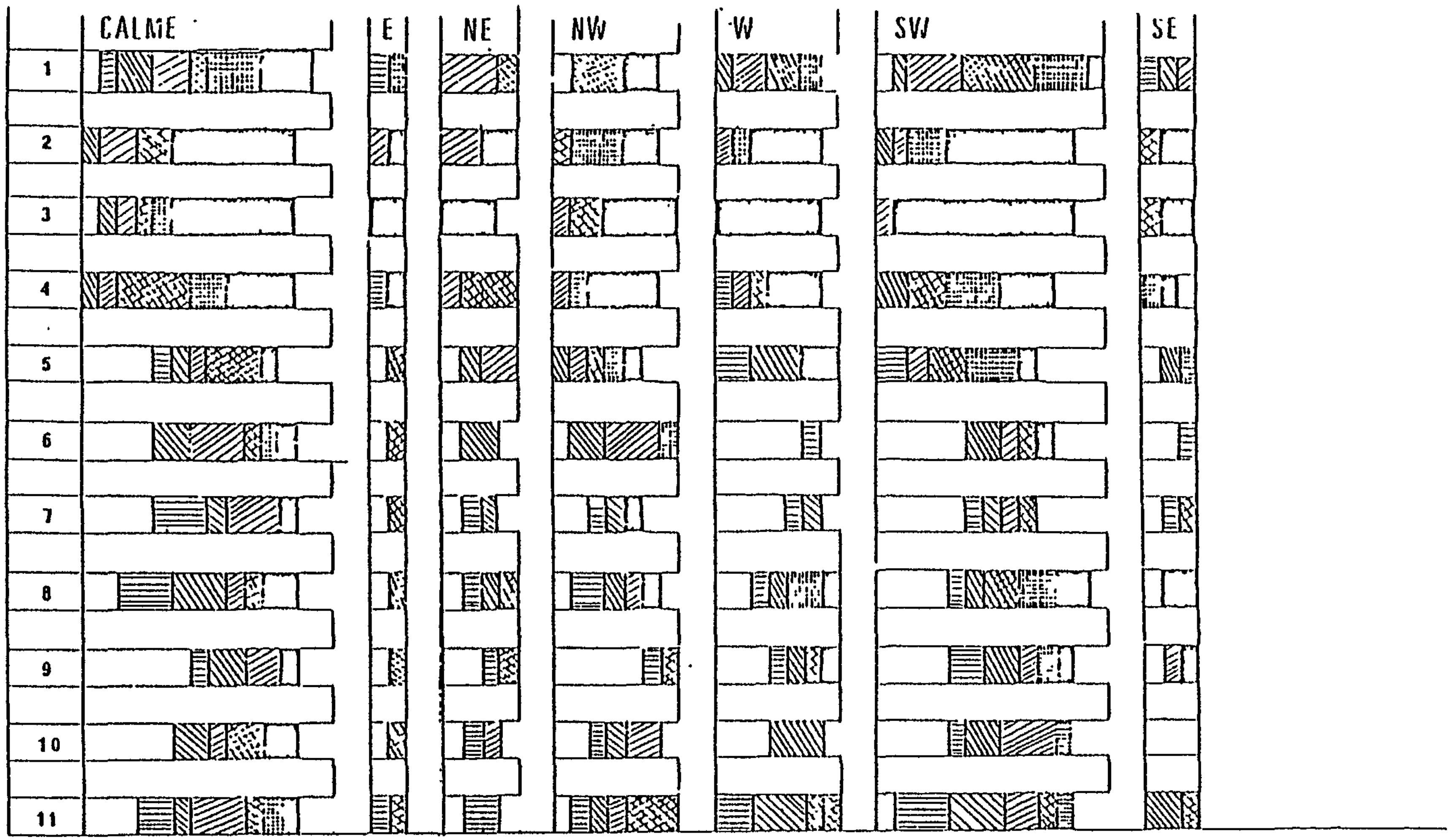
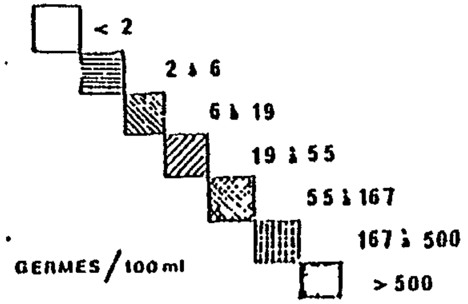

CALME
EST
NE
NW
W
SW
SE
1
2
3
4
5
6
7
8
9
10
11
< 2
2 à 6
6 à 19
19 à 55
55 à 167
167 à 500
> 500
GERMES/100ml
AUTOMNE

Figure 4





HIVER

Figure 5

Research Centre: Public Health Laboratory
Department of Health
VALLETTA
Malta

Principal Investigator: L.J. SPITERI

INTRODUCTION

Health Inspectors routinely submit samples of sea-water to the Health Department Laboratory. Recreational waters, especially those liable to sewage contamination are examined at least weekly during the bathing season. The MPN. method is usually used as reference, and bathing is prohibited when counts constantly exceed the figure of 1000 E. coli per 100 ml.

Special attention has been paid to samples of sea-water liable to sewage contamination. A search for the presence of salmonellae has been carried out with a view to:

(a) eradicating typhoid; and

(b) studying the incidence of salmonellosis in Malta, in relation to sea pollution.

AREA(S) STUDIED

The attached map (Figure 1) shows the sampling sites, which are as follows:

(a) Station 1: San Lucian (reference area - clean)

(b) Station 2: Rinella (reference area near sewage outfall)

Since August 1978 a submarine outfall has been installed at Wied Ghammieq, which is the island's main sewage outfall. The area sampled is liable to this sewage contamination when the prevalent wind is N.E.

(c) Stations: 3, 4, 5 and 6: Ghadira Bay

After heavy rainfall in winter, overflow of an adjacent sewer is possible with contamination with faecal organisms.

Length of coastline: 2 km.

Description of Ghadira Bay: No waste-water outlets. Occasional overflow of public sewer after heavy storms may contaminate bay. No solid waste dumping sites onshores or offshore. Prevailing local current - north - easterly. Area is sandy. Meteorological data are those applicable to Malta as a whole. Rocky hills on either side. Some cultivated patches. Various types of soil, mainly in isolated pockets. Storm water enters coastal area during N. E. wind periods.

Main recreational season June-September. The two hotels near the beach area, Mellieha Bay hotel and the Blue Lake snack bar, are joined to the main sewer system (Santa Maria Estate going to Cumnija outfalls). This sewer may overflow and contaminate the bay after heavy rainfall in winter.

The three restaurants adjoining this beach are not connected to the sewer and have a cesspit which is regularly serviced in summer. A small public convenience near there is served also by a cesspit.

The possibility of local pollution from the three restaurants exists irrespective of prevailing winds. Samples from these sites are collected regularly during summer.

MATERIALS AND METHODS

The parameters which have been measured are:

- Surface temperature
- Salinity
- Visual appearance of beach
- State of waves
- Wind direction
- Bacteriological tests include: total coliforms
  faecal coliforms
  faecal streptococci

The bacteriological indicators were measured by the MF method and the MPN method carried out in parallel.

The following nutrients were used for the MF method:

For total coliforms: Teepol broth (OXOID, MM 369) incubated for 24 hours at 35°C.

For faecal coliforms: m-FC broth incubated for 24 hours at 44.5°C. Blue colonies are confirmed by indole and MacConkey medium at 44.5°C, and

For faecal streptococci: m-enterococcus agar incubated for 48 hours at 35°C.

Thirteen beaches in Malta and three beaches in Gozo cover practically the whole bathing area used during the summer period (see Tables IV, V, VI, VIII and IX.

RESULTS AND THEIR INTERPRETATION

Figures obtained during 1978 by MF were tabulated and mean values, standard deviation and distribution were obtained according to seasonal variations as shown in Tables I, II and III.

The number of coliforms in samples is much higher than that of enterococci and the number of faecal coliforms is between the above two.

Only St. Paul's Bay area fails the accepted interim microbiological criteria (100 E. coli/100 ml and no more than 10%, of at least ten consecutive samples, should exceed 1000 E. coli/100 ml).

On the whole higher counts are registered by the MPN method than by the MF.

However St Paul's Bay area now has a new sewage system and the unsatisfory results experienced in 1978 were eliminated in 1979. (Tables IV, V and VI).

The importance of regular sampling from Ghadira during summer in view of possible local contamination, can also be seen from the results appearing in Tables VI, VIII and IX.

The medians and deviation factors for the mandatory parameters (total coliforms, faecal coliforms and faecal streptococci) for the year 1978 appear in Table VII. Similar data for the period January 1979 to September 1980 are given in Tables X, XI, XII and XIII. Faecal streptococci persist more than other indicators and may indicate a remote sewage pollution.

Tables XIV, XV, and XVI give the results for the period October 1980 to April 1981.

The results obtained clearly show the importance of wave heights, currents and contamination from sewage overflow, especially in winter after rainfall.

On the whole, higher counts are registered by the MPN method than by the MF.

DISCUSSION OF RESULTS

Local legislation against the selling of shellfish as well as the prohibition of bathing in polluted areas have helped against the incidence of intestinal diseases in Malta. The incidence of typhoid declined by 75% during 1978.

Work will continue and monitoring along the above accepted lines will ensure that bathing areas in Malta will be clean according to the accepted interim microbiological quality criteria.

In 1979 we had only three cases of typhoid fever in Malta. Only one was traced to seafood. The other two cases were attributed to raw vegetables contaminated with sewage.

In 1980 so far no cases of typhoid fever have been detected.

No less than fifteen cases of salmonellosis occurring in summer were studied in detail. No case was related to sea pollution or to ingestion of contaminated shellfish.

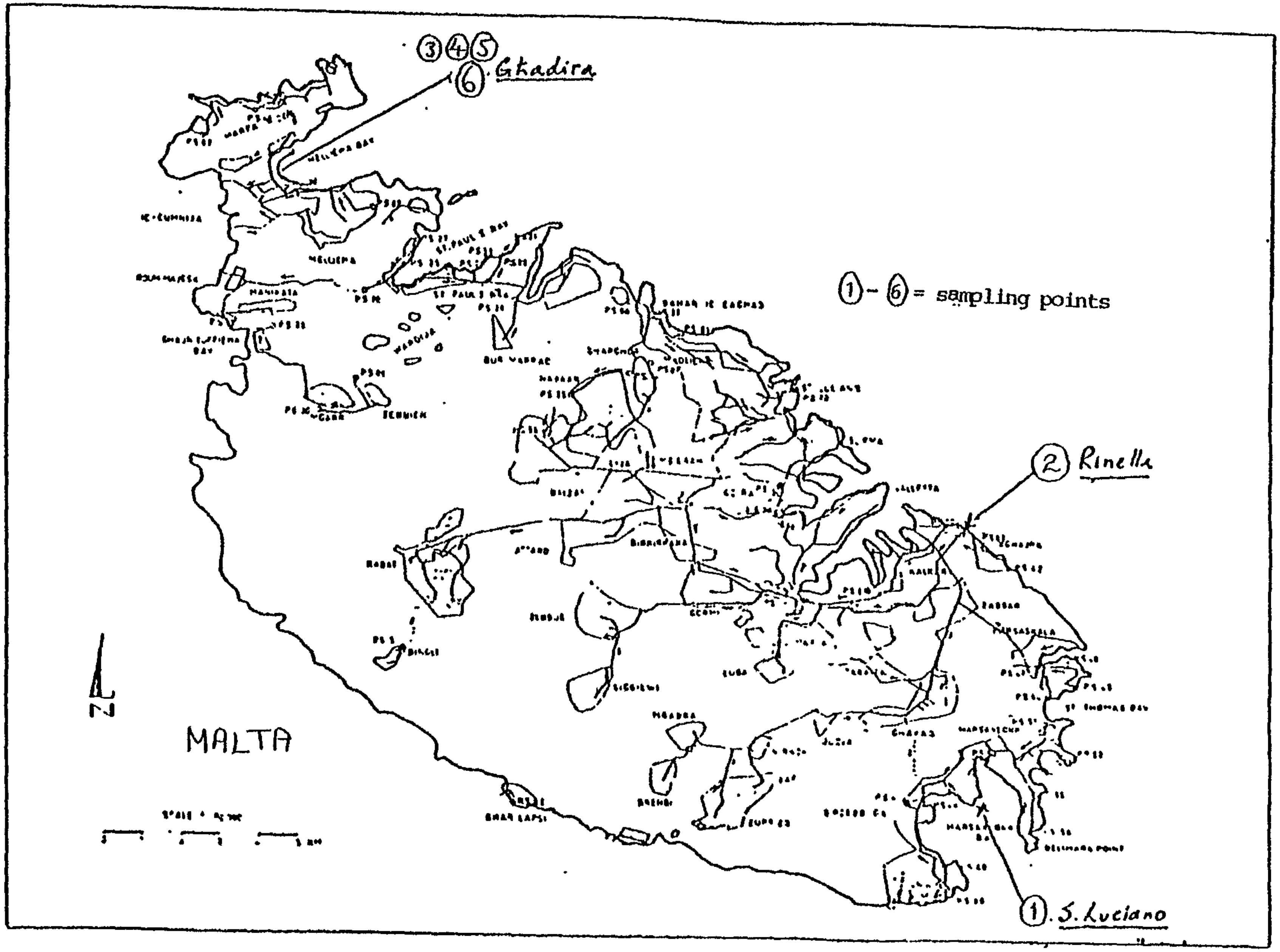


Fig. 1. Sampling sites

Table I: Total coliforms - No./100 ml; sampling point - Mellieha Bay

Sample values	Point 3	Point 4	Point 5	Point 6	All points
Date (1978):					
7.2	4	42	0	0	11.50
27.2	0	0	6	4	2.50
7.3	57	4	0	2	15.75
23.5	0	75	60	3	34.50
5.7	0	0	40	2400	610
25.7	16	96	10	26	37
8.8	40	57	1320	2400	954.25
12.9	6	266	48	176	124
Mean values					
Summer	15.50	104.75	354.5	1250.50	431.31
Others	15.25	30.25	16.5	2.25	16.06
Total	15.38	67.50	185.5	626.38	223.69
Standard deviations					
Summer	17.62	114.50	643.87	1328.74	430.24
Others	27.90	53.33	29.14	1.71	13.48
Total	21.60	87.97	459.00	1096.29	358.71

Distributions - P.C.	No.	%	No.	%	No.	%	No.	%	No.	%
0 - 100	8	100	7	87.5	7	87.5	5	62.5	5	62.5
101 - 1000	0	0	1	12.5	1	12.5	1	12.5	3	37.5
> 1000	0	0	0	0	0	0	2	25.0	0	0

Table II.

Faecal coliforms - No./100 ml; sampling point - Mellieha Bay

Sample values	Point 3	Point 4	Point 5	Point 6	All points
Date (1978):					
7.2	2	42	2	0	11.5
27.2	0	0	6	0	1.5
7.3	34	4	0	2	10.0
23.5	0	75	9	3	21.75
5.7	0	0	3	47	12.50
25.7	4	6	5	7	5.50
8.8	5	57	516	720	324.50
12.9	2	146	17	60	56.25
Mean values					
Summer	2.75	52.25	135.25	208.50	99.69
Others	9	30.25	4.25	1.25	11.19
Total	5.88	41.25	69.75	104.88	55.44
Standard deviations					
Summer	2.22	67.53	253.91	341.59	151.55
Others	16.69	35.33	4.03	1.50	8.31
Total	11.52	51.26	180.39	249.65	110.05

Distributions - P.C.	No.	%	No.	%	No.	%	No.	%	No.	%
0 - 100	8	100	7	87.5	7	87.5	7	87.5	7	87.5
101 - 1000	0	0	1	12.5	1	12.5	1	12.5	1	12.5
> 1000	0	0	0	0	0	0	0	0	0	0

Table III.

Faecal streptococci - No./100 ml; sampling point - Mellieha Bay

Sample values	Point 3		Point 4		Point 5		Point 6		All points	
Date (1978):										
7.2	1		104		1		0		26.50	
27.2	1		0		13		2		4	
7.3	0		0		1		1		0.5	
23.5	0		24		22		1		11.75	
5.7	1		0		3		7		2.75	
25.7	10		20		12		5		11.75	
3.8	5		70		118		48		60.25	
12.9	18		13		8		38		19.25	
Mean values										
Summer	8.5		25.75		35.25		24.5		23.50	
Others	0.5		32.0		9.25		1.0		10.69	
Total	4.5		28.88		22.25		12.75		17.10	
Standard deviations										
Summer	7.33		30.64		55.29		21.76		25.41	
Others	0.58		49.32		10.21		0.82		11.54	
Total	6.44		38.16		39.34		19.00		19.51	
Distributions - P.C.	No.	%	No.	%	No.	%	No.	%	No.	%
0 - 100	8	100	7	87.5	7	87.5	8	100	8	100
101 - 1000	0	0	1	12.5	1	12.5	0	0	0	0
> 1000	0	0	0	0	0	0	0	0	0	0

Table IV.

Sea-water - bacteriological data MPN (1 January - 30 September 1978)

Area	E. coli 0-100 in 100 ml	E. coli 101 - 1000	E. coli in excess of 1000/100 ml
Malta			
Armier	17	6	3
Ghadira	94	11	1
St Paul's Bay Area	402	119	129
Sliema Area	450	11	2
Valletta	123		
Xghira	58	2	
Delimara	36	1	
M'Xlokk Area	66		
Wied iz-Zurrieq	26	1	
Ghar Lapsi	15		
St Thomas Bay	39		
Ghajn Tuffieha	43		
M'Scala	90	1	1
Salina Bay	41		
Bahar ic-Caghaq	22		
B'Bugia Area	221	7	3
Gozo			
M'Forn	37		
Xlendi	36		
Ramla	17		

TABLE V

SEA WATER - BACTERIOLOGICAL DATA M.P.N.

(1st January 1979 - 30th April 1979)

AREA	E-coli 0-100/100ml	E-coli 101-1000/100ml	E-coli in excess of 1000/100ml
Malta			
Armier	1		
Ghadira	10	1	
St. Paul's Bay Area	40		
Xghira	22	1	1
Delimara	3		
M'Xlokk Area	8	1	
Wied iz-Zurrieq	7		
Ghar Lapsi	4		
St. Thomas Bay	11		
Ghajn Tuffieha	3		
M'Scala	23	4	
Salina Bay	2		
Bahar ic-Caghaq	1		
Gozo			
M'Forn	3		
Xlendi	4		
Ramla	1		

TABLE VI

SEA WATER - BACTERIOLOGICAL DATA M.P.N.

(1st May 1979 - 15th September 1979)

AREA	E-coli 0-100/100ml	E-coli 101-1000/100ml	E-coli in excess of 1000/100ml
Malta			
Armier	9		
Ghadira	29	4	2
St. Paul's Bay Area	48	6	2
Xghira	43		
Delimara	7		
M'Xlokk Area	17	1	
Wied iz-Zurrieq	21		
Ghar Lapsi	7		
St. Thomas Bay	28		
Ghajn Tuffieha	12	1	
M'Scala	50	1	4
Salina Bay	9		
Bahar ic-Caghaq	1		
Gozo			
M'Forn	8		
Xlendi	6		
Ramla	3		

TABLE VII

Sampling medians and deviations for each sampling point

Sampling point numbers	Total Coliforms				E. Coli				F. Strept			
	Winter		Summer		Winter		Summer		Winter		Summer	
	Median	Deviation	Median	Deviation	Median	Deviation	Median	Deviation	Median	Deviation	Median	Deviation
3	12.43	43.83	2.13	2.96	7.05	29.43	1.00	1.00	23.27	2.05	8.85	7.04
4	41.60	8.86	5.48	10.62	9.33	6.92	5.48	10.62	31.46	2.41	29.57	5.44
5	31.75	21.13	1.50	2.24	1.26	1.49	1.50	2.24	26.13	3.77	183.07	6.78
6	30.13	19.11	35.79	4.34	29.04	18.49	35.79	4.34	22.38	2.46	81.75	4.88

TABLE VIII.

SEA WATER - BACTERIOLOGICAL DATA M.P.N.

1 October 1979 - 31 May 1980

MALTA	E.coli 0-100/100 ml	E.coli 101-1000/100 ml	E.coli in excess of 1000/100 ml
Armier	2	-	-
St. Paul's Bay area	24	3	-
Ghadira	26	10	2
Xghira	41	-	2
Delimara	3	-	-
M'Xlokk area	20	-	-
Wied iz-Zurrieq	17	-	-
Ghar Lapsi	4	-	-
St. Thomas Bay	4	-	-
Ghajn Tuffieha	5	-	-
M'Scala	53	-	-
Bahar ic-Caghaq	5	-	-
B'Bugia area	24	-	-
Salina Bay	8	-	-
GOZO			
M'Forn	7	-	-
Xlendi	6	-	-
Ramla	1	-	-

TABLE IX.

SEA WATER - BACTERIOLOGICAL DATA M.P.N.

1 June 1980 - 30 September 1980

MALTA	E.coli 0-100/100 ml	E.coli 101-1000/100 ml	E.coli in excess of 1000/100 ml
Armier	23	-	-
St. Paul's Bay area	136	4	-
Ghadira	104	4	-
Xghira	32	-	-
Delimara	11	-	-
M'Xlokk area	26	1	-
Wied iz-Zurrieq	20	-	-
Ghar Lapsi	2	-	-
St. Thomas Bay	5	-	-
Ghajn Tuffieha	4	-	-
M'Scala	51	-	-
Bahar ic-Caghaq	8	-	-
B'Bugia area	21	-	-
Salina Bay	4	-	-
GOZO			
M'Forn	53	1	-
Xlendi	48	-	-
Ramla	7	-	-

Table x. Total Coliforms - No/100 ml; Sampling Point - Mellieha Bay.

Sample Values.

Date	Point 3	Point 4	Point 5	Point 6	All Points
Summer					
June '79	2	150	5	6	40.75
July '79	10	0	0	152	40.5
August '79	0	0	0	90	22.5
September '79	0	6	0	20	6.5
July '80	3600	1	0	0	900.25
August '80	106	84	400	20	152.5
September '80	400	588.25/ 1300	10	100	452.5
Winter					
January '79	960	300	320	180	440
February '79	66	14	98	7	46.25
March '79	0	4	0	0	1.0
April '79	100	300	8	800	302
May '79	78	38	32	0	37
October '79	8	8	50	74	35
November '79	3	4	6	0	3.25
December '79	0	30	100	0	32.5
January '80	530	20	30	70	162.5
February '80	2180	80	100	2000	1090
March '80	3780	10	400	0	1047.5
April '80	6	0	0	0	1.5
May '80	3110	80	27	0	804.25
Mean Values					
Summer	588.29	220.14	59.29	54.43	230.79
Winter	832.38	68.31	90.08	240.85	307.90
Total	746.95	121.45	79.30	175.95	280.91
Standard Deviations					
Summer	1335.96	479.64	150.29	58.50	334.04
Winter	1320.63	106.18	126.42	572.2	409.95
Total	1295.92	292.05	132.31	464.85	377.89

Distributions - P.C.	No.	%	No.	%	No.	%	No.	%	No.	%
0 - 100	12	60	16	80	17	85	16	80	11	55
101 - 1000	4	20	3	15	3	15	3	15	7	35
> 1000	4	20	1	5	0	0	1	5	2	10

Table XI. Faecal Coliforms - No/100 ml. Sampling Point: Mellieha Bay.

Date	Point 3		Point 4		Point 5		Point 6		All Points	
Sample Values.										
Summer										
June '79	0		15		5		6		40.25	
July '79	0		0		0		152		38	
August '79	0		0		0		90		22.5	
September '79	0		6		0		20		6.5	
July '80	164		1		0		0		41.25	
August '80	53		42		4		5		26	
September '80	0		840		2		0		210.50	
Winter										
January '79	350		29		2		161		135.5	
February '79	40		2		1		7		12.5	
March '79	0		0		0		0		0	
April '79	3		2		0		35		10	
May '79	3		9		10		0		5.5	
October '79	0		0		50		0		12.5	
November '79	3		0		4		0		1.75	
December '79	0		0		8		0		2	
January '80	15		2		0		0		4.5	
February '80	672		0		0		04		169	
March '80	3		1		0		0		1	
April '80	6		0		0		0		1.5	
May '80	1080		45		27		0		288	
Mean Values										
Summer	31.0		129.14		1.57		39.0		55	
Winter	167.38		6.92		7.85		15.92		49.52	
Total	119.65		49.70		5.65		24.0		51.44	
Standard Deviations										
Summer	61.88		313.82		2.15		59.19		69.67	
Winter	338.89		13.96		14.76		44.64		90.58	
Total	279.64		186.55		12.28		49.92		81.99	
Distributions - P.C.	No.	%	No.	%	No.	%	No.	%	No.	%
0 - 100	16	80	19	95	20	100	18	90	16	80
101 - 1000	3	15	1	5	0	0	2	10	4	20
> 1000	1	5	0	0	0	0	0	0	0	0

Table XII. Faecal Streptocci - No/100 mls. Sampling Point: Mellieha Bay.

Sample Values

Date	Point 3	Point 4	Point 5	Point 6	All Points
Summer					
June '79	1	18	360	13	98
July '79	4	4	13	90	27.75
August '79	96	47	>1200	62	351.25
September '79	16	226	200	616	264.5
July '80	0	0	0	20	5.0
August '80	3	11	23	9	11.50
September '80	42	7	1	8	14.50
Winter					
January '79	50	25	10	10	23.75
February '79	189	10	112	66	94.25
March '79	12	15	15	19	15.25
April '79	17	6	3	38	16.00
May '79	1000	23	26	52	275.25
October '79	26	14	368	90	124.5
November '79	33	20	43	27	30.75
December '79	2	1	390	0	98.25
January '80	1	5	17	5	7.0
February '80	414	2	2	4	105.5
March '80	3	2	144	1	37.5
April '80	2	1	5	0	2
May '80	72	21	19	7	29.75
Mean Values					
Summer	23.14	44.71	256.71	116.86	110.36
Winter	140.08	11.15	88.77	24.54	66.13
Total	99.15	22.89	147.55	56.85	81.61
Standard Deviations					
Summer	35.39	81.44	437.60	222.31	140.73
Winter	283.13	8.99	135.98	28.95	75.51
Total	233.02	49.15	260.90	134.82	101.60

Distributions P.C.	No.	%	No.	%	No.	%	No.	%	No.	%
0 - 100	17	85	19	95	13	65	19	95	15	75
101 - 1000	3	15	1	5	6	30	1	5	5	25
> 1000	0	0	0	0	1	5	0	0	0	0

Table XIII. Sampling Medians and Deviations for each Sampling Point.

Sampling Point No	Total Coliforms				E-Coli				F. Strept.			
	Winter		Summer		Winter		Summer		Winter		Summer	
	Median	Deviation	Median	Deviation	Median	Deviation	Median	Deviation	Median	Deviation	Median	Deviation
3	69.98	20.64	22.65	25.12	11.72	12.39	3.65	9.36	23.28	8.59	6.94	6.03
4	21.69	5.46	13.86	18.44	2.41	3.67	8.49	12.32	6.76	3.33	12.88	5.73
5	28.39	6.83	5.72	11.28	2.86	4.09	1.69	2.04	26.80	5.53	30.72	16.56
6	10.03	18.11	22.88	6.00	2.51	5.27	9.72	7.41	9.87	5.07	35.00	4.80

TABLE XIV.

MELLIEHA BAY - TOTAL COLIFORMS - NO./100mls

WINTER	POINT 3		POINT 4		POINT 5		POINT 6		ALL POINTS	
October 1980	10		10		20		0		10	
November 1980	540		10		210		0		190	
January 1981	0		1		3		0		1	
March 1981	1		0		6		0		1.75	
April 1981	1		0		156		0		39.25	
Mean Value	110.4		4.2		79		0		48.4	
Distribution P.C.	No.	%	No.	%	No.	%	No.	%	No.	%
0 - 100	4	80	5	100	3	60	5	100	4	80
101 - 1000	1	20	0	0	2	40	0	0	1	20
More than 1000	0	0	0	0	0	0	0	0	0	0

FAECAL COLIFORMS - NO./100mls

WINTER	POINT 3		POINT 4		POINT 5		POINT 6		ALL POINTS	
October 1980	1		3		0		0		1	
November 1980	2		0		2		0		1	
January 1981	0		0		2		0		0.5	
March 1981	0		0		0		0		0	
April 1981	0		0		0		0		0	
Mean Value	0.6		0.6		0.8		0		0.5	
Distribution P.C.	No.	%	No.	%	No.	%	No.	%	No.	%
0-100	5	100	5	100	5	100	5	100	5	100
101 - 1000	0	0	0	0	0	0	0	0	0	0
More than 1000	0	0	0	0	0	0	0	0	0	0

TABLE XV.

SEA WATER - BACTERIOLOGICAL DATA M.P.N. 1 OCTOBER 1980 - 31 MARCH 1981

MALTA	E.COLI 0-100/100ml	E.COLI 101-1000/100ml	E.COLI In Excess of 1000/100ml
Ghadira Bay	13		
Sliema Area	48	2	3
Xghira	38		
Delimara	3		
M'Xlokk Area	10		
W/Zurrieq	19		
Ghar Lapsi	2		
St. Thomas Bay	8		
Ghajn Tuffieha	4		
M'Scala	31		
B'Bugia	24		
Bahar ic-Caghaq	3		
GOZO			
M'Forn	17	1	
Xlendi	8		

TABLE XVI.

FAECAL STREPT. - NO./100 mls

WINTER	POINT 3	POINT 4	POINT 5	POINT 6	ALL POINTS
October 1980	1	1	0	20	5.5
November 1980	0	0	2	1	0.75
January 1981	4	1	5	16	6.5
March 1981	0	0	0	0	0
April 1981	0	0	0	0	0
Mean Value	1	0.4	1.4	7.4	2.55

Distribution F.C.	No.	%	No.	%	No.	%	No.	%	No.	%
0 - 100	5	100	5	100	5	100	5	100	5	100
101 - 1000	0	0	0	0	0	0	0	0	0	0
More than 1000	0	0	0	0	0	0	0	0	0	0

Centre de Recherche : Institut National d'Hygiène
Ministère de la Santé Publique
RABAT
Maroc

Chercheur Principal : N. BENMANSOUR

INTRODUCTION

C'est en 1978 que l'I.N.H. a commencé à s'intéresser au projet pilote OMS/PNUE MED POL VII. Toutefois en raison surtout de la distance entre la mer Méditerranée et Rabat où l'I.N.H. et situé, des activités régulières n'ont pû démarrer qu'au mois de mai 1979 grâce à la création d'une antenne de l'I.N.H. au sein du laboratoire provincial de TETOUAN. Durant la période de précédente nous avons fait du travail de mise au point et d'essai en effectuant sporadiquement des prélèments d'eau de mer dans les différentes provinces de la côte Méditerranéenne ainsi que des recherches de mytilotoxines et de bactéries pathogènes dans des échantillons de fruits de mer.

Durant cette période nous avant aussi entrainé un technicien de laboratoire aux analyses bactéréologiques de l'eau marine par la méthode de filtration. Ce technicien a été affecté par la suite à Tetouan où il effectue les analyses sur place.

ZONES ETUDIEES

La zone choisié pour la surveillance of des eaux côtières dans le cadre du projet MED POL VII se situe au littoral Nord de Tetouan. Elle consiste de deux plages dont l'une à fréquentation populaire (Martil) et l'autre à caractère touristique (Smir).

Identification géographique:

Latitude 35°34'N - Longitude 05°23'W

MATERIEL ET METHODES

Pour les analyses d'eau de mer nous avons adopté la méthode de filtration par membrane millipore comme conseillé dans le document "Directives applicables à la surveillance sanitaire de la qualité des eaux littorales". Au début nous avons cultivé les membranes sur Tergitol 7 - TTC (à 37°C pour les coliformes totaux et à 44°C pour les E. coli fécaux) et sur milieu Slanetz-Bartley (pour les streptocoques fécaux). Ces milieux furent changés dès que les milieux préconisés par le projet furent reçus, à savoir; le m-FC pour les coliformes totaux et les coliformes fécaux et le m-Enterococcus pour les streptocoques fécaux.

Dans la zone de surveillance, sept points (1-7) ont fait l'objet de prélèvements mensuels. Trois points (1-3) dans la localité Smir et quatres (4-7) dans la localité Martil. Six de ces points (1 - 6) sont fréquenté par de nombreux baigneurs en période estivale. Le dernier point (7) et situé par contre à proximité d'un effluent traversant le quartier Martil, source vraisemblable de pollution.

es analyses effectuées sur les 7 prélèvements visent uniquement à déterminer la qualité bactériologique de l'eau de mer. Les prélèvements se font à 100 m environ de la berge et à 20 - 30 cm environ de la surface. On note l'heure du prélèvement et la température de l'air et de l'eau. Les conditions dynamiques et métérologiques ne sont pas relevées.

RESULTATS ET LEUR INTERPRETATION

Les sept tableux en annexe (I à VII) donnent les résultats bactériologiques obtenus pendant la période septembre 1979 - septembre 1980.

Les trois points de prélèvement en localité Smir (points 1 à 3) se maintiennent pratiquement indemnes de pollution fécale pendant toute l'année. Les quatre points de prélèvement en localité Martil (points 4 à 7) ont donné lieu à des résultats variant d'un point à l'autre. Le point le plus éloigné de l'effluent de l'oued Martil (point 4) reste pratiquement indemne de pollution fécale durant tous les mois de l'année. Le point situé en proximité de l'éffluent de l'oued Martil (point 7) présente en permaneance des indices de pollution fécale. Les deux points intermédiaires (5 et 6) ne montrent des signes de pollution fécale que pendant les mois les plus froids de l'année, durant lesquel il n'y a pas de baigneurs (phénomène qui pourrait s'expliquer: (1) soit, par la plus longue durée de survie bactérienne à de températures plus basse, permettant une plus large dispersion à partir de l'éffluent; (2) soit par le jeux des courants).

Pendant la période octobre 1980 à mars 1981 des résultats similaires aux précédents ont été obtenues. Les tableaux VIII à XIV donnent les détails de ces résultats.

DISCUSSION DES RESULTATS

Compte tenu des données nécessairement limitées dont nous disposons jusqu'à présent pour la période septembre 1979 - septembre 1980 , la seule conclusion qui nous semble possible concerne le degré de pollution fécale de la zone choisie pour l'étude. Exception faite des eaux de mer en proximité immédiate de l'effluent de l'oued Martil, tous les autres points de baignade en localités Smir et Martil paraissent dépourvus de danger d'infection pour les usagers.

Les résultats de la période octobre 1980 à mars 1981 renforcent les conclusions ci-haut énoncées.

Sur la base des données obtenues jusqu'à présent la recherche des germes pathogènes éventuellement présents dans l'eau de mer, ne se justificeraient à notre avis que pour le point de prélèvement No. 7.

Tableau I

POINT DE PRELEVEMENT N° 1

(Localité Smir)

DATE	COLIFORMES TOTAUX	COLIFORMES FECAUX	STREPTOCOCQUES FECAUX
3 Septembre 1979	0	0	0
1 Octobre 1979	31	0	0
5 Novembre 1979	5	0	0
5 Décembre 1979	22	0	0
3 Janvier 1980	18	0	0
4 Février 1980	13	0	0
6 Mars 1980	20	0	0
5 Avril 1980	15	0	0
5 Mai 1980	21	0	0
6 Juin 1980	130	0	0
5 Juillet 1980	31	1	0
8 Août 1980	32	0	0

Tableau II.

POINT DE PRELEVEMENT N° 2

(Localité Smir)

DATE	COLIFORMES TOTAUX	COLIFORMES FECAUX	STREPTOCOCQUES FECAUX
3 Septembre 1979	0	0	0
1 Octobre 1979	3	0	0
5 Novembre 1979	7	0	0
5 Décembre 1979	16	0	0
3 Janvier 1980	25	0	0
4 Février 1980	20	0	0
6 Mars 1980	6	0	0
5 Avril 1980	9	0	0
5 Mai 1980	10	0	0
6 Juin 1980	31	0	0
5 Juillet 1980	45	2	0
8 Août 1980	57	0	0

Tableau III

POINT DE PRELEVEMENT N° 3

(Localité Smir)

DATE	COLIFORMES TOTAUX	COLIFORMES FECAUX	STREPTOCOQUES FECAUX
3 Septembre 1979.	0	0	0
1 Octobre 1970	20	0	0
5 Novembre 1979	4	0	0
5 Décembre 1979	31	0	0
3 Janvier 1980.	11	0	0
4 Février 1980.	17	0	0
6 Mars 1980	1	0	0
5 Avril 1980.	10	8	0
5 Mai 1980	17	0	0
6 Juin 1980	13	1	0
5 Juillet 1980.	25	0	0
8 Août 1980.	38	0	0

Tableau IV.

POINT DE PRELEVEMENT N° 4

(Localité Martil)

DATE	COLIFORMES TOTAUX	COLIFORMES FECAUX	STREPTOCOQUES FECAUX
3 Septembre 1979.	30	3	0
1 Octobre 1979	89	0	0
5 Novembre 1979	24	0	0
5 Décembre 1979	100	0	0
3 Janvier 1980	30	1	0
4 Février 1980	2	3	0
6 Mars 1980	25	0	0
5 Avril 1980.	37	0	0
5 Mai 1980	25	0	0
6 Juin 1980	47	1	0
5 Juillet 1980	101	0	0
8 Août 1980	99	0	0

Tableau V.

POINT DE PRELEVEMENT N° 5
(Localité Martil)

DATE	COLIFORMES TOTAUX	COLIFORMES FECAUX	STREPTOCOCQUES FECAUX
3 Septembre 1979.	15	4	0
1 Octobre 1979	148	0	0
5 Novembre 1979	170	0	0
5 Décembre 1979	100	50	3
3 Janvier 1980	2	23	0
4 Février 1980	130	17	0
6 Mars 1980	9	0	0
5 Avril 1980	19	0	0
5 Mai 1980	15	0	0
6 uin 1980	97	1	0
5 Juillet 1980.	70	3	10
8 Août 1980	87	1	0

Tableau VI

POINT DE PRELEVEMENT N° 6
(Localité Martil)

DATE	COLIFORMES TOTAUX	COLIFORMES FECAUX	STREPTOCOCQUES F2CAUX
3 Septembre 1979	12	10	10
1 ctobre 1979	71	0	0
5 vembre 1979.	17	0	0
5 Décembre 1979.	50	45	0
3 Janvier 1980	7	50	0
4 Février 1980	89	34	0
6 Mars 1980	24	0	0
5 Avril 1980.	24	0	0
5 Mai 1980	31	1	0
6 Juin 1980	150	9	0
5 Juillet 1980.	115	3	0
8 Août 1980	123	0	0

Tableau VII.

POINT DE PRELEVEMENT N° 7

(Localité Martil)

DATE	COLIFORMES TOTAUX	COLIFORMES FECAUX	STREPTOCOQUES FECAUX
3 Septembre 1979.	280	200	100
1 Octobre 1979.	illisible	30	60
5 Novembre 1979	illisible	100	400
5 Décembre 1979	illisible	50	290
3 Janvier 1980	illisible	70	0
4 Février 1980	illisible	NR	0
6 Mars 1980.	680	50	0
5 Avril 1980	300	0	?
5 Mai 1980.	illisible	50	0
6 Juin 1980.	illisible	130	0
5 Juillet 1980	illisible	370	30
8 Août 1980.	illisible	120	10

N.B. (1) Les chiffres rapportées dans les tableaux*qui précédent indiquent le nombre de colonies par 100 ml d'eau marine. * (Tableaux I-VII)

(2) Nous avons indiqué "illisible" lorsque le nombre de colonies développées était pour chaque dilution de travail (1, 1/10, 1/100), trop élevée pour permettre leur dénombrement.

(3) Nous avons indiqué " ? " lorsque le dénombrement du germe recherché était rendu impossible par le développement en nappe d'un germe saprophyte.

(4) NR = Donnée non reçue.

Tableau VIII. POINT DE PRELEVEMENT N° 8

(Localité SMIR)

DATE	COLIFORMES TOTAUX	COLIFORMES FECAUX	STREPTOCOQUES FECAUX
4 Octobre 1980	18	0	0
3 Novembre 1980.	42	0	0
3 Décembre 1980.	37	0	0
5 Janvier 1981	28	0	0
2 Février 1981	31	0	0
5 Mars 1981	38	1	0

Tableau IX.

POINT DE PRELEVEMENT N° 9

(Localité SMIR)

DATE	COLIFORMES TOTAUX	COLIFORMES FECAUX	STREPTOCOQUES FECAUX
4 Octobre 1980.	27	0	0
3 Novembre 1980	48	1	0
3 Décembre 1980	53	0	0
5 Janvier 1981	44	0	0
2 Février 1981	30	1	0
5 Mars 1981	39	1	0

Tableau X. POINT DE PRELEVEMENT N° 10

(Localité [illegible])

DATE	COLIFORMES TOTAUX	COLIFORMES FECAUX	STREPTOCOQUES FECAUX
4 Octobre 1980.	41	1	0
3 Novembre 1980	51	0	0
3 Décembre 1980	24	0	0
5 Janvier 1981	26	0	0
2 Février 1981	40	0	0
5 Mars 1981	61	0	0

Tableau XI. POINT DE PRELEVEMENT N° 11

(Localité Martil)

DATE	COLIFORMES TOTAUX	COLIFORMES FECAUX	STREPTOCOQUES FECAUX
4 Octobre 1980.	90	10	0
3 Novembre 1980	140	10	0
3 Décembre 1980	83	0	0
5 Janvier 1981	91	1	0
2 Février 1981	70	0	0
5 Mars 1981.	55	1	0

Tableau XII.

POINT DE PRELEVEMENT N° 12

(Localité Kartil)

DATE	COLIFORMES TOTAUX	COLIFORMES FECAUX	STREPTOCOQUES FECAUX
4 Octobre 1980.	190	3	0
3 Novembre 1980	200	14	10
3 Décembre 1980	77	1	0
5 Janvier 1981	99	0	0
2 Février 1981	100	1	0
5 Mars 1981	130	2	0

Tableau XIII

POINT DE PRELEVEMENT N° 13

(Localité Kartil)

DATE	COLIFORMES TOTAUX	COLIFORMES FECAUX	STREPTOCOQUES FECAUX
4 Octobre 1980	130	10	0
3 Novembre 1980.	140	26	10
3 Décembre 1980.	85	10	1
5 Janvier 1981	97	1	1
2 Février 1981	82	1	0
5 Mars 1981	110	2	0

Tableau XIV.

POINT DE PRELEVEMENT N° 14

(Localité Martil)

DATE	COLIFORMES TOTAUX	COLIFORMES FECAUX	STREPTOCOQUES FECAUX
4 Octobre 1980.	Illisible	50	50
3 Novembre 1980	1.000	290	70
3 Décembre 1980	1.200	180	20
5 Janvier 1981.	Illisible	110	30
2 Février 1981.	Illisible	230	0
5 Mars 1981.	2.500	120	0

N.B. 1. Les chiffres rapportées dansles tableaux* qui précèdent indiquent le nombre de colonies par 100 ml d'eau marine. * (Tableaux VIII-XIV)

2. Nous avons indiqué " illisible" lorsque le nombre de colonies était pour chaque dilution, trop élevé pour permettre leur dénombrement.

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INTRODUCTION

The Public Health Authorities of Malaga and Tarragona have been participating in the MED POL VII pilot project since August 1977. The work carried out during the third and fourth years of participation represents the culmination of previous activities, and has resulted in very valuable scientific and technical information.

AREA(S) STUDIED

The pilot zones covered by this report are described in Figures 1 and 2.

MATERIALS AND METHODS

The two basic reference documents were:

1. Guidelines for Health Related Monitoring of Coastal Water Quality.

2. Health Criteria and Epidemiological Studies Related to Coastal Water Pollution.

RESULTS AND DISCUSSION

The activities carried out during 1979 and 1981 can be classified into two main periods: winter and summer season. The summer season starts from the beginning of June to the end of September, and the winter season includes the remaining months of the year.

The work programme during 1979 has been the same at both pilot zones of Malaga and Tarragona, however, activities during 1980 were only continued at the pilot zone of Tarragona. It is expected that administrative and financial difficulties at the pilot zone of Malaga can be overcome in future years, and that monitoring and research activities can be resumed normally.

Main activities:

The main activities carried out during 1979 and 1980 were the following:

1. A microbiological water quality control programme was conducted at 47 sampling stations in Malaga, and 27 sampling stations in Tarragona. The three

microbial indicators used were: total coliforms, faecal coliforms and faecal streptococci.

2. An epidemiological survey has been conducted among recreationists of coastal waters. More than 20,000 questionnaires have been collected by direct interview on the beach, along 14 beaches in Malaga and 10 beaches in Tarragona. Each of the coastal stretches considered included at least one sampling station for microbiological water quality monitoring.

3. A comparative study was done on the recovery efficiency and classification potential of the MPN and the MF techniques for total and faecal coliforms in coastal waters.

4. A field study was executed on the inactivation rates of the three microbial indicators considered: total coliforms, faecal coliforms and faecal streptococci. The inactivation studies were carried out in the drifting plume of two 1-km submarine outfalls discharging 60 and 300 l/s of raw domestic waste-water, at 20 m depth.

Inactivation rate of microbial indicators:

The field study of inactivation rates for total coliforms, faecal coliforms, and faecal streptococci showed a remarkable difference among the three micro-organisms. While total coliforms and faecal coliforms are quickly and permanently inactivated after disposal into the sea, faecal streptococci shows a similar inactivation rate only during the first minutes, and then gradually approaches a steady concentration. This latter behaviour makes inapplicable the commonly assumed exponential inactivation model, and consequently deprives the T90 parameter of any real meaning.

Figures 3 and 4 illustrate the behaviour of faecal coliforms and faecal streptococci, as observed along the upper surface of the plume of a 1-km submarine outfall discharging 60 l/s of raw domestic sewage at 20 m depth. Measurements were carried out within the 11:00 - 15:00 hour period, during July and August 1979 at the coast of Malaga.

The available information suggests mean T90 values under 20 minutes, well below those reported in the literature. Studies are being presently conducted at several submarine outfalls, over the summer and winter seasons, to further evaluate the inactivation process.

Relative microbial concentrations at sampling stations:

Figure 5 illustrates a comparative analysis of the faecal coliforms to faecal streptococci ratio based on all the analytical results gathered at the coastal zone of Malaga during the summer of 1979. The experimental points clearly show the variable trend of the correlation between faecal coliforms and faecal streptococci over a wide interval of faecal coliform concentrations. While this observation would explain the variable correlation coefficient reported by different investigators, the considerable number of experimental points available show an even more critical fact, apparently related to the previously discussed inactivation rates.

While high concentrations of faecal coliforms are clearly associated with a ratio of faecal coliforms to faecal streptococci in the 1 to 10 interval, as expected from ratio values typical of human faecal material, lower and lower faecal coliform concentrations bring about a rapid reduction of the faecal coliform to faecal streptococci ratio, up to the point of the latter being 100 or more times higher than the former.

In adddition to being consistent with the previously discussed inactivation rates, this observation clearly points out that coastal waters which could be considered satisfactory under present proposed interim criteria and Spanish standards, would actually contain a considerably higher concentration of faecal streptococci, and possibly of pathogens, which would represent a human health hazard.

In spite of the notable scattering of the experimental points, Figure 5 evidences the limited value of faecal coliforms as a single coastal water quality indicator.

Statistical interpretation of microbiological data:

The systematic analysis and interpretation of sets of 18 to 22 microbial values collected during 1979 in 74 coastal water sampling stations, for the three microbial indicators considered, has revealed the lognormal probability model as a practical and powerful method for statistically interpreting the microbiological quality of coastal waters.

Though the main aspects of the method and its potential applications are described in the paper "Statistical Variation of Microbiological Quality of Coastal Waters: Regulatory Implications", presented at the joint ICSEM/UNEP Workshop on Pollution of the Mediterranean, held in Cagliari in 1980, the conclusions of this study can be summarized as follows:

1. The microbiological quality of coastal waters can be adequately interpreted by a lognormal probability distribution model.

2. Correct compliance with any statistically expressed water quality standards requires comparison of the two probability distributions and not only two pairs of frequencies.

3. Standard deviations of the distribution of the three microbial indicators at the coast of Malaga and Tarragona approach quite closely those implied by the proposed interim criteria and Spanish standards.

4. The standard deviation of a microbial indicator, at a sampling station, is a useful and sensitive parameter for detecting discontinuous sources of pollution.

5. A standard deviation estimate, derived from sets of 12-14 values of the natural logarithms of the microbial concentrations, which lie outside the 1 to 3 interval can be likely associated to a singular water sampling station.

The model adjustment is based on a graphical interpolation of a straight line, using a lognormal probability paper. The calculation procedure is currently being adapted for use with a computer system, and will allow preparation of graphical display records, tabulation of water quality classification according to desired standards, as well as several analysis of variance tests.

Comparative study of MF and MPN methods:

A comparative analyis of the recovery efficiency of the MF and MPN methods for faecal coliform analysis in coastal waters, using the m-FC broth and the

MacConkey broth media respectively, showed a notable difference between microbial densities for any given water sample, as was expected. However, a comparison of the statistical parameters of the water quality at a given sampling station, in terms of faecal coliform concentrations, and as derived by the lognormal probability model, results in an identical classification of the sampling station, regardless of the analytical method used.

Table I summarizes the results obtained in 5 sampling stations of the coast of Tarragona. These results clearly illustrate the need to abandon the common approach of comparing individual pairs of data, as obtained by the MF and MPN methods for a given sample, in favour of a comparison of the over-all water quality of a given station based on series of data derived by the MF and MPN techniques. This approach seems more appropriate for understanding coastal water quality over long periods of time, and certainly is more proportionate to the precision and accuracy of present analytical methods. Further analysis of Mediterranean data should provide a valuable contribution to this subject.

Analytical method for total coliforms:

Experimental results gathered at Malaga and Tarragona show consistent results between the total coliform concentrations obtained by the m-Endo broth and the faecal coliform concentrations obtained by the m-FC broth. Based on these results and the current methodology contained in Standard Methods for the Examination of Water and Wastewaters, as well as in Geldreich's Handbook for evaluating water bacteriological laboratories, we support the use of the m-FC medium exclusively for faecal coliforms, and the m-Endo medium exclusively for total coliforms.

Furthermore, incubation temperature for faecal streptococci determination using m-Enterococci agar should be kept at 35°C, as specified in the above two references, as well as in the original paper discussing the formulation and use of that medium.

Quality of coastal waters:

Tables II and III summarize the microbiological quality of the coastal waters of Malaga and Tarragona included in the pilot project. As can be seen in these tables, consistent application of the European Economic Community requirements for bathing waters classify the vast majority of the sampling stations surveyed as unsatisfactory, while the proposed interim criteria and Spanish standards give similar and more satisfactory over-all results. A comparative study of the above three microbial requirements have shown that the limitation imposed by the concentration of 500 total coliforms per 100 ml not to be exceeded in 80% of the samples, and particularly that imposed by the concentration of 100 faecal coliforms per 100 ml not to be exceeded in 80% of the samples, are the most restrictive of the EEC requirements, and determine by themselves the over-all classification of the sampling stations surveyed.

Water quality appears to be more satisfactory during the winter time than during the bathing season. Aesthetic quality, as estimated by the California standard, appears to be the priority concern, followed by microbiological quality required from a public health point of view.

Epidemiological study among coastal water recreationists:

The results of the epidemiological study, carried out during the summer season of 1979 among 20,000 recreationists at 14 beaches in Malaga and 6 beaches in Tarragona, can be summarized as follows:

1. Sea-water is the coastal area component with the less satisfactory aesthetic quality at the two pilot zones in Malaga and Tarragona. Food and drink establishments at the beach are the components with the more satisfactory quality at both pilot zones, while the aesthetic quality of the beach itself lies between those of the two other components.

2. Aesthetic classification of coastal areas reveals the presence of a radicalized public opinion, both at local and national levels, on the aesthetic quality of coastal waters. While foreign recreationists give superior grades to that of Spaniards, Spanish residents from inland provinces give considerable higher grades than local residents.

3. The transparency of the water especially, and the presence of floating material on its surface are the two determining factors of the opinion that recreationists form themselves on the aesthetic quality of coastal waters.

4. There is an empirical and statistically significant relationship between aesthetic quality and microbiological quality of coastal waters. The statistical limits thus derived for acceptable aesthetic quality, under present sociological conditions in Malaga and Tarragona and present practice of raw waste-water discharges, are quite in agreement with the California standards, the proposed interim criteria and Spanish standards.

5. Skin ailments, pimples and mycosis, are the two most frequent health ailments suffered by recreationists, with morbidity rates close to 2%. Ear and eye ailments follow next, with morbidity rates close to 1.5%. Gastrointestinal ailments appear to have a much lower incidence with morbidity rates close to 0.8%.

6. The morbidity rates for pimple rashes observed in Tarragona are in evident contrast with the very satisfactory level of its coastal water quality. This points out the possibility of alternative infection routes as well as of conditions favourable to pathogens persistence, even at very low levels of microbial indicators.

7. The habit of immersing the head while swimming follows a statistically significant association with a higher incidence of ailments of the exposed mucoses, ears and eyes mainly. The consequences of this habit seems to follow an increasing trend from the coast of Tarragona, where it only results in ear ailments, to the coast of Malaga, where it results in ear and eye ailments.

8. A comparative study of the morbidity rates for mycoses and ear and eye ailments among recreationists at the satisfactory and unsatisfactory beaches in Malaga, clearly shows the apparent unsuitability of standards based exclusively on faecal coliforms for evaluating the microbiological quality of coastal waters.

9. The fact that faecal streptococci predominate over faecal coliforms in the satisfactory coastal waters of Malaga is consistent with the different inactivation behaviour of both indicators, and suggests that other micro-organisms, among them the pathogens, can be capable of better persistence and adaptation in sea-water than faecal coliforms.

10. Increasing concentrations of microbial indicators follow a statistically significant association with higher over-all morbidity rates of mycosis, ear and eye ailments. Figures 6 and 7 illustrate a statistically significant

association between water quality parameters, in terms of faecal streptococci, and morbidity rates of ear ailments among recreationists. The relatively low number of questionnaires by beach, approximately 1000, results in morbidity rate fluctuations which makes it difficult to derive statistically significant associations for other ailments.

11. A standard for coastal water quality should include limits for both faecal coliforms and faecal streptococci. Results obtained at the pilot zones of Malaga and Tarragona show the interest to maintain water quality levels at least as satisfactory as implied by the proposed interim criteria and Spanish standards, both in terms of faecal coliforms.

12. From the available statistical association between morbidity rates of ear ailments and faecal streptococci concentrations it seems advisable to maintain water quality levels that require 50% of at least 10 consecutive water samples collected during the bathing season should not exceed a value between 10 and 100 faecal streptococci per 100 ml, and that 90% of the same set of samples should not exceed a value between 100 and 1000 faecal streptococci per 100 ml.

CONCLUSIONS

From the studies carried out during 1979 and 1980 at the two MED POL VII pilot zones of Malaga and Tarragona, the following conclusions can be drawn:

1. Coastal disposal of waste-water effluents, generally discharging raw domestic sewage, is the main contributing factor of the aesthetic and microbiological quality of the recreational waters at both pilot zones. A waste-water disposal system incorporating an effective removal of suspended solids, floatable materials, oil and grease, coupled with a well designed submarine outfall, capable of achieving a high initial dilution, should significantly improve the aesthetic and microbiological quality of the water of many coastal resort towns.

2. While total coliforms and faecal coliforms seem to follow an exponential rate of inactivation upon discharge in the sea, faecal streptococci behave quite differently; after an exponential inactivation occuring during the first few minutes they gradually approach a steady concentration. Mean values for T90 characteristic of the three microbial indicators are below 20 minutes, during the summer period, considerably lower than previously reported values.

3. Correlation between faecal coliforms and faecal streptococci concentrations in a coastal water sample is highly dependent on the evolution of that water mass since it was discharged into the sea. It is not uncommon that faecal coliform concentrations be associated with relatively higher faecal streptococci concentrations due to the relatively different inactivation rates of both microbial indicators.

4. While the previous observations help to explain the variable correlation coefficients between faecal coliforms and faecal streptococci found by many investigators, it also points out the likelihood of pathogens being present in considerable numbers, even in waters with low levels of faecal coliforms. This observation evidences the limited value of faecal coliforms as a single coastal water quality indicator.

5. A lognormal probability distribution model, graphically adjusted, is a practical and powerful method for interpreting microbiological quality of coastal waters. Specifically, the model has provided evidence of the balanced

character of the two microbial limits contained in the proposed interim criteria and Spanish standards. Further use and adaptation to Mediterranean results should provide very valuable information on that subject.

6. A comparison of over-all water quality parameters for a single station, as obtained by the lognormal probability model, shows an identical classification of 5 coastal water stations, regardless of the method of analysis used: MF and MPN. The common approach of comparing individual pairs of results should be abandoned in favour of the one proposed here. Conclusions derived from Mediterranean data would provide much needed interpretation guidelines.

7. Water quality varies according to different pilot zones. Over-all results show aesthetic quality of the coastal waters studied as the priority concern under present conditions.

8. Analytical methods for the three microbial indicators considered should be clearly established, taking into consideration experience gathered during the pilot phase of MED POL VII.

9. Consistent application of the EEC requirements for bathing waters classify as unsatisfactory the vast majority of the sampling stations surveyed. The "Guide" requirements are the most restrictive limitations, and determine by themselves alone the over-all quality of a water sampling station.

10. The epidemiological study carried out reveals that skin, ear and eye ailments are the most frequently suffered by recreationists of coastal waters. Morbidity rates for these ailments vary from 2 to 1.5%. Gastrointestinal ailments appear to be much less important, with morbidity rates close to 0.8%.

11. Increasing concentrations of microbial indicators are statistically associated with higher over-all incidence of skin, ear and eye ailments. In particular, faecal streptococci seems to be the microbial indicator best correlated with the morbidity rate of ear ailments. Based on that significant relationship, and in addition to presently used faecal coliform standards, a faecal streptococci standard is proposed that requires 50% of the samples from at least 10 consecutive samples collected during the bathing season should not exceed a value between 10 and 100 faecal streptococci per 100 ml, and that 90% of the same set of samples should not exceed a value between 100 and 1000 faecal streptococci per 100 ml.

Recommendations:

Based on the results and experience gathered during the pilot phase of the MED POL VII Project, the following recommendations can be made:

1. The studies on inactivation of microbial indicators in the sea should be continued, to better understand the specific behaviour of the different micro-organisms, and to define the parameters most adequately representing the inactivation process. Results from these studies would contribute to the selection of microbial indicators of coastal water quality, as well as in the design of facilities for waste-water disposal in the sea.

2. Studies should be continued on the interest and adequacy of the lognormal probability distribution for interpreting the microbiological quality of coastal waters. The studies should consider, among other specific objectives,

the influence in the water quality classification caused by factors such as the sampling time of the day, the sampling location, the sampling frequency, the season of the year, the microbial indicator considered, the method of analysis, and the over-all quality level of the water.

Results from these studies would be very useful for enlarging the scientific basis of the quality criteria for coastal waters.

3. Epidemiological studies should be continued to further appraise the public health status of recreationists in Mediterranean coastal waters. Specific attention should be given, among other aspects, to the establishment of the priority list of ailments most frequently suffered by recreationists, the possible routes of infection for the already observed ailments, the relative influence of bathing in the incidence levels of those ailments, and the possible association between water quality and public health incidence of the observed ailments.

Results obtained from these studies could provide the much needed information on which to base appropriate quality criteria for recreational coastal waters as regards public health protection.

4. A quality control programme should be carried out among laboratories participating in the microbiological evaluation of coastal water quality, to ensure that analytical results are accurate, precise and comparable, and that classification of coastal bathing areas follows a systematic and common methodology.

PUBLICATIONS

The studies carried out at the pilot zones of Malaga and Tarragona have resulted in the following publications:

MUJERIEGO, R., et al. (1980). Calidad de aguas costeras y vertido de aguas residuales en el mar: sus àspectos sobre la salud publica. Subdireccion General de Sanidad Ambiental. Ministerio de Sanidad y Seguridad Social, Madrid.

MUJERIEGO, R., et al. (1980). Statistical variations of microbiological quality of coastal waters: regulatory implications. ICSEM/UNEP Workshop on Pollution of the Mediterranean. Cagliari, 1980.

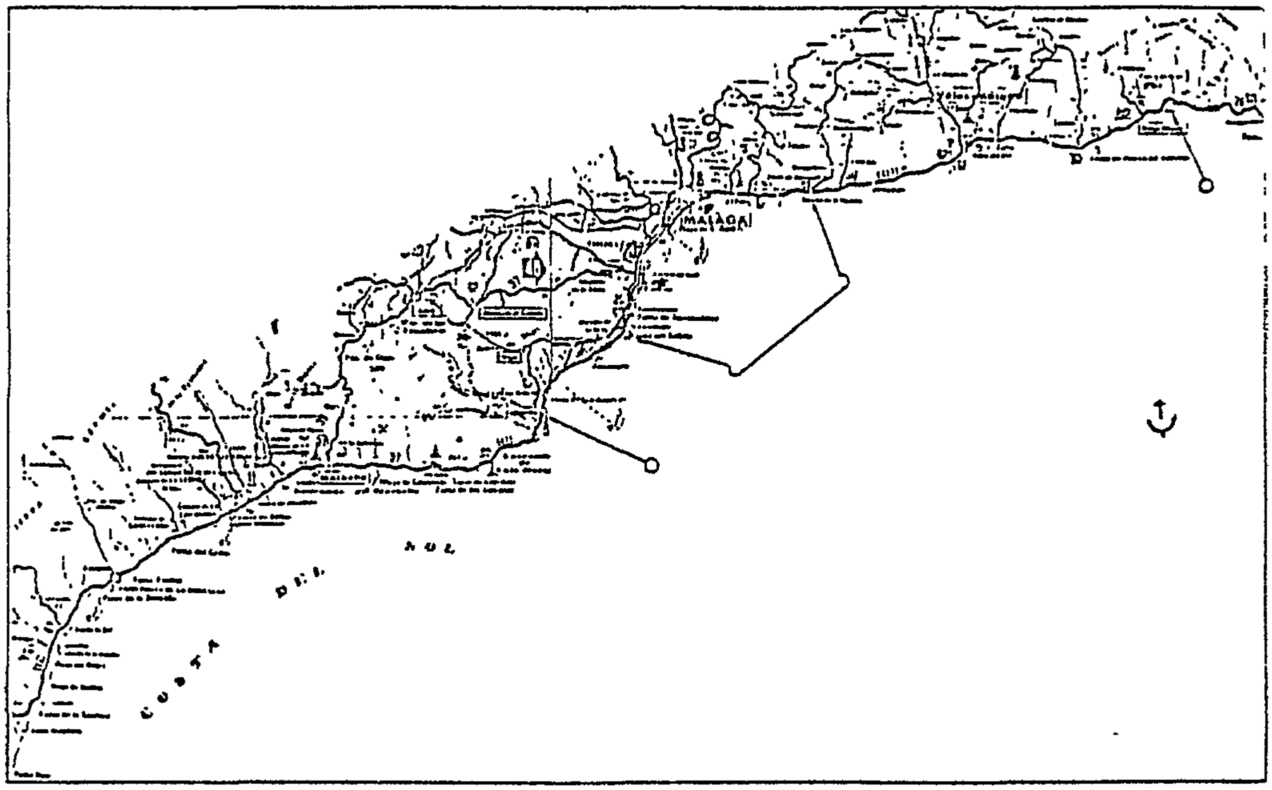

Fig. 1. MED VII pilot zone of Malaga

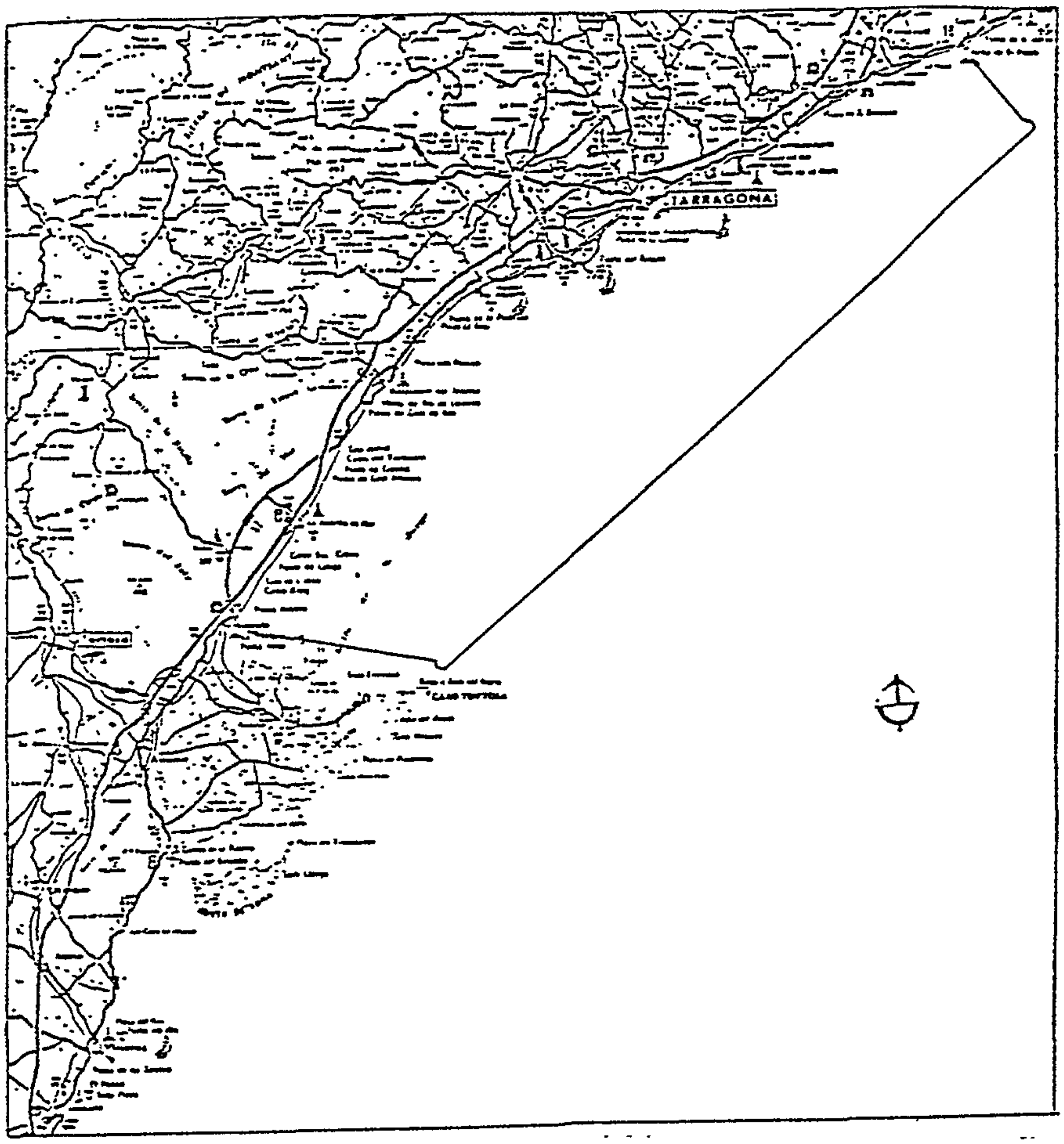

Fig. 2. MED VII pilot zone of Tarragona

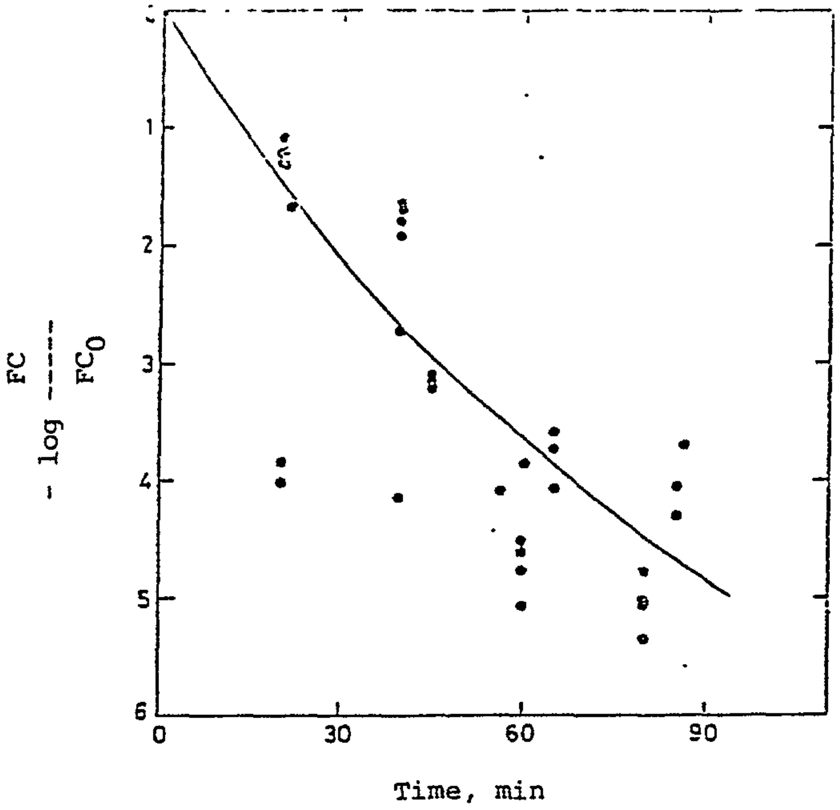

Fig. 3. Inactivation rates of faecal coliforms in the drifting plume of a submarine outfall. Coastal zone of Malaga, Summer of 1979

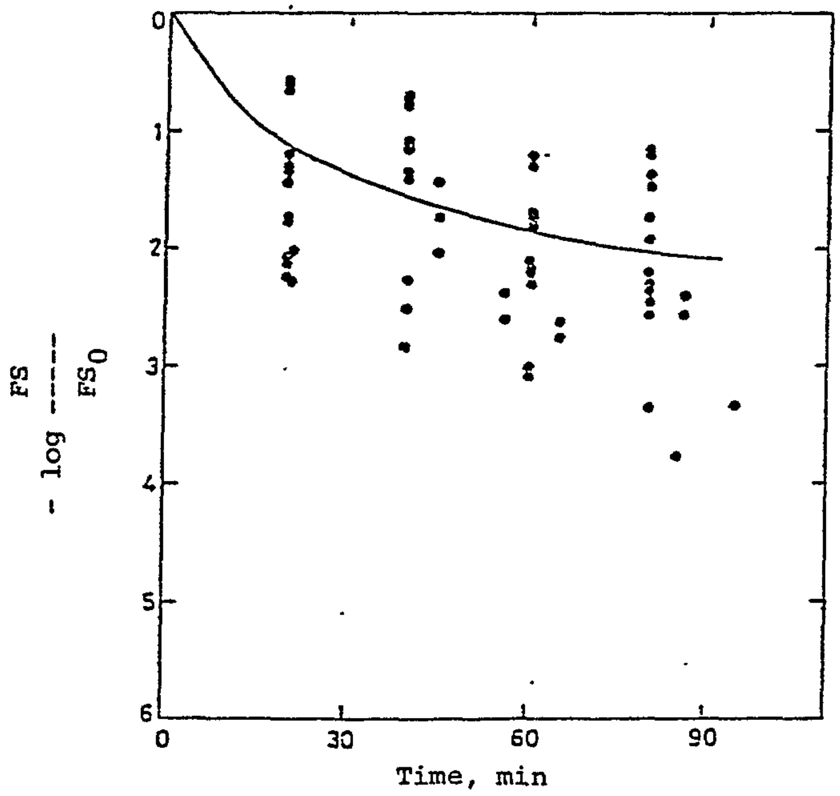

Fig. 4. Inactivation rates of faecal streptococci in the drifting plume of a submarine outfall. Coastal zone of Malaga. Summer of 1979

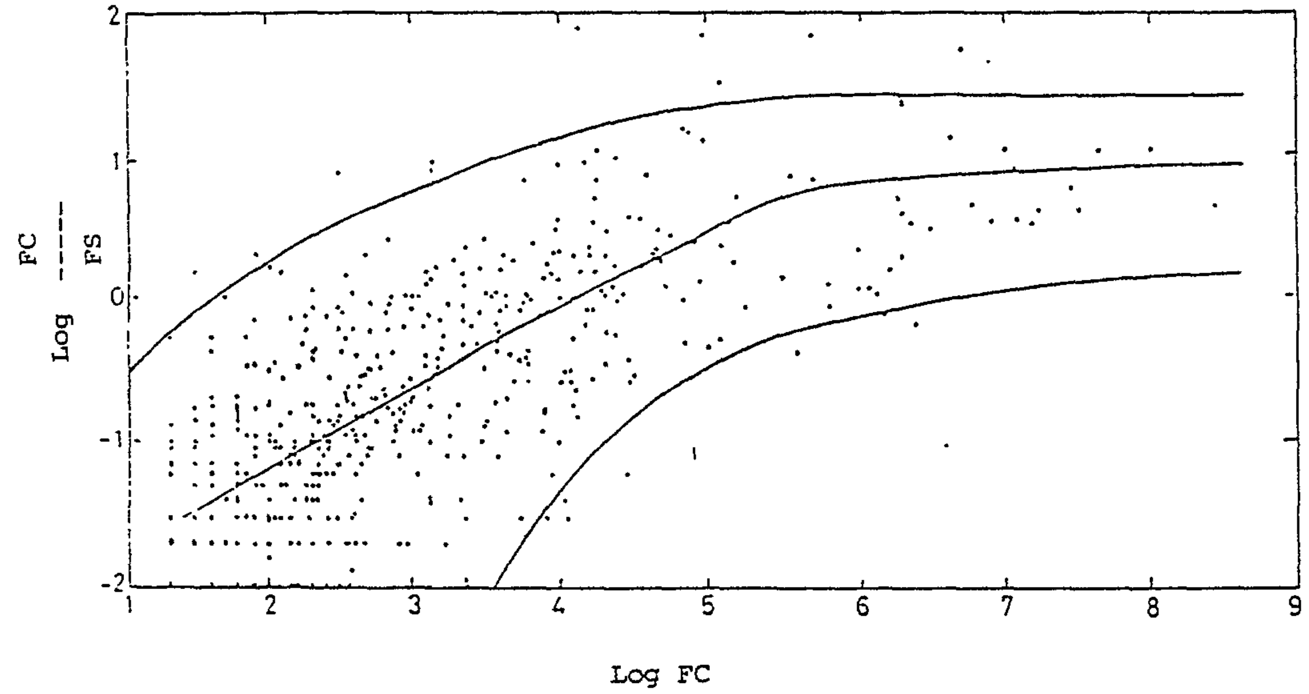

Fig. 5. Faecal coliforms to faecal streptococci ratio as a function of faecal coliforms concentration. Coastal zone of Malaga, summer of 1979

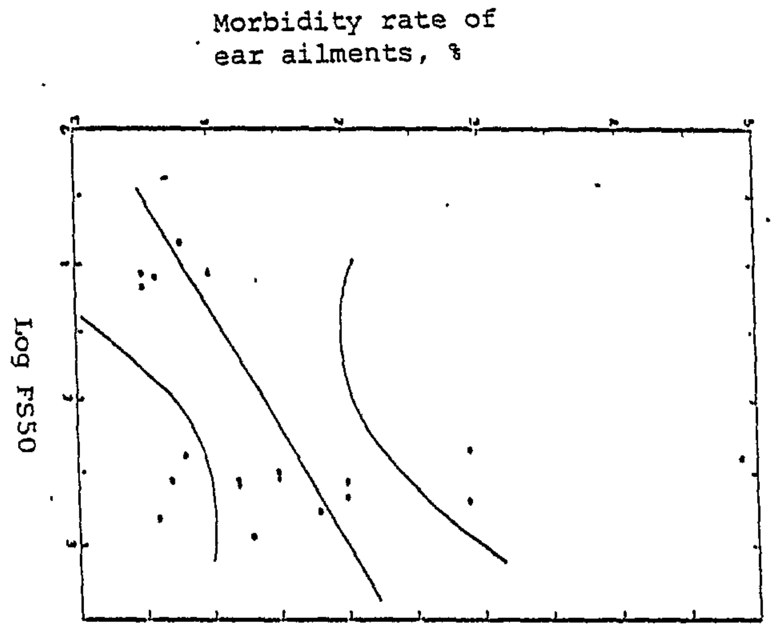

Fig. 6. Regression line and 95% confidence limits for the expected morbidity rate of ear ailments associated with a given value of the concentration of faecal streptococci reached in 50% of the samples

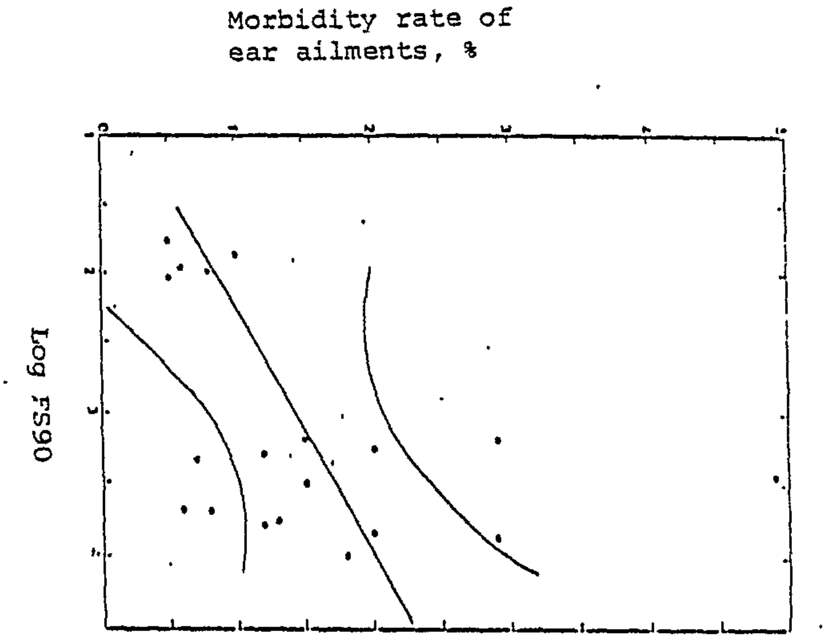

Fig. 7. Regression line and 95% confidence limits for the expected morbidity rate of ear ailments associated with a given value of the concentration of faecal streptococci reached in 90% of the samples

TABLE I: COMPARATIVE STUDY OF THE CAPABILITIES OF THE MPN AND THE MF ANALYTICAL TECHIQUES FOR EVALUATING COASTAL WATER QUALITY IN TERMS OF FAECAL COLIFORMS CONCENTRATIONS, TARRAGONA,1979

SAMPLING STATION	NUMBER OF SAMPLES	MPN[a], FC/100 ML		MF[b], FC/100ML	
		FC50	FC90	FC50	FC90
30	9	15	53	44	180
31	7	39	2400	37	1150
46	7	6	25	3	40
51	7	4	58	28	620
65	7	50	355	70	290

a),b): FC50. Faecal coliform concentration not exceeded in 50% of the time.

a) : MacConkey broth at $36 \pm 1^{o}C$ for 24h, then at $44^{o}C$ for 24h.

b) : m-FC broth at $44^{o}C$ for 24h.

TABLE II: MICROBIOLOGICAL QUALITY OF COASTAL WATERS.
PILOT ZONE OF MALAGA

Quality Criteria	Number of Sampling Stations	
	Total	Satisfactory
SPRING 1979		
WHO, 1974	39	28 (72%)
SPAIN, 1977	39	31 (79%)
EEC, 1975(*)	39	15 (38%)
CALIFORNIA, 1943	39	32 (82%)
SUMMER 1979		
WHO, 1974	47	19 (40%)
SPAIN, 1977	47	21 (45%)
EEC, 1975(*)	47	1 (2%)
CALIFORNIA, 1943	47	18 (38%)

(*) Not considering the faecal streptococci requirement.

TABLE III: MICROBIOLOGICAL QUALITY OF COASTAL WATERS.
PILOT ZONE OF TARRAGONA

Quality Criteria	Number of Sampling Stations: Total	Number of Sampling Stations: Satisfactory
SPRING 1979		
WHO, 1974	27	24 (89%)
SPAIN, 1977	27	24 (89%)
EEC, 1975(3)	27	21 (78%)
CALIFORNIA, 1943	27	26 (96%)
SUMMER 1979		
WHO, 1974	27	26 (96%)
SPAIN, 1977	27	25 (93%)
EEC, 1974(*)	27	0
CALIFORNIA, 1943	27	15 (56%)
SUMMER 1980		
WHO, 1974	27	25 (93%)
SPAIN, 1977	27	26 (96%)
CALIFORNIA, 1943	27	19 (70%)

(*) Not considering the faecal streptococci requirement.

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INTRODUCTION

L'Institut Pasteur de Tunis a pour objet l'étude de maladies virulentes et parasitaires et effectue toutes activités relatives à ce sujet. Il collabore à l'enseignement supérieur dans le domaine de ses compétences. Il assure enfin le fonctionnement de tout service practique jugé utile pour la santé publique.

Le laboratoire régional de Santé Publique de Sousse rattaché sur le plan technique à l'Institut Pasteur de Tunis couvre entre autres les analyses bactériologiques des services de prévention de Sousse, Monastir, Mahdia et Kairouan.

Dans le cadre de la surveillance prévue par le projet pilote MED POL VII ce laboratoire, de janvier 1977 à mars 1979, a effectué des contrôles sur la qualité bactériologique de l'eau de mer le long du littoral du Sahel. Cependant la participation de l'Institut au projet pilote MED POL VII a débuté le 13 mars 1979.

Le présent résumé se réfère plus spécialement à la période mars 1979 à mars 1981.

ZONE(S) ETUDIEE(S)

Région de Tunis :

Le contrôle sur la qualité bactériologique de l'eau de mer a été effectué le long du littoral qui borde la Région de Tunis (Nord et Sud) de Raouad à Bir El Bey.

Cette région concentre près du 25% de la population du pays qui fréquente les plages et à laquelle se joint un grand nombre de touristes. La région est plus industrialisée que le reste du territoire national.

L'arrière pays est couvert de terrains riches plantées en blé, vignes et cultures maraichères. Deux oueds pérennes, le Miliane et le Soltane, traversent l'arrière pays; cependant l'action plus au Nord de l'Oued Medjerdah n'est pas à négliger.

Région du Sahel :

Le contrôle est étendu sur trois secteurs du littoral du Sahel (au Nord à partir de Hergla, au Sud jusqu'à Salacta, soit 60 km) à vocation essentiellement touristique et récréative : Sousse, Monastir et Mahdia.

Abstraction faite des zones urbaines de Sousse, Monastir et Mahdia, les terrains environnant les stations de prélèvement sont plantés d'oliviers ou sont sablonneux non cultivés et ne présentent pas de sources de pollution.

Les hôtels implantée dans la zone étudiée disposent de stations d'épuration où se déversent les eaux usées.

Pour la période janvier à décembre 1980 plus particulièrement furent étudiées les zones côtieres de Bizerte, Tunis Nord, Tunis Sud, Nabeul, Sousse,Monastir. Les échantillons ont été prélevés dans 94 stations fixes siégeant de preférence sur des plages à vocation balnéaire. Leur répartition en zones et secteurs est présenté dans le tableau XIX et sur la carte (Figure 1).

Zone de Bizerte :

Les points de prélèvements sont répartis au Nord de Bizerte (Secteur Corniche) sur une côte à vocation balnéaire dont les plages sont largement fréquentées par la population et par les touristes. Signalons la présence dans ce secteur de cinq grands hôtels hébergeant des milliers de vacanciers pendant la saison estivale. On trouve des amas d'algues de types Posidoniers et de Zoostères.

L'arrière-pays est argilo-sableux. Les terrains sont plantés de cultures maraîchères, d'oliviers et d'agrumes. Le secteur, y compris la zone de Bizerte, est adossé à quelques collines en partie couvertes de forêts. Tout au long de la côte de ce secteur, on trouve une rangée d'habitations isolées. Il n'existe pas de développement industriel ni artisanal. La côte est exempte d'effluents et de déversements d'eaux usées.

Zone de Tunis :

Cette région compte près du 1/4 de la population du pays. La banlieue Sud est industrialisée.

Tunis Nord :

L'arrière-pays est argilo-gréseux et calcaire. On y trouve des étangs d'eau saumâtre sans accès sur la mer. Le terrain est riche et planté de blé, de cultures maraîchères et d'agrumes. Il existe quelques collines qui ne dépassent pas 80 m. Sur leurs versants, se situent les agglomérations de La Marsa, de Sidi Bou Said, de Carthage où la population double ou triple pendant la saison estivale. Le littoral qui borde ces agglomérations reçoit les eaux côtières par le biais de petit oueds encombrés de décharges domestiques. Cette zone constitue un vaste lieu de baignade avec plusieurs sites récréatifs.

Tunis Sud :

L'arrière-pays est argilo-sableux, plat, riche en étangs et en lagunes d'eau saumâtre avec accès sur la mer par des canaux naturels et artificiels. Au large, on trouve des algues marines. Le littoral est sableux et partiellement vaseux, il reçoit l'Oued Milane.

L'industrie est concentrée au Sud de Tunis. Les alentours des plages, en ggrande partie sites récréatifs, sont encombrés de décharges domestiques et même industrielles.

Zone de Nabeul :

L'arrière-pays est gréseux, argilo-gréseux ou marneux. Il forme la presqu'île du Cap Bon, terminaison est de la dorsale tunisienne. On y trouve quelques collines qui culminent à 300 - 400 m environ. La région est riche, propre aux cultures maraîchères, aux agrume et à l'élevage.

La côte est en pente douce et sableuse avec de larges plages bordées par de nombreux hôtels.

Plages et hôtels sont très fréquentés en saison estivale et l'agglomération de Nabeul qui compte 40 000 habitants double, voire triple en cette période de l'année. Il existe un important développement artisanal dans ce secteur (pôteries, tapis, ferronerie) qui ne semble pas entrainer un phénomène de pollution important au niveau de la frange littorale.

Zone de Sousse :

L'arrière-pays est argilo-gréseux, plat avec quelques collines qui ne dépassent pas 80 m de haut. La région se prête à la culture de l'olivier et des agrumes. La culture maraîchère sous serre s'y développe progressivement.

La côte est sableuse, basse avec un plateau continental qui s'étend très loin au large. Les plages, larges et vastes, se succèdent pratiquement sans interruption au niveau de la bordure littorale sur une distance de 50 - 60 km environ.

Ces plages ont permis la création du plus important complexe touristique de Tunisie par l'implantation d'un nombre important d'hôtels de haute tenue et de sites récréatifs à vocation balnéaire.

La population du Sahel triple peut-être plus en été, mais la beauté de la région, sa richesse archéologique jointes à la douceur relative du climat et à une infrastructure hôtelière particulièrment bien agencée font que cette région et fréquentée tout au long de l'année par les touristes étrangers.

MATERIEL ET METHODES

Pour la période mars à septembre 1979 :

Région de Tunis :

Dix-huit stations sont surveillées. Elles comprennent huit stations de surveillance dans une zone recréative, cinq (5) stations dans une zone exposée à une pollution tellurique et cinq (5) stations dans une zone éloignée d'une source quelconque de pollution. Les prélèvements sont effectués à 30 cm environ de la surface et à 10 m environ de la berge. Ils ont lieu une fois par mois.

Les procédés utilisés pour l'analyse des indicateurs de pollution fécale (coliformes totaux, coliformes fécaux, streptocoques fécaux) sont ceux préconisés par le projet pilote WHO/UNEP MED POL VII. L'identification des *E. coli* est faite à base de tests de fermentation du lactose à 44°C et production d'indole (44°C).

Région du Sahel :

Deux cents stations réparties sur 3 secteurs du littoral du Sahel (au Nord à partir de Hergla, au Sud jusqu'à Salacta, soit 60 kms) ont été prospectées. Ces secteurs à vocation essentiellement touristique sont Sousse, Monastir et Mahdia. Ces stations comprennent : 80 stations de surveillance dans des zones recréatives, 70 stations dans des zones exposées à une pollution tellurique, et 50 stations dans des zones éloignées non influencées par une source quelconque de pollution.

Les prélèvements on été effectués dans les eaux superficielles à 30 cm de la surface étant donné que les eaux de baignade dans cette région sont peu profondes le long de la berge (elles dépassent rarement 1 m de profondeur à 10-15 m de la berge).

Les prélèvements étaient hebdomadaires dans les stations de référence et mensuels dans les autres stations.

De mars à septembre 1979, 1 656 échantillons d'eau de mer ont été prélevés. Des échantillons de sable de certaines plage ont été également prélevés mais leur étude ne fait pas l'objet de ce rapport.

Les procédés utilisés pour évaluer les nombres les plus probables des indicateurs de pollution sont les même que ceux utilisés dans la région de Tunis. Cependant on a utilisé le milieu liquide "Lactose Broth/standard américain" au lieu de celui de MacConkey pour la determination des coliformes totaux en ajoutant comme indicateur pH du bleu de bromothymol.

Pour la période janvier - decembre 1980 :

Les prélèvements suivèrent les méthodes déjà utilisées. Un prélèvement de sédiment à été effectué à chaque point d'échantionnage.

Le nombre total des échantillons prélevés étaient de 3 021 (eau de mer 1 525 - sédiments 1 496). Les prélèvements de sédiments débutèrent en février 1980.

Pendant la même période 50 échantillons de mollusque sont été collectés dans les deux parcs de coquillages correspondant au points de prélèvements 13 à 17 et 27 à 31 dans le but de rechercher les correlations entre qualité de l'eau et des mollusques.

Les tests pratiqués furent les suivants :

a) Tests indicateurs de pollution fécale :

   Le nombre le plus probable (NPP) des coliformes totaux/100 ml.

   Le nombre le plus probable (NPP) Escherichia coli/100 ml.

   Le nombre le plus probable (NPP) Streptocoques fécaux/100 ml.

   Le titre des clostridium sulfito-réducteurs.

b) Tests indicateurs de pollution organique en général :

   Le nombre total de germes organotrophes mésophiles/ml. (37°C).

   Le nombre total de germes organotrophes mésophiles/ml. (20°C).

c) Germes pathogènes :

Présence de salmonella dans les échantillons de mollusques.

d) Tests physiques :

Température de l'eau;

Température de l'air;

Direction des vents;

Dynamique de l'eau de mer (mer calme, mer agitée).

Les procédés utilisés pour évaluer ces tests sont ceux recommendés par le projet (Guide pour la surveillance sanitaire de la qualité des eaux côtières, EURO/OMS, 1977).

RESULTATS ET LEURS INTERPRETATION

L'interprétation des résultats et les conclusions présentées dans ce rapport s'inspirent des normes recommandées par l'O.M.S. et la CEE (voir WHO/W.POLL.72, 10; Chroniques O.M.S., No.4, Vol.27; Journal Officiel des Communautés Européennes No. L 31 / 5 - 5.2.76).

Pour la périod mars - septembre 1979 :

Région de Tunis :

D'après les tableaux I à XVIII (ci-joints) et la position géographique des différentes stations, il semble que les eaux deviennent de plus en plus contaminées au fur et à mesure que l'on se rapproche des zones urbaines en général et de Tunis en particulier. Les eaux deviennent également de plus en plus impropres à la baignade avec la saison (maximums significatifs en juillet et en août). Ces phénomènes sont bien entendu liés au climat et à la température qui contribuent à la multiplication des germes pathogènes par augmentation de la charge du milieu en éléments nutritifs, à la mort et à la décomposition d'organismes benthiques et de vertébrés marins. L'homme aussi, joue un rôle fondamental dans cette contamination : les zones fréquentées par les baigneurs sont significativement plus polluées et cette pollution croît significativement en été où la fréquentation est multipliée par plusieurs milliers. Il apparaît également, au cours de l'année, que dans certaines stations normalement propres à la baignade, la contamination augmente brutalement et de façon significative. Ce phénomène se remarque lorsque la mer est agitée à fortement agitée : les rejets d'égoût qui se déversent au large des côtes sont refluées vers celles-ci qu'il polluent, principalement dans la région de Raouad qui les centralise. Cette action se fait davantage ressentir dans les stations impropres : Hamman-Lif notamment.

Région du Sahel :

Les résultats concernant les nombres les plus probables des germes indicateurs de pollution (coliformes totaux, coliformes fécaux, streptocoques fécaux) ont été analysés comme dans le cas de la région de Tunis. Cette analyse a abouti à une interprétation similaire des résultats obtenus.

Pour la période janvier - décembre 1980 :

Les résultats obtenus lors de la surveillance de la qualité de l'eau de mer éffectuée en 1980 sont présentés dans les tableaux XX à XXIX ci-joints.

l'examen des distributions par classe de contamination des eaux en coliformes totaux et fécaux et le calcul des moyennes relatives à ces mêmes distributions montrent que les eaux de mer analysées sont dans leur grande majorité significativement propres à la baignade.

En effet, 98.01% des échantillons observés sont nettement en-dessous des normes de pollution arrêtées par la C.E.E; 1.99% seulement des échantillons sont au-dessus de ces normes et s'avèrent donc impropres à la baignade.

Un examen analogue effectué sur les sédiments fait apparaître des résultats significativement identiques.

L'évaluation de la qualité bactériologique des eaux de mer et leur détermination en propres et impropres à la baignade est réalisée d'après les données concernant les tests coliformes : nombre le plus probable des coliformes totaux et nombre le plus probable des coliformes fécaux per 100 ml d'eau de mer analysée.

Ces résultats sont comparés aux normes arrêtées par la C.E.E. qui exigent :

- pour les coliformes totaux que l'eau définie "propre à la baignade ne doit pas contenir plus de 500 coliformes totaux dans 100 ml.

- pour les coliformes fécaux que cette même eau ne doit pas contenir plus de 200 coliformes fécaux dans 100 ml.

CONCLUSIONS

Pour la période mars - septembre 1979 :

Région de Tunis :

Dans la contamination des eaux de baignade, plusieurs facteurs semblent intervenir; ce sont, par ordre d'importance, dans le secteur concerné :

- rejets d'égoûts, déversoirs industriels etc.;

- facteurs climatiques, physico-chemiques et biologiques;

- éléments humain;

- courantologie et action des vents dont les influences sont difficiles, a priori, à délimiter et qui méritent de ce fait une étude plus approfondie.

Région du Sahel :

Nous aboutissons aux mêmes conclusions générales que pour la région de Tunis; il convient, cependant, de noter que dans cette région il existe des oueds non perennes dans lesquels sont déversées des déchets qui, au moment des crues, sont emportés par les eaux et polluent la milieu marin.

Pour la période janvier - décembre 1980 :

L'analyse des résultats permettant de conclure à une amélioration par rapport à nos constations antérieures notamment celles de 1979 concernant la région de Tunis et de Sousse. Cette amélioration serait la conséquence de la mise en fonction par l'Office National de l'Assainissement au début de l'année 1980 de stations d'épuration à Sousse, Nabeul et Monastir. Il faut reconnaître, également, qu'un effort non négligeable a été fait par les Municipalités dans le domaine de la collecte et l'évacuation des ordures ménagères dans des terrains éloignés du littoral.

Le pourcentage des secteurs qui restent encore pollués ne dépasse pas 1,9%.

De plus, la comparaison des différents secteurs où eaux de baignade et sédiments sont pollués met en évidence qu'ils correspondent aux mêmes points de prélèvements. Les germes pathogènes pourraient affecter d'abord l'eau de mer et, par dépôts successifs, les sédiments et ces derniers, par agitation, contamineraient l'eau de mer sus-jacente; un cyle de pollution très localisé s'établirait éventuellement.

Ces sites pollués concernent des secteurs encombrés par les décharges publiques et des déversement d'eau d'égoûts.

Enfin, les 98% de nos points de prélèvements où l'examen bactériologique a révélé une eau propre à la baignade, les sédiments au niveaux des mêmes points se sont également avérés non pollués même lorsque la mer est agitée, ce qui démontre bien la pureté naturelle et la protection des eaux littorales tunisiennes.

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CHADLI, A., CAPAPE, C. et CHOURABI, A. Note préliminaire à l'étude de la pollution bactérienne des eaux littorales des banlieues Nord et Sud de Tunis. Arch. Inst. Pasteur Tunis, 1979, 56, No. 4, pp.371-402.

Troisième Rapport sur la surveillance des zones côtières à usage récréatif et des parcs à coquillages (MED POL VII) Organisation Mondiale de la Santé - Bureau Régional de l'Europe - Copenhague, 1980.

CHADLI, A. et JEKOV, S. Application de la colimètrie à la surveillance des eaux côtières tunisiennes. Arch. Inst. Pasteur Tunis, 1980, 57, No.4, pp. 300-312. Comunication présentée au XXVII Congrès de la Commission Internationale pour l'exploration de la Méditerranée (CIESM) à Cagliari du 9 au 18 octobre 1980.

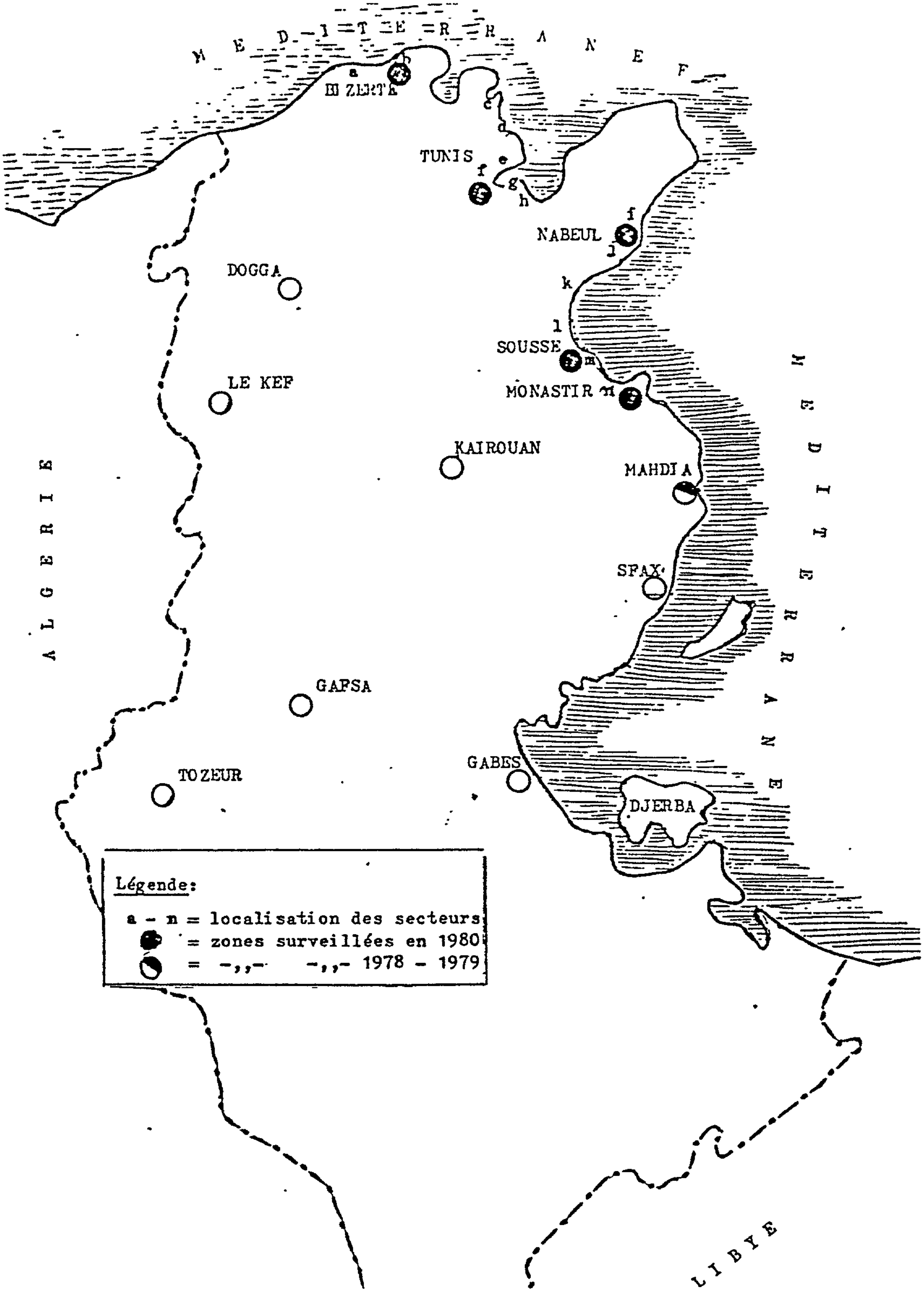

Fig. 1. MED VII-Zones et secteurs où sont effectués les prélèvements - 1980

Tableau 1

STATION 1

RAOUAD - Large

Témoin

Dates	Coliformes Totaux	Log	Coliformes Fécaux	Log	Streptocoques	Log
13.03.79	0	0	0	0	10	1
17.04.79	8	0,903	8	0,903	10	1
15.05.79	0	0	0	0	10	1
12.06.79	0	0	0	0	0	0
17.07.79	5	0,698	0	0	10	1
17.08.79	0	0	0	0	10	1
X Log		0,266		0,150		0,833
Ecart-type		0,380		0,336		0,371
Variance		0,145		0,113		0,138
Déviation Standard		0,418		0,368		0,408

Tableau 11

STATION 2

RAOUAD - "La Vague"

Dates	Coliformes Totaux	Log	Coliformes Fécaux	Log	Streptocoques	Log
13.03.79	0	0	0	0	10	1
17.04.79	9	0,954	9	0,954	10	1
15.05.79	240	2,380	64	1,806	10	1
12.06.79	32	1,505	32	1,505	10	1
17.07.79	64	1,806	64	1,806	10	1
17.08.79	0	0	0	0	10	1
X Log		1,107		1,101		1
Ecart-type		0,888		0,769		0
Variance		0,790		0,592		0
Déviation Standard		0,973		0,843		0

Tableau 111

STATION 3

RAOUAD - "Pêcheur"

Dates	Coliformes Totaux	Log	Coliformes Fécaux	Log	Streptocoques	Log
13.03.79	15	1,176	15	1,176	10	1
17.04.79	64	1,806	64	1,806	10	1
15.05.79	0	0	0	0	10	1
12.06.79	64	1,806	64	1,806	10	1
17.07.79	15	1,176	9	0,954	10	1
17.08.79	39	1,591	31	1,491	10	1
X Log.		1,259		1,204		1
Ecart-type		0,824		0,622		0
Variance		0,384		0,387		0
Déviation Standard		0,680		0,681		0

Tableau IV

STATION 4

MARSA Cube

Dates	Coliformes Totaux	Log	Coliformes Fécaux	Log	Streptocoques	Log
13.03.79	0	0	0	0	10	1
17.04.79	0	0	0	0	10	1
15.05.79	0	0	0	0	10	1
12.06.79	32	1,505	32	1,505	10	1
17.07.79	240	2,380	240	1,380	10	1
17.08.79	64	1,806	9	0,954	10	1
X Log.		0,948		0,639		1
Ecart-type		1,076		0,724		0
Variance		0,965		0,437		0
Déviation Standard		0,986		0,724		0

Tableau V

STATION 5

MARSA PLAGE 1

Dates	Coliformes Totaux	Log	Coliformes Fécaux	Log	Streptocoques	Log
13.03.79	700	2,845	700	2,845	10	1
17.04.79	0	0	0	0	10	1
15.05.79	64	1,806	64	1,806	10	1
12.06.79	700	2,845	700	2,845	10	1
17.07.79	0	0	0	0	10	1
17.08.79	0	0	0	0	10	1
X Log.		1,249		1,249		1
Ecart-type		1,480		1,480		0
Variance		0,704		0,704		0
Déviation Standard		1,420		1,420		0

Tableau VI

STATION 6

MARSA PLAGE 2

Dates	Coliformes Totaux	Log	Coliformes Fécaux	Log	Streptocoques	Log
13.03.79	0	0	0	0	10	1
17.04.79	15	1,176	15	1,176	10	1
15.05.79	240	2,380	240	2,380	10	1
12.06.79	700	2,845	700	2,845	10	1
17.07.79	32	1,505	32	1,505	10	1
17.08.79	2400	3,380	2400	3,380	10	1
X Log.		1,881		1,881		1
Ecart-type		1,134		1,134		0
Variance		1,286		1,286		0
Déviation Standard		1,233		1,233		0

Tableau VII

STATION 7

AMILCAR

Dates	Coliformes Totaux	Log	Coliformes Fécaux	Log	Streptocoques	Log
13.03.79	0	0	0	0	10	1
17.04.79	15	1,176	15	1,176	10	1
15.05.79	2400	3,380	2400	3,380	10	1
12.06.79	0	0	0	0	0	0
17.07.79	0	0	0	0	0	0
17.08.79	0	0	0	0	10	1
X Log.		0,759		0,759		0,667
Ecart-type		1,247		1,247		0,516
Variance		1,557		1,557		0;222
Déviation Standard		1,367		1,367		0,516

Tableau VIII

STATION 8

CARTHAGE

Dates	Coliformes Totaux	Log	Coliformes Fécaux	Log	Streptocoques	Log
13.03.79	5	0,698	5	0,698	10	1
17.04.79	32	1,505	32	1,505	10	1
15.05.79	64	1,806	64	1,806	10	1
12.06.79	0	0	0	0	0	0
17.07.79	64	1,806	64	1,806	10	1
17.08.79	0	0	0	0	10	1
X Log.		0,969		0,969		1
Ecart-type		0,778		0,778		0
Variance		0,606		0,606		0
Déviation Standard		0,853		0,853		0

Tableau IX

STATION 9

Le Kram

Polluée

Dates	Coliformes Totaux	Log	Coliformes Fécaux	Log	Streptocoques	Log
13.03.79	5	0,698	5	0,698	10	1
17.04.79	240	2,380	240	2,380	10	1
15.05.79	2400	3,380	2400	3,380	10	1
12.06.79	700	2,845	700	2,845	10	1
17.07.79	240	2,380	240	2,380	10	1
17.08.79	700	2,845	700	2,845	10	1
X Log.		2,421		2,421		1
Ecart-type		0,841		0,841		0
Variance		0,708		0,708		0
Déviation Standard		0,922		0,922		0

Tableau X

STATION 10

KHEREDDINE

Dates	Coliformes Totaux	Log	Coliformes Fécaux	Log	Streptocoques	Log
13.03.79	9	0,952	9	0,952	10	1
17.04.79	0	0	0	0	10	1
15.05.79	32	1,505	32	1,505	10	1
12.06.79	32	1,505	32	1,505	10	1
17.07.79	9	0,952	9	0,952	10	1
17.08.79	700	2,845	700	2,845	10	1
X Log.		1,293		1,293		1
Ecart-type		0,856		0,856		0
Variance		0,733		0,733		0
Déviation Standard		0,938		0,938		0

Tableau XI

STATION 11

La Goulette-Casino

Dates	Coliformes Totaux	Log	Coliformes Fécaux	Log	Streptocoques	Log
13.03.79	64	1,806	64	1,806	10	1
17.04.79	0	0	0	0	10	1
15.05.79	32	1,505	32	1,505	10	1
12.06.79	32	1,505	32	1,505	10	1
17.07.79	9	0,954	9	0,954	10	1
17.08.79	0	0	0	0	10	1
X Log.		0,961		0,961		1
Ecart-type		0,891		0,891		0
Variance		0,525		0,525		0
Déviation Standard		0,794		0,794		0

Tableau XII

STATION 12

La Goulette - Plage
Polluée

Dates	Coliformes Totaux	Log	Coliformes Fécaux	Log	Streptocoques	Log
13.03.79	86	1,934	86	1,934	10	1
17.04.79	0	0	0	0	0	0
15.05.79	48	1,681	20	1,301	10	1
12.06.79	240	2,380	240	2,380	10	1
17.07.79	32	1,505	32	1,505	10	1
17.08.79	0	0	0	0	10	1
X Log.		1,250		1,186		1
Ecart-type		0,952		0,904		0
Variance		0,853		0,818		0
Déviation Standard		1,011		0,991		0

Tableau XIII

STATION 13

RADES

Témoin

Dates	Coliformes Totaux	Log	Coliformes Fécaux	Log	Streptocoques	Log
13.03.79	0	0	0	0	10	1
17.04.79	0	0	0	0	0	0
15.05.79	0	0	0	0	10	1
12.06.79	0	0	0	0	10	1
17.07.79	0	0	0	0	0	0
17.08.79	0	0	0	0	0	0
X Log.						0,500
Ecart-type						0,5
Variance						0,250
Déviation Standard						0,547

Tableau XIV

STATION 14

EZ-ZAHRA

Témoin

Dates	Coliformes Totaux	Log	Coliformes Fécaux	Log	Streptocoques	Log
13.03.79	0	0	0	0	0	0
17.04.79	0	0	0	0	0	0
15.05.79	0	0	0	0	10	1
12.06.79	0	0	0	0	0	0
17.07.79	700	2,845	700	2,845	10	1
17.08.79	0	0	0	0	0	0
X Log.		0,474		0,474		0,333
Ecart-type		1,060		1,060		0,471
Variance		1,124		1,124		0,222
Déviation Standard		1,161		1,161		0,516

Tableau XV

STATION 15

HAMMAM-LIF - LA SIRENE

Polluée

Dates	Coliformes Totaux	Log	Coliformes Fécaux	Log	Streptocoques	Log
13.03.79	240	2,380	240	2,380	10	1
17.04.79	2400	3,380	2400	3,380	10	1
15.05.79	2400	3,380	2400	3,380	10	1
12.06.79	2400	3,380	2400	3,380	10	1
17.07.79	2400	3,380	2400	3,380	10	1
17.08.79	2400	3,380	2400	3,380	10	1
X Log.		3,213		3,213		1
Ecart-type		0,371		0,371		0
Variance		0,138		0,138		0
Déviation Standard		0,408		0,408		0

Tableau XVI

STATION 16

HAMMAM-LIF - PLAGE

Polluée

Dates	Coliformes Totaux	Log	Coliformes Fécaux	Log	Streptocoques	Log
13.03.79	15	2,708	15	2,708	10	1
17.04.79	9	0,954	9	0,954	10	1
15.05.79	64	1,806	32	1,505	10	1
12.06.79	700	2,845	700	2,845	10	1
17.07.79	2400	3,380	2400	3,380	10	1
17.08.79	64	1,806	64	1,806	10	1
X Log.		2,249		2,199		1
Ecart-type		0,884		0,842		0
Variance		0,652		0,709		0
Déviation Standard		0,885		0,922		0

Tableau XVII

STATION 17

BIR - EL - BEY

Témoin

Dates	Coliformes Totaux	Log	Coliformes Fécaux	Log	Streptocoques	Log
13.03.79	0	0	0	0	0	0
17.04.79	0	0	0	0	10	1
15.05.79	5	0,698	0	0	10	1
12.06.79	0	0	0	0	10	1
17.07.79	2400	3,380	2400	3,380	10	1
17.08.79	0	0	0	0	10	1
X Log.		0,679		0,563		0,833
Ecart-type		1,234		1,259		0,408
Variance		1,523		1,586		0,138
Déviation Standard		1,352		1,379		0,408

Tableau XVIII

STATION 18

BORJ - CEDRIA

Témoin

Dates	Coliformes Totaux	Log	Coliformes Fécaux	Log	Streptocoques	Log
13.03.79	0	0	0	0	0	0
17.04.79	0	0	0	0	10	1
15.05.79	2400	3,380	2400	3,380	10	1
12.06.79	0	0	0	0	0	0
17.07.79	64	1,806	38	1,505	10	0
17.08.79	0	0	0	0	10	1
X Log.		0,864		0,814		0,5
Ecart-type		1,194		1,180		0,5
Variance		1,700		1,618		0,25
Déviation Standard		1,428		1,393		0,547

Tableau XIX

	ZONES	SECTEURS	Nbre de stations par sect.	Nbre de stations par zone
1	BIZERTE	Corniche (a)	12	
		Menzel Jemil (b)	5	17
2	TUNIS	Gammarth (c)	9	
		Le Pêcheur (d)	6	
		La Marsa (e)	6	
		La Goulette (f)	4	
		Ez-Zahra (g)	8	
		Hammam-Lif (h)	6	39
3	NABEUL	Nabeul Ville (i)	8	
		Hammamet (j)	7	15
4	SOUSSE	Hergla (k)	5	
		Port de Plaisance (l)	6	
		Sousse-Ville (m)	7	
		Monastir (n)	5	23
TOTAL	4	14	94	94

Tableau XX

Direction des vents et dynamique de l'eau de mer lors de l'échantillonnage en 1980

Secteur	Dynamique de	Direction des Vents												
Mois - 1980	l'eau de Mer	A	B	C	D	E	F	G	H	I	J	K	L	M
JANVIER	Agitée	S.O	S.O	S/S.O	O/S.O	O/S.O								
FEVRIER	"	N.E	N.E	N.O	N.O	N.O	N.O	N.O	N.O	N.O	N.O	E/S.E	E/SE	E/SE
MARS	"	N	N	O	O	N	N	N	N	O	O	S.E	S.E	S.E
AVRIL	"	N.O	N	N.O	N.O	N.O	N.O	N.O	N.O	N.O	N.O	N.O	N.O	N.O
MAI	"	N.E	N.E	S.E	S.E	N.O	N.O	E	E	$\frac{N.O}{E}$	NO/NE	NO/O	NO/O	NO/O
JUIN	Calme	Variable	Variable	N.E NE/NO	NE/NO	E/N.O	E/NO	E/N.O	E/N.O	E/NO	E	E	S.E	S.E
JUILLET	"	E/SE	E/SE	$\frac{N.E}{N.O}$	$\frac{N.E}{N.O}$	$\frac{N.O}{N.E}$	$\frac{N.O}{N.E}$	$\frac{S.E}{N.O}$	$\frac{S.E}{N.O}$	$\frac{N.E}{E}$	$\frac{N.E}{E}$	$\frac{N.O}{E}$	N.O	N.O
AOUT	"	S.E	S.E	E	E	E	N.O	N.O	N.O	S.E	S.E	$\frac{O}{N.O}$	$\frac{O}{N.O}$	$\frac{O}{N.O}$
SEPTEMBRE	Agitée	Variable	Variable	N.O	N.O	N.O	$\frac{O}{N.O}$	$\frac{O}{N.O}$	$\frac{O}{N.O}$	$\frac{N.O}{N.E}$	$\frac{N.O}{N.E}$	$\frac{N.E}{E}$	$\frac{N.E}{E}$	$\frac{N.E}{E}$
OCTOBRE	"	$\frac{O}{N.O}$	$\frac{O}{N.O}$	$\frac{E}{N.O}$	$\frac{E}{N.E}$	$\frac{E}{N.E}$	E	$\frac{N.O}{N.E}$	$\frac{N.O}{N.E}$	E	E	$\frac{S.O}{S.E}$	$\frac{S.O}{S.E}$	N.E
NOVEMBRE	"	N/O	N	$\frac{S.O}{N.O}$	$\frac{S.O}{N.O}$	O	O	$\frac{O}{E}$	$\frac{O}{E}$	E	E	S	S	S
DECEMBRE	"	N.E	N.E	N.E	N.E	N.E	N.E	N.E	N.E	N.E	N.E	N	N	N.O

Tableaux XXI

Distribution par classe de contamination
des eaux en Coliformes totaux (N.P.P C.T/100 ml)

CLASSES (EN %)																	
N° Station	< 10	11 à 100	101 à 500	501 à 1000	> 1000	N° Station	< 10	11 à 100	101 à 500	501 à 1000	> 1000	N° Station	< 10	11 à 100	101 à 500	501 à 1000	> 1000
	%						%						%				
1	53		0	0	0	33	82	18	0	0	0	65	100	0	0	0	0
2	59	23	6	0	12	34	88	12	0	0	0	66	100	0	0	0	0
3	94	6	0	0	0	35	94	6	0	0	0	67	94	6	0	0	0
4	94	6	0	0	0	36	94	6	0	0	0	68	100	0	0	0	0
5	88	12	0	0	0	37	88	12	0	0	0	69	94	6	0	0	0
6	76	24	0	0	0	38	82	18	0	0	0	70	94	6	0	0	0
7	88	12	0	0	0	39	72	30	0	0	0	71	94	6	0	0	0
8	82	18	0	0	0	40	67	22	11	0	0	72	94	6	0	0	0
9	82	12	0	0	6	41	67	28	5	0	0	73	94	6	0	0	0
10	94	6	0	0	0	42	61	39	0	0	0	74					
11	81	12	0	0	7	43	76	24	0	0	0	75	88	6	0	0	6
12	62	25	6	0	7	44	76	24	0	0	0	76	81	19	0	0	0
13	93	7	0	0	0	45	76	18	6	0	0	77	69	31	0	0	0
14	93	7	0	0	0	46	70	30	0	0	0	78	75	25	0	0	0
15	93	7	0	0	0	47	76	24	0	0	0	79	88	12	0	0	0
16	100	0	0	0	0	48	65	35	0	0	0	80	56	38	0	0	6
17	93	7	0	0	0	49	76	24	0	0	0	81	60	40	0	0	0
18	89	6	0	5	0	50	70	30	0	0	0	82	69	31	0	0	0
19	94	0	0	6	0	51	12	41	12	6	30	83	71	29	0	0	0
20	89	11	0	0	0	52	41	35	12	6	6	84	67	33	0	0	0
21	89	6	5	0	0	53	41	23	12	18	6	85	67	33	0	0	0
22	94	0	6	0	0	54	41	47	0	6	6	86	56	38	6	0	0
23	89	11	0	0	0	55	53	18	23	0	6	87	53	47	0	0	0
24	89	11	0	0	0	56	64	18	6	6	6	88	50	50	0	0	0
25	94	6	0	0	0	57	100	0	0	0	0	89	67	33	0	0	0
26	78	22	0	0	0	58	94	6	0	0	0	90	58	42	0	0	0
27	73	27	0	0	0	59	100	0	0	0	0	91	92	8	0	0	0
28	93	7	0	0	0	60	88	12	0	0	0	92	75	25	0	0	0
29	93	7	0	0	0	61	88	12	0	0	0	93	58	42	0	0	0
30	100	0	0	0	0	62	88	12	0	0	0	94	92	8	0	0	0
31	93	7	0	0	0	63	88	12	0	0	0						
32	87	13	0	0	0	64	88	12	0	0	0						

Moyenne (%) :

< 10	=	79,50
de 11 à 100	=	17,3043
de 101 à 500	=	1,5073
de 501 à 1000	=	0,5798
> 1000	=	1,1102

Tableaux XXII

Distribution par classe de contamination des eaux de mer en Escherichia coli (N.P.P Coliformes fécaux /100 ml)

								C L A S S E S									
N° Station	< 10	11 à 100	101 à 200	201 à 500	> 500	N° Station	< 10	11 à 100	101 à 200	201 à 500	> 500	N° Station	< 10	11 à 100	101 à 200	201 à 500	> 50
		%						%						%			
1	72	28	0	0	0	33	100	0	0	0	0	65	100	0	0	0	0
2	61	39	0	0	0	34	100	0	0	0	0	66	100	0	0	0	0
3	94	6	0	0	0	35	100	0	0	0	0	67	94	0	0	0	6
4	94	6	0	0	0	36	94	6	0	0	0	68	100	0	0	0	0
5	82	18	0	0	0	37	94	6	0	0	0	69	94	0	0	0	6
6	88	12	0	0	0	38	94	6	0	0	0	70	100	0	0	0	0
7	100	0	0	0	0	39	72	28	0	0	0	71	100	0	0	0	0
8	94	6	0	0	0	40	83	11	0	6	0	72	100	0	0	0	0
9	94	6	0	0	0	41	67	28	0	5	0	73	94	6	0	0	0
10	100	0	0	0	0	42	72	28	0	0	0	74					
11	88	6	0	6	0	43	82	18	0	0	0	75	94	6	0	0	0
12	63	31	0	6	0	44	76	24	0	0	0	76	94	6	0	0	0
13	100	0	0	0	0	45	88	12	0	0	0	77	87	13	0	0	0
14	100	0	0	0	0	46	76	24	0	0	0	78	81	19	0	0	0
15	100	0	0	0	0	47	82	18	0	0	0	79	87	13	0	0	0
16	100	0	0	0	0	48	71	23	6	0	0	80	75	25	0	0	0
17	100	0	0	0	0	49	82	12	0	6	0	81	60	40	0	0	0
18	100	0	0	0	0	50	88	6	0	6	0	82	81	19	0	0	0
19	94	6	0	0	0	51	24	35	6	6	29	83	73	27	0	0	0
20	100	0	0	0	0	52	35	41	0	12	12	84	80	20	0	0	0
21	94	6	0	0	0	53	47	29	0	12	12	85	87	13	0	0	0
22	100	0	0	0	0	54	47	35	0	6	12	86	62	38	0	0	0
23	100	0	0	0	0	55	59	23	0	12	6	87	67	33	0	0	0
24	100	0	0	0	0	56	59	23	0	18	0	88	71	29	0	0	0
25	100	0	0	0	0	57	100	0	0	0	0	89	80	20	0	0	0
26	94	6	0	0	0	58	100	0	0	0	0	90	75	25	0	0	0
27	67	33	0	0	0	59	100	0	0	0	0	91	92	80	0	0	0
28	67	33	0	0	0	60	100	0	0	0	0	92	83	17	0	0	0
29	100	0	0	0	0	61	94	6	0	0	0	93	92	80	0	0	0
30	100	0	0	0	0	62	81	13	0	0	6	94	92	80	0	0	0
31	100	0	0	0	0	63	87	13	0	0	0						
32	100	0	0	0	0	64	94	6	0	0	0						

Moyenne (%) :

< 10	=	86 %
de 11 à 100	=	13,74 %
de 101 à 200	=	0,13 %
de 201 à 500	=	0 %
> 500	=	0,13 %

Tableau XXIII

Distribution des classe de contamination des Sédiments en coliformes (N.P.P.C./100 ml) totaux

N° Station	< 10 (%)	11 à 100 (%)	101 à 500 (%)	501 à 1000 (%)	> 1000 (%)
1	50	50	0	0	0
2	50	31	6	0	13
3	88	12	0	0	0
4	94	6	0	0	0
5	81	19	0	0	0
6	69	31	0	8	0
7	100	0	0	0	0
8	94	6	0	0	0
9	88	6	0	0	6
10	88	12	0	0	0
11	93	7	0	0	0
12	53	40	0	0	7
13	93	0	7	0	0
14	93	7	0	0	0
15	93	7	0	0	0
16	100	0	0	0	0
17	93	7	0	0	0
18	89	5	0	6	0
19	89	5	0	6	0
20	94	0	0	6	0
21	89	5	6	0	0
22	88	6	6	0	0
23	94	0	0	6	0
24	83	17	0	0	0
25	94	0	6	0	0
26	83	17	0	0	0
27	73	13	0	13	0
28	93	7	0	0	0
29	87	13	0	0	0
30	100	0	0	0	0
31	87	13	0	0	0
32	87	13	0	0	0
33	82	12	6	0	0
34	94	6	0	0	0
35	82	18	0	0	0
36	94	6	0	0	0
37	76	24	0	0	0
38	76	24	0	0	0
39	50	33			
40	50	44	6	0	0
41	72	28	0	0	0
42	65	29	6	0	0
43	70	30	0	0	0
44	76	24	0	0	0
45	76	24	0	0	0
46	76	24	0	0	0
47	70	24	6	0	0
48	76	24	0	0	0
49	70	30	0	0	0
50	76	24	0	0	0
51	18	29	17	6	30
52	35	35	12	0	18
53	47	18	23	0	12
54	47	41	6	6	0
55	59	18	12	6	5
56	35	47	6	6	6
57	100	0	0	0	0
58	100	0	0	0	0
59	100	0	0	0	0
60	73	27	0	0	0
61	87	13	0	0	0
62	80	20	0	0	0
63	80	20	0	0	0
64	100	0	0	0	0
65	100	0	0	0	0
66	100	0	0	0	0
67	87	7	0	0	6
68	93	7	0	0	0
69	88	6	6	0	0
70	100	0	0	0	0
71	100	0	0	0	0
72	100	0	0	0	0
73	93	0	7	0	0
74					
75	86	14	0	0	0
76	79	21	0	0	0
77	67	33	0	0	0
78	60	40	0	0	0
79	80	20	0	0	0
80	40	60	0	0	0
81	86	14	0	0	0
82	67	33	0	0	0
83	57	43	0	0	0
84	57	43	0	0	0
85	64	36	0	0	0
86	60	33	7	0	0
87	47	46	7	0	0
88	64	29	7	0	0
89	53	40	7	0	0
90	75	25	0	0	0
91	83	17	0	0	0
92	75	25	0	0	0
93	58	42	0	0	0
94	75	25	0	0	0

Moyenne (%) :

< 10	=	77,8064
de 11 à 100	=	18,4070
de 101 à 500	=	1,8695
de 501 à 1000	=	0,6630
> 1000	=	1,1195

Tableaux XXIV

Distribution par classe de contamination des sédimentes en Escherichia coli (N.P.P Coliformes fécaux /100 ml)

	CLASSES																
N° Station	< 10	11 à 100	101 à 200	201 à 500	> 500	N° Station	< 10	11 à 100	101 à 200	201 à 500	> 500	N° Station	< 10	11 à 100	101 à 200	201 à 500	> 500
	%						%						%				
1	71	29	0	0	0	33	88	6	6	0	0	65	100	0	0	0	0
2	53	35	0	12	0	34	100	0	0	0	0	66	100	0	0	0	0
3	94	6	0	0	0	35	88	12	0	0	0	67	93	0	0	0	7
4	94	6	0	0	0	36	94	6	0	0	0	68	100	0	0	0	0
5	81	19	0	0	0	37	82	18	0	0	0	69	94	0	0	6	0
6	81	19	0	0	0	38	94	6	0	0	0	70	100	0	0	0	0
7	100	0	0	0	0	39	78	11	0	11	0	71	100	0	0	0	0
8	100	0	0	0	0	40	72	28	0	0	0	72	100	0	0	0	0
9	93	7	0	0	0	41	89	11	0	0	0	73	93	0	0	7	0
10	94	6	0	0	0	42	71	23	0	6	0	74					
11	93	7	0	0	0	43	82	12	0	0	6	75	93	7	0	0	0
12	60	33	0	7	0	44	82	18	0	0	0	76	93	7	0	0	0
13	100	0	0	0	0	45	76	24	0	0	0	77	87	13	0	0	0
14	100	0	0	0	0	46	100	8	0	0	0	78	67	33	0	0	0
15	100	0	0	0	0	47	70	30	0	0	0	79	87	13	0	0	0
16	100	0	0	0	0	48	76	24	0	0	0	80	67	33	0	0	0
17	93	7	0	0	0	49	76	24	0	0	0	81	86	14	0	0	0
18	100	0	0	0	0	50	76	18	0	0	6	82	70	30	0	0	0
19	94	6	0	0	0	51	7	60	0	13	20	83	71	29	0	0	0
20	100	0	0	0	0	52	35	35	6	12	12	84	71	29	0	0	0
21	94	6	0	0	0	53	48	30	0	11	11	85	79	21	0	0	0
22	100	0	0	0	0	54	47	41	0	6	6	86	87	13	0	0	0
23	100	0	0	0	0	55	59	29	0	6	6	87	73	27	0	0	0
24	94	6	0	0	0	56	47	41	0	12	0	88	64	29	7	0	0
25	100	0	0	0	0	57	100	0	0	0	0	89	80	13	0	7	0
26	94	6	0	0	0	58	100	0	0	0	0	90	75	25	0	0	0
27	73	20	0	0	0	59	100	0	0	0	0	91	83	17	0	0	0
28	67	33	0	0	0	60	87	13	0	0	0	92	75	25	0	0	0
29	100	0	0	0	0	61	93	7	0	0	0	93	83	17	0	0	0
30	100	0	0	0	0	62	88	20	0	0	0	94	92	8	0	0	0
31	100	0	0	0	0	63	93	7	0	0	0						
32	100	0	0	0	0	64	93	7	0	0	0						

Moyenne (%) : < 10 = 85 %
de 11 à 100 = 13 %
de 101 à 200 = 0
de 201 à 500 = 1 %
> 500 = 1 %

Tableaux XXV

Distribution par classe de contamination des eaux de mer et des sédiments en Coliformes totaux et en Escherichia coli (Coliformes fécaux) présentée en moyenes %

Classe : Coliformes Totaux / Fécaux — Test	< 10		11 à 100		101 à 500 / 101 à 200		501 à 1000 / 201 à 500		> 1.000 / > 500	
	Eau	Sédim.	Eau	Sédim.	Eau	Sédim	Eau	Sédim.	Eau	Séd
Coliformes Totaux	79,47	77,80	17,30	18,38	1,24	1,86	0,56	0,66	1,18	1,1
Escherichia Coli (Coliformes Fécaux)	85	84	13	14	1	0,1	1	1	0	0,9

Tableau XXVI

Distribution par classe "Propre à la baignade " ou "Impropre à la baignade " selon les Normes de CEE concernant les testes : NPP Coliformes totaux / 100 ml et NPP Coliformes fécaux/100 ml .

	Propre à la Baignade (%)		Impropre à la baignade (%)	
	Eau	Sédiment	Eau	Sédiment
Coliformes totaux	98,01	98,04	1,99	1, 96
Escherichia coli (Coliformes fécaux)	99,00	98,10	1	1,90

Tableaux XXVII

Temperatures de l'air et de l'eau de mer
lors de l'échantillonnage 1980

Mois	Température	A	B	C	D	E	F	G	H	I	J	K	L	M	N
		SECTEURS													
JANVIER	1° l'air	17°	17°	15°	15°	18°	18°	12°	12°			14°	14°	14°	
	2° l'Eau	15°	15°	13°	13°	13°	13°	12°	12°			13°	13°	13°	
FEVRIER	1° l'Air	16°	16°	15°	15°	13°	13°	16°	16°	13°	13°	15°	14°	14°	
	2° l'Eau	14°	14°	14°	14°	12°	12°	13°	13°	12°	12°	13°	13°	13°	
MARS	1° L'air	15°	15°	17°	20°	16°	16°	17°	17°	18°	18°	19°	19°	19°	19°
	2° L'eau	14°	14°	16°	16°	16°	16°	14°	14°	17°	17°	17°	17°	17°	17°
AVRIL	1° l'air	18°	18°	19°	19°	18°	18°	17°	17°	18°	18°	21°	21°	21°	21°
	2° l'eau	17°	17°	18°	18°	17°	17°	15°	15°	17°	17°	18°	18°	18°	18°
MAI	1° L'air	20°	20°	19°	19°	22°	22°	19°	19°	23°	23°	21°	21°	21°	21°
		20°	20°	14°	14°	14°	14°	20°	20°	19°	19°				
	2° L'eau	19°	19°	18°	18°	18°	18°	18°	18°	20°	20°	20°	20°	20°	20°
		18°	18°	15°	15°	15°	15°	19°	19°	21°	21°				
JUIN	1° L'air	24°	24°	18°	18°	18°	24°	24°	24°	23°	23°	25°	25°	25°	25°
		24°	24°	24°	24°	22°	22°	27°	27°	28°	28°	23°	23°	23°	23°
	2° l'Eau	22°	22°	21°	19°	21°	21°	21°	21°	25°	25°	26°	26°	26°	26°
		22°	22°	21°	21°	23°	23°	24°	24°	22°	22°	22°	22°	22°	22°
JUILLET	1° L'air	28°	28°	24°	24°	25°	25°	35°	35°	25°	25°	24°	24°	24°	24°
		22°	22°	26°	26°	26°	26°	26°	26°	31°	31°	25°	25°	25°	25°
	2° L'eau	26°	26°	26°	26°	24°	24°	28°	28°	21°	21°	26°	26°	26°	26°
		24°	24°	24°	24°	24°	24°	24°	24°	28°	28°	24°	24°	24°	24°
AOUT	1° L'air	28°	28°	30°	30°	30°	34°	34°	34°	30°	30°	30°	30°	30°	30°
		29°	29°	27°	27°	30°	30°	30°		28°	28°	30°	30°	30°	30°
	2° L'eau	27°	27°	28°	28°	28°	28°	28°	28°	28°	28°	28°	28°	28°	28°
		28°	28°	25°	25°	28°	28°	28°		27°	27°	28°	26°	28°	28°
SEPTEMBRE	1° L'air	28°	28°	27°	27°	27°	30°	30°	30°	29°	29°	28°	28°	29°	29°
		24°	24°	25°	25°	25°	25°	24°	24°					24°	24°
	2° L'eau	24°	24°	25°	25°	25°	28°	28°	28°	28°	28°	27°	27°	28°	28°
		26°	26°	23°	23°	24°	24°	26°	26°					25°	25°
OCTOBRE	1° L'air	19°	19°	25°	25°	24°	24°	26°	26°	29°	29°	24°	24°		
				20°	20°	20°	21°	21°	21°	22°	22°				
	2° L'eau	18°	18°	26°	26°	23°	23°	24°	24°	26°	26°	21°	21°		
				19°	19°	19°	19°	19°	19°	20°	20°				
NOVEMBRE	1° L'air	19°	19°	20°	20°	19°	19°	21°	21°	19°	19°	22°	22°	22°	22°
	2° L'eau	18°	18°	19°	19°	20°	20°	20°	20°	20°	20°	20°	20°	20°	20°
DECEMBRE	1° L'air	14°	14°	10°	10°	10°	10°	10°	10°	12°	12°	12°	12°	12°	12°
	2° L'eau	14°	14°	14°	14°	14°	14°	14°	14°	11°	11°				

Tableau XXVIII

TABLEAU COMPARATIF DES DONNEES SUR LES N.P.P DES COLIFORMES TOTAUX /100 ML TRANSFORMEES EN MOYENNE LOGARITHMIQUE, VARIANCE ET ECART TYPE RELATIVES AUX ECHANTILLONS D'EAU DE MER ET AUX ECHANTILLONS DE SEDIMENTS.

N° Station	Nombre d'Echantillon X/S	N.P.P /100 ml Coliformes Totaux					
		EAU DE MER			SEDIMENT		
		Moyenne Logarithmique	Variance	Ecart Type	Moyenne Logarithmique	Variance	Ecart Type
1	18/17	0,7855	0,2841	0,5330	0,9134	0,3104	0,5572
2	18/17	1,1537	1,1075	1,0524	1,1931	1,2478	1,1170
3	18/17	0,2926	0,1594	0,3993	0,3111	0,2824	0,5314
4	18/17	0,2696	0,2261	0,4755	0,2897	0,2085	0,4566
5	17/16	0,3769	0,2653	0,5151	0,5399	0,4899	0,6999
6	17/16	0,5795	0,3086	0,555	0,5295	0,2411	0,4910
7	17/14	0,2605	0,4124	0,6421	0,3109	0,2425	0,4925
8	17/16	0,3399	0,2438	0,4937	0,3464	0,2527	0,5027
9	17/16	0,4452	0,2925	0,5408	0,4413	0,4458	0,6677
10	17/16	0,2755	0,1936	0,4400	0,2780	0,1731	0,4161
11	16/15	0,4219	0,7741	0,8798	0,2680	0,1442	0,3797
12	16/15	1,0346	0,8281	0,9100	0,1745	0,6545	0,8090
13	16/15	0,3507	0,2935	0,5434	0,3215	0,3925	0,6265
14	15/15	0,1934	0,1867	0,4321	0,3127	0,3904	0,6248
15	15/15	0,3195	0,2310	0,4807	0,3194	0,3704	0,6086
16	15/15	0,1968	0,1461	0,3822	0,2668	0,4021	0,6341
17	15/15	0,1722	0,1291	0,3593	0,3794	0,4267	0,6532
18	18/18	0,3179	0,6865	0,8285	0,4290	0,5171	0,7190
19	18/18	0,3265	0,4748	0,6890	0,3205	0,7052	0,4973
20	18/18	0,2970	0,2401	0,4901	0,3228	0,3701	0,6083
21	18/18	0,2758	0,41	0,0403	0,2979	0,4732	0,6879
22	17/17	0,2696	0,2969	0,5449	0,4182	0,3347	0,5785
23	18/18	0,4122	0,1945	0,4410	0,4378	0,3912	0,6254
24	18/18	0,3632	0,1893	0,4351	0,3968	0,3344	0,5785
25	18/18	0,4304	0,3587	0,5989	0,3222	0,1817	0,5308
26	18/18	0,6742	0,4155	0,6446	0,3924	0,2949	0,3430
27	15/15	0,7493	0,3648	0,6040	0,9171	0,8275	0,9097
28	16/16	0,3550	0,2562	0,5062	0,6299	0,5017	0,7083
29	16/16	0,3283	0,2452	0,4951	0,4402	0,4873	0,6980
30	16/16	0,2693	0,1376	0,3709	0,3184	0,1124	0,3352
31	16/16	0,3450	0,1738	0,4169	1,5066	0,3264	0,8064
32	16/16	0,7773	0,3555	0,5962	0,7487	0,3182	0,5681
33	17/17	0,3310	0,1885	0,4342	0,4352	0,2601	0,5100
34	17/17	0,3628	0,1232	0,3510	0,4239	0,1670	0,4087
35	17/17	0,3154	0,1375	0,3709	0,5387	0,1791	0,4232
36	17/17	0,2331	0,1015	0,3187	0,1759	0,0569	0,2387

.../... (1) Tableau XXVIII (suite)

37	17	0,2743	0,0616	0,2483	0,4766	0,1866	0,4320	17
38	17	0,3546	0,1906	0,4360	0,3797	0,26	0,5167	17
39	18	0,7233	0,5906	0,6669	0,9688	0,6651	0,8155	18
40	18	0,8321	0,5511	0,7424	0,9893	0,4261	0,6525	18
41	18	0,7279	0,5681	0,7537	0,6670	0,3288	0,5734	18
42	18	0,7392	0,3845	0,6200	0,7253	0,5402	0,7349	17
43	17	0,6231	0,3199	0,5656	0,8052	0,6295	0,7926	17
44	17	0,6697	0,4792	0,6922	0,6133	0,2318	0,4814	17
45	17	0,6429	0,5310	0,7287	0,6564	0,5196	0,7209	17
46	17	0,7947	0,3499	0,5915	0,6694	0,3114	0,5580	17
47	17	0,6599	0,4460	0,6678	0,8984	0,4493	0,6703	17
48	17	0,8976	0,5569	0,9463	0,6764	0,5969	0,7726	17
49	17	0,6467	0,4792	0,6923	0,7032	0,2534	0,5943	17
50	17	0,6977	0,5433	0,7371	0,9487	0,5217	0,7222	17
51	17	1,3468	1,1121	1,0545	2,2503	0,9225	0,9605	17
52	17	1,4849	0,7229	0,8502	1,8166	0,8484	0,9211	17
53	17	1,6213	0,9455	0,9723	1,5171	0,9270	0,9628	17
54	17	1,2432	0,8625	0,9287	1,1998	0,5932	0,7702	17
55	17	1,1232	1,2376	1,1125	1,1469	1,0387	1,0191	17
56	17	0,9713	1,1552	1,0748	1,3444	0,8087	0,8993	17
57	16	0,0752	0,0117	0,1081	0,1925	0,0749	0,2737	15
58	16	0,0716	0,0821	0,2866	0,0666	0,0366	0,1913	15
59	16	0,0784	0,0601	0,2452	0,1469	0,2735	0,5230	15
60	16	0,2653	0,1993	0,4464	0,5583	0,5727	0,7568	15
61	16	0,2551	0,2450	0,4949	0,5158	0,2634	0,5132	15
62	16	0,4145	0,5845	0,7645	0,4850	0,5313	0,7289	15
63	16	0,3259	0,2611	0,5110	0,3844	0,2749	0,5243	15
64	16	0,2568	0,1408	0,3753	0,2340	0,0904	0,3001	15
65	15	0,0318	0,0151	0,1231	0,0770	0,0250	0,1582	14
66	16	0,0298	0,0142	0,1192	0,0518	0,0198	0,1408	15
67	16	0,2787	0,7061	0,8402	0,4040	0,8424	0,9178	15
68	16	0,1629	0,0553	0,2351	0,2389	0,1690	0,4111	15
69	17	0,1716	0,1641	0,4051	0,2992	0,5237	0,7237	16
70	16	0,1500	0,0999	0,3161	0,1199	0,0680	0,2609	15
71	16	0,1856	0,1064	0,3261	0,1102	0,0543	0,2332	15
72	16	0.2374	0,1593	0,3991	0,2374	0.1636	0,4118	15
73	16	0,1377	0,2050	0.4528	0,2253	0,3917	0.6259	15
74		0,3245	0,5957	0.7718	0,1778	0.1250	0,3536	
75	16	0,3617	0,7912	0.8895	0.2790	0,2684	0,5181	14
76	16	0,3164	0,3597	0,5997	0,3243	0,3922	0,6263	14
77	16	0,5079	0,5523	0.7432	0,5217	0.6200	0,7874	15
78	16	0,3588	0,3674	0.6061	0,5980	0,3373	0,5813	15
79	16	0,4483	0,3143	0,5606	0.440	0,2927	0,5411	15
80	16	0,9102	0,7385	0.8594	0,9497	0,5005	0,7074	15
81	15	0,6889	0,3893	0.6240	0,4965	0,3405	0,5836	14
82	16	0,5195	0,3865	0.6216	1,2231	0.7754	0,8805	15
83	14	0,5362	0,3971	0,6302	0,7194	0,4452	0,6672	14
84	15	0.7257	0,2229	0.4721	0,8975	0.4047	0.6362	14
85	15	0.6973	0,3524	0,5936	0,7470	0,2513	0,5927	14
86	16	0,7907	0,4624	0,5800	0,9306	0,4025	0,6344	15

.../... (2) Tableau XXVIII (suite)

87	15	0,7409	0,3355	0,6209	1,0115	0,5168	0,6189	15
88	14	0,8256	0,3689	0,6074	0,8649	0,4321	0,8015	14
89	15	0,7474	0,3509	0,5924	0,6839	0,5885	0,7171	15
90	12	0,7306	0,4793	0,6916	0,5261	0,3218	0,5673	12
91	12	0,5404	0,1750	0,4183	0,5985	0,2465	0,4965	12
92	12	0,5130	0,2764	0;5257	0,4499	0,3094	0,5563	12
93	12	0,7214	0,3365	0,5801	0,6685	0,4706	0,6861	12
94	12	0,2725	0,2058	0,4536	0,3199	0,2224	0,4716	12

Tableau XXIX

TABLEAU COMPARATIF DES DONNEES SUR LES N.P.P DES COLIFORMES FECAUX /100 ML TRANSFORMEES EN MOYENNE LOGARITHMIQUE, VARIANCE ET ECART TYPE RELATIVES AUX ECHANTILLONS D'EAU DE MER ET AUX ECHANTILLONS DE SEDIMENTS.

N.P.P/100 ml Coliformes Fécaux								
EAU DE MER					SEDIMENT			
N° Station	Nombre d'Echantillon	Moyenne Logarithmique	Variance	Ecart Type	Moyenne Logarithmique	Variance	Ecart Type	Nombre d'Echantillon
1	18	0,4995	0,6250	0,3909	0,5214	0,3364	0,5800	17
2	18	0,7617	0,4974	0,7052	0,9710	0,8359	0,9143	17
3	18	0,2692	0,1481	0,3853	0,3179	0,3793	0,6159	17
4	18	0,1874	0,1403	0,3746	0,2708	0,2137	0,4623	17
5	17	0,3841	0,3239	0,5691	0,4385	0,3385	0,5818	16
6	17	0,3374	0,2553	0,5053	0,3617	0,1696	0,4118	16
7	17	0,1961	0,0944	0,3073	0,2989	0,1180	0,3435	14
8	17	0,1663	0,08995	0,2992	0,1927	0,1294	0,3578	16
9	17	0,3243	0,7276	0,8530	0,3138	0,1367	0,3697	16
10	17	0,1373	0,0680	0,2609	0,2264	0,0960	0,3131	16
11	16	0,3315	0,4078	0,6386	0,2214	0,1337	0,3657	15
12	16	0,7702	0,5959	0,7719	0,7764	0,4088	0,6392	15
13	15	0,0984	0,0683	0,2613	0,1722	0,1992	0,4463	15
14	15	0,1082	0,0975	0,3122	0,1772	0,1317	0,3629	15
15	15	0,0984	0,0472	0,2173	0,2329	0,2967	0,5447	15
16	15	0,1055	0,0500	0,2237	0,2741	0,4119	0,6418	15
17	15	0,1484	0,0588	0,2426	0,3233	0,4587	0,6772	15
18	18	0,1325	0,1018	0,3190	0,1208	0,0606	0,2462	18
19	18	0,2087	0,2063	0,4542	0,1403	0,0857	0,2928	18
20	18	0,1155	0,0439	0,2097	0,1183	0,0808	0,2843	18
21	18	0,1602	0,1460	0,3821	0,1602	0,1993	0,4465	18
22	17	0,1119	0,0410	0,2024	0,1184	0,0288	0,1699	17
23	18	0,2037	0,0611	0,2473	0,3856	0,3586	0,5988	18
24	18	0,1517	0,0551	0,2348	0,2463	0,1333	0,3651	18
25	18	0,1685	0,0548	0,2341	0,1900	0,0697	0,2641	18
26	18	0,2055	0,1738	0,4169	0,2814	0,2119	0,4604	18
27	15	0,6057	0,4177	0,6463	0,6544	0,8074	0,8985	15
28	16	0,2712	0,1272	0,3567	0,3858	0,2706	0,5202	16
29	16	0,1789	0,0872	0,2953	0,1569	0,0465	0,2156	16
30	16	0,1380	0,0464	0,2154	0,1380	0,0464	0,2154	16
31	16	0,2414	0,0978	0,3127	0,2739	0,1066	0,3264	16
32	16	0,7597	0,3133	0,5597	0,5253	0,3735	0,6111	16
33	17	0,2272	0,1133	0,3366	0,3730	0,2393	0,4892	17
34	17	0,2743	0,068	0,2610	0,2120	0,0646	0,2542	17
35	17	0,1707	0,0496	0,2228	0,3730	0,090	0,3302	17
36	17	0,2331	0,1015	0,3187	0,1753	0,0569	0,2387	17
37	17	0,2747	0,1327	0,3644	0,4091	0,1821	0,4268	17
38	17	0,3652	0,2432	0,4932	0,3016	0,1306	0,3614	17
39	18	0,4917	0,3488	0,5906	0,6725	0,6585	0,8115	18
40	18	0,5765	0,4471	0,6687	0,5663	0,3515	0,5929	18
41	18	0,6675	0,6059	0,7784	0,5128	0,3136	0,5600	18
42	18	0,6036	0,4767	0,6904	0,6352	0,3715	0,6095	17
43	17	0,3653	0,2852	0,5341	0,5641	0,6565	0,8102	17
44	17	0,5487	0,4413	0,6643 [illegible]	0,5088	0,2954	0,5435	17
45	17	0,3919	0,2834	0,5324	0,5573	0,3339	0,5778	17
46	17	0,4973	0,3687	0,6072	0,6208	0,3032	0,5506	17
47	17	0,4760	0,2926	0,5409	0,6868	0,4126	0,6423	17

Tableau XXIX (suite)

48	17	0,6995	0,5353	0,7316	0,5962	0,5622	0,7498	17
49	17	0,4640	0,4131	0,6427	0,7032	0,3534	0,5945	17
50	17	0,6212	0,5667	0,7528	0,9310	0,5513	0,7424	17
51	17	1,3913	1,1271	1,0616	1,9006	1,1265	1,0613	1
52	17	1,4329	0,8975	0,9473	1,7275	0,8501	0,9220	1
53	17	1,3507	1,1146	1,0557	1,2662	1,2634	1,1240	1
54	17	1,1497	0,9657	0,9827	1,0048	0,7946	0,8914	17
55	17	1,0696	0,9723	0,9723	0,9104	0,8980	0,9476	17
56	17	0,9081	0,9566	0,9781	1,0806	0,6333	0,7958	17
57	16	0,0752	0,0117	0,1081	0,1268	0,0564	0,2376	15
58	16	0,0188	0,0056	0,0752	0,0666	0,0366	0,1913	15
59	16	0,0564	0,0267	0,1636	0,0871	0,581	0,2411	15
60	16	0,2374	0,1592	0,3991	0,5118	0,5784	0,7605	15
61	16	0,2551	0,2450	0,4949	0,2630	0,1696	0,4118	15
62	16	0,3769	0,6037	0,7770	0,4483	0,4713	0,6865	15
63	16	0,2580	0,2213	0,4704	0,3558	0,2364	0,4862	15
64	16	0,1987	0,1044	0,3231	0,2202	0,1110	0,3332	15
65	15	0,0318	0,0151	0,1231	0,0770	0,0250	0,1582	14
66	16	0,0298	0,0142	0,1192	0,0518	0,0198	0,1408	15
67	16	0,2598	0,7108	0,8431	0,2571	0,7615	0,8726	15
68	16	0,0596	0,0265	0,1629	0,1586	0,0629	0,2509	15
69	17	0,2143	0,5519	0,7429	0,1785	0,3588	0,5990	14
70 ±6	16	0,0784	0,0298	0,1726	0,1199	0,0680	0,2609	15
71	16	0,1160	0,2693	0,5190	0,1102	0,0543	0,2332	15
72	16	0,1062	0,0592	0,2433	0,1133	0,0625	0,2500	15
73	16	0,1129	0,2038	0,4514	0,2253	0,3917	0,6259	15
74		0,2886	0,4590	0,6775	0,1133	0,0625	0,2500	
75	16	0,2033	0,1726	0,4154	0,1756	0,2110	0,4594	14
76	16	0,1341	0,1069	0,3270	0,1715	0,1463	0,3825	14
77	16	0,2694	0,2934	0,5416	0,2578	0,2579	0,5079	15
78	16	0,3460	0,2951	0,5433	0,4356	0,3448	0,5872	15
79	16	0,4185	0,2963	0,5442	0,3763	0,2790	0,5282	15
80	16	0,5806	0,3472	0,5892	0,7039	0,5431	0,7370	15
81	15	0,5782	0,4152	0,6444	0,4783	0,3111	0,5578	14
82	16	0,4626	0,2558	0,5058	0,4460	0,3647	0,6039	15
83	14	0,4751	0,3587	0,5989	0,5780	0,3969	0,6300	14
84	15	0,4763	0,2528	0,5028	0,6892	0,6309	0,3980	14
85	15	0,4340	0,2513	0,5013	0,5727	0,2923	0,5406	14
86	16	0,6903	0,3625	0,6021	0,5528	0,2228	0,4783	15
87	15	0,5827	0,2652	0,5150	0,6072	0,3959	0,6290	15
88	14	0,5865	0,3648	0,6040	0,7140	0,6006	0,7750	14
89	15	0,5460	0,3785	0,6152	0,7123	0,5025	0,7089	15
90	12	0,4727	0,4798	0,6927	0,3594	0,3725	0,6103	12
91	12	0,3193	0,2026	0,4501	0,4605	0,2561	0,5061	12
92	12	0,3771	0,2796	0,5288	0,3812	0,3150	0,5613	12
93	12	0,4804	0,2912	0,5396	0,5476	0,3774	0,6143	12
94	12	2,9821	0,3323	0,5764	0,2948	0,2310	0,4806	12

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INTRODUCTION

The first steps to develop a methodology for the study of microbiological parameters relevant to the quality of coastal waters were taken at the Centre in 1972.

Systematic monitoring of the sanitary quality of recreational beaches and shellfish-growing waters started in 1973 at a limited number of selected stations in the vicinity of Rovinj, using a few basic parameters such as total and faecal coliforms, BOD, basic chemical, physical and meteorological factors. Since then this monitoring programme has evolved considerably and resulted in a number of publications and reports.

Today, regular surveys made by the Centre cover large areas of the northern Adriatic, in particular along the western and eastern coast of the Istrian peninsula and the Bay of Rijeka. The number and type of parameters studied in these areas have also increased and diversified, and at present the Centre is successfully carrying out complex studies on the quality of coastal waters at the request of the Government (e.g. MED POL VII), local authorities and industry.

AREA(S) STUDIED

The Bay of Rijeka, as well as the western and eastern coast of the Istrian peninsula, were selected to investigate systematically the quality of the recreational waters as the Centre's contribution to MED POL VII.

The Bay and the eastern coast of Istria are surrounded by limestone mountains with steep slopes, which continue under the sea, while the western coast of Istria is surrounded by relatively shallow waters. The shoreline is in, most cases, rocky.

One of the surface waters entering the area is the small river Rjecina (average flow 20 m^3/s), which is heavily polluted by domestic and industrial wastes originating from Rijeka. The other surface water entering the region (river Mirna) is relatively clean and carries on average 60 m^3/s of water. The waters of the northern Adriatic, including the coastal waters of western Istria, are influenced by the northern Italian rivers, in particular the river Po.

Owing to the specific characteristics of the region, there are numerous underwater wells in the vicinity of the coastline, their content of water depending on the amount of rain falling over the adjacent mainland. During heavier rainfall the stormwater entering the Bay is considerable. The average annual precipitation in the area is 1,400 mm.

The shores of the area are used intensively as an almost year-round recreational zone, which, in the peak of the season, can accommodate up to 250,000 tourists a day.

The town of Rijeka, situated in the Bay, is one of the largest Yugoslav coastal cities (160,000 inhabitants) and its harbour (8 million tonnes/year) is one of the most important in the country. There are a large number of activities in the city itself and in its surroundings: an airport terminal, shipyards, refineries, coking plant, petrochemical, paper, textile, machine and tool industries, etc.

The sanitary quality of the recreational waters of the area has been systematically monitored at 27 coastal stations (not more than 10 m from the shoreline), grouped in four regions (Figure 1) from the summer of 1976 to June 1978. Since then the sanitary quality of the recreational waters of Rovinj have been systematically monitored at 12 coastal stations and 3 open water stations (Figure 2). This shift was caused by budgetary difficulties.

MATERIALS AND METHODS

The operational document for the MED VII project (document EHE/76.1) and the Guidelines for Health Related Monitoring of Coastal Water Quality (WHO, Copenhagen, 1977) were strictly applied in carrying out the work described.

RESULTS AND THEIR INTERPRETATION

Period July 1976 to September 1979:

The following parameters were monitored regularly at all stations: total coliforms, faecal coliforms, faecal streptococci, dissolved oxygen, BOD_5, pH, salinity, temperature and atmospheric conditions. In addition, at the eight open water stations in the Rijeka area, nutrients, primary productivity and currents were measured.

In Rovinj's three open water stations only currents were measured.

1. Rijeka Area

The comparative analysis of the data obtained in the four selected regions (Figure 1) shows that there exists a significant difference between the stations of these regions. As expected, stations located closer to the land-based sources of pollution, i.e. sewage outfalls, revealed a higher degree of coastal pollution when measured by the indicators used in this study.

The recorded variations of sea and air temperature at the various stations were closely related to the climatological and meteorological conditions of the area. At some stations (e.g. station no. 8) these parameters were also modified by the amount of fresh water entering the sea in the vicinity of tnese stations, directly from land or through underwater wells. In general, between September and February, when the measurements were made, the temperature of the air was lower than that of the sea. The surface sea temperature varies between 9°C (January 1980, station no. 23) and 27.6°C (July 1977, station no. 27).

As a result of uneven inflow of surface waters and fresh waters from underwater wells, the salinity of the sea surface showed great variations at most of the stations.

Salinity ranges recorded at stations in the region of Rijeka showed particularly wide variation (19.35^{o}/oo - 37.43^{o}/oo for all stations of the region with the exception of station no. 8 where salinity occasionally dropped to 4.20^{o}/oo). Salinity variations at the West Istrian stations were in the range 26.44^{o}/oo - 37.89^{o}/oo.

Owing to the high buffer capacity of the sea-water, pH values were in the range of 8.00 - 8.40. Exceptionally low values were found only at stations (e.g. station No. 8) heavily influenced by coastal waste discharge where a minimum pH of 7.40 was recorded.

Oxygen saturation of sea-water was regularly close to 100%, with occasionally slightly lower saturation at stations in the Rijeka region, due to the amount of oxygen-consuming organic waste.

The mean biochemical oxygen demand was somewhat lower at the stations along the West Istrian coast (0.8 - 1.3 mg O_2/l) than at the stations in the region of Rijeka (1.3 - 1.6 mg O_2/l). The highest recorded value for BOD_5 was at station No 6 (5.1 mg O_2/l).

The mean values for total coliforms, faecal coliforms and faecal streptococci are listed in Table I.

The majority of stations (except stations nos. 4 and 8) in the region of Rijeka showed significantly lower values during the summer season than during the remainder of the year. High mean values during the out-of-season period indicate the certain influence of meteorological and hydrological conditions on the state of pollution in this area.

Higher mean values noted during the summer season, compared with those noted during other seasons at the majority of stations along the West Istrian coast, indicate the increase in coastal pollution due to the growing number of summer tourists accommodated at hotels and other facilities along the coast.

Although the concentration of total coliforms might not be the best indicator for contamination of sea-water with faecal material, results obtained in our survey (Table I) show good correlation with the location of outfalls bringing into the sea either faecal material or material enhancing the survival and reproduction of micro-organisms in the area.

Faecal coliforms (E. coli) were measured at all stations as one of the most sensitive indicators of the degree of sewage pollution and sewage dispersion around points of sewage discharge.

Highly satisfactory bathing areas should show E. coli (faecal coliforms) counts of consistently less than 100 per 100 ml, and to be considered acceptable, bathing waters should not give counts consistently greater than 1000 E. coli per 100 ml. No more than 10% of at least 10 consecutive samples collected during the bathing season should exceed 1000 E. coli per 100 ml.

Taking these criteria into account, stations nos. 1 and 7 are beyond the acceptable limits set for recreational waters (more than 10% of samples having 1000 FC/100 ml). However, it should be noted that during the bathing season all these stations could be considered as "acceptable". None of the stations can be considered as highly satisfactory from a recreational standpoint (Table II).

The computed ratios of faecal coliforms and faecal streptococci (FC/FS) for stations nos. 1-8 are between 2.3 and 5.4 indicating that they are under the direct influence of human faecal material.

Results obtained at stations in the Pula region indicate their high recreational quality, although the computed FC/FS ratios (0.5-2.3) show occasional influence of contamination with human faecal materials from sources that are not in the vicinity of the stations.

Stations in the region of Porec show somewhat higher faecal coliform values, some of them occasionally exceeding (not in the bathing season) the 1000 FC/100 ml. Two of six examined beaches can be considered as "highly satisfactory bathing areas". The FC/CS ratios indicate that none of the stations is under the direct influence of human faecal contamination.

Stations in the Umag region have never exceeded the 1000 faecal coliforms/100 ml and had a low FC/FS ration (0.1 - 1.8). Three stations of six examined beaches can be considered as highly satisfactory from a recreational standpoint.

Table III gives the period of sampling and the number of analyses per stations in the controlled areas.

The correlation between total coliforms and faecal coliforms in 27 stations examined, are presented in Table IV. If the "0.01 level" is used as a criterion of significance, a good correlation was then found between TC and FC for stations Nos. 1-8, 10, 11, 16-22, 24-27. No correlation between TC and FC was found for stations Nos. 9, 12, 14, 23. One could speculate that the correlation dropped with the degree of pollution.

Seasonal variations of the number of faecal coliforms caused by the influence of NE and S winds on the spreading of pollution in coastal water are presented in Table 5. Due to the lack of data with the same meteorological conditions only stations Nos. 1-8 were analysed.

The S wind (in Rijeka Bay) has driven back sewage released from the outlet to the shore and caused higher median values at all stations (summer and the remaining part of year).

The NE wind has removed pollution from the seashore and caused significantly lower median values at all stations (except No. 8).

Significantly higher median values were found for stations Nos. 1-6 influenced by the S wind.

2. Rovinj area

The medians for total coliforms, faecal coliforms and faecal streptococci are listed in Table VI.

The comparative analyses of data show that pollution of stations depend on the position as well as of the type (operational period) of sewage outfalls close to beaches.

Stations 28, 31 and 37 are not influenced by urban pollutants and the median oscillates slightly from season to season.

Stations 29, 30, 38 and 39 are situated on the beaches belonging to the facilities (autocamps, bungalows, hotels) occupied by tourists from May to October. Because of this, medians for bacterial indicators in the summer season are higher compared to the rest of the year. The strong connection between the degree of pollution and meteorological conditions is apparent at station No. 38; high median value influenced by S wind (Table VII).

Stations 32, 33, 34, 35, and 36 are under permanent direct or indirect influence of contaminants containing human faecal materials. At stations 32 and 33 there is a slight influence of the S wind on dispersion of pollution and consequent decrease during summer. Stations 34 and 35 are close to the permanently operating urban sewage outfalls. The influence of the S wind is visible at stations 34 and 35 during the winter (Table VII).

Faecal coliforms (E. coli) were measured at all stations as "one of the most sensitive indicators of the degree of sewage pollution and sewage dispersion around points of sewage discharge" (4).

"Highly satisfactory bathing areas should not show E. coli (faecal coliforms) counts of consistently greater than 1000 E. coli per 100 ml. No more than 10% of, at least, 10 consecutive samples collected during the bathing season should exceed 1000 E. coli per 100 ml". (4, 5).

Taking these criteria into account, stations 28-31, 33 35-37; 39 could be considered as "acceptable", while three (28, 31 and 37) of the twelve beaches examined can be considered as "highly satisfactory bathing areas".

Period September 1979 to September 1980:

The median and deviation factor for total coliforms, faecal coliforms and faecal streptococci are listed in Table Ia.

The comparative analyses of data show, as in the past, that pollution of stations depends on the position as well as of the type (operational period) of sewage outfalls close to beaches.

Stations Nos. 28, 31 and 37 are not influenced with urban pollutants and the median slightly oscilate during the seasons.

Stations Nos. 39, 30, 38 and 39 are situated on the beaches belonging to the facilities occupied by tourists from May to October. Due to this reason, the median for bacterial indicators at stations Nos. 38 and 39, in the summer season, are higher, compared to the rest of the year. Stations Nos. 29 and 30 are not remarkably influenced with polluted waters from the nearby outfalls during all seasons.

Stations Nos. 32, 33, 34, 35 and 36 are under permanent or indirect influence of polluted waters containing human faecal material. The water quality of station No. 32 is directly influenced with polluted water from two hotels' sewage outfalls. Station Nos. 33, 34 and 35 are close to permanently operating urban sewage outfalls. Oscillations of the quality of water at these stations are not remarkable during the year. Water of the beach at station No. 36 is slightly contaminated with waste-waters entering the sea from the nearby fish processing plant.

Considering the proposed interim criteria for recreational waters, stations Nos. 28, 30, 31, 36 and 37 showed high recreational quality of coastal waters

(Table IIa). Stations Nos. 29, 33, 34, 35 and 39 could be considered as "acceptable" for recreational waters. Stations Nos. 32 and 38 are beyond the acceptable limits.

Concerning the evaluation of quality of coastal waters, covered by the previous report (October, 1979), the number of samples (during the bathing season of 1980) exceeding the limits of 100 and 1000 faecal coliforms/100 ml were higher at stations Nos. 35, 38 and 39.

Period October 1980 to May 1981:

The same parameters as previously were monitored. The median and deviation factor for total coliforms, faecal coliforms and steptococci are listed in Table IIIa.

It was confirmed that position as well as type of sewage outfall close to the beaches influences pollution. Station 28, remote from urban sewage outfalls, is used as a background station.

The influence of tourists on the pollution of stations near their facilities has been further confirmed.

The median of faecal coliforms/100 ml ranged from 68.7 to 249.3 for the stations nos. 32, 33, 34, 35 and 36. They are under permanent direct or indirect influence of polluted waters containing human faecal material. Similarly, stations J and K are also influenced by urban sewage.

The results of data collected during the period under review show that samples at four stations (Nos. 32, 33, 34 and 35) exceed the limit of 1000 faecal coliforms/100 ml (Table IVa).

DISCUSSION OF RESULTS

Period July 1976 to September 1979:

1. Rijeka area

The survey of recreational waters in four selected regions of the north Adriatic (Figure 1) revealed the correlation between the sanitary (recreational) quality of waters at selected stations and the vicinity of land-based sources of contamination.

The region of Rijeka is influenced by pollutants and some of the stations of this region are close to the limit set for "acceptable" bathing waters. The stations surveyed in the other three regions (Pula, Porec, Umag) are clean (or sporadically slightly polluted) and nine of the nineteen controlled beaches can be considered as highly satisfactory from a recreational standpoint, although some of surveyed stations are occasionally influenced by indirect pollution from land-based sources.

2. Rovinj area

The survey of recreational waters confirmed the correlation between the sanitary/recreational quality of waters at the selected stations and the vicinity of land-based soures of contamination. Twenty-five per cent of stations investigated are beyond the limit set for "acceptable bathing waters", half the beaches monitored are occasionally influenced by indirect contamination from land-based sources of pollution. Only a quarter of examined beaches have a highly satisfactory quality of water.

Period September 1979 to September 1980:

The control of recreational waters at Rovinj during 1980 revealed the correlation between the sanitary quality of waters at the selected stations and the vicinity of land-based sources of contamination.

Two out of the examined stations are beyond the limit set for "acceptable" bathing waters, five of the controlled beaches are occasionally influenced by indirect contamination from land-based sources, while five of the beaches have a "highly satisfactory" quality of water.

Period October 1980 to May 1981:

The monitoring of recreational waters at Rovinj during the period under review confirmed the correlation between the sanitary quality of waters at the selected stations and the location and the type of sewage discharges.

The fluctuations in the quality of recreational waters in the Rovinj area during the off-season are not important. This has been the experience since March 1978.

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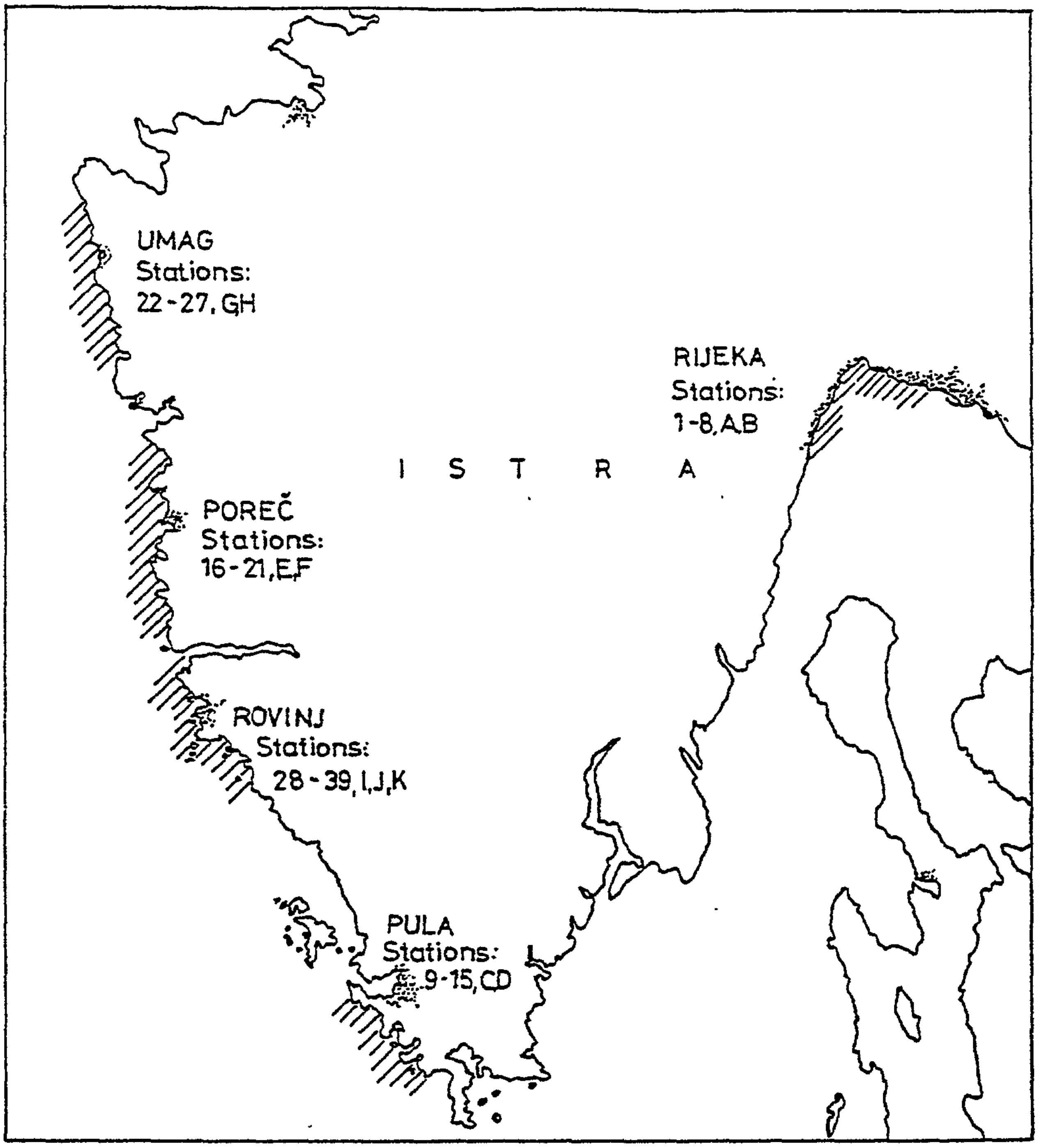

Fig. 1. Rijeka Area

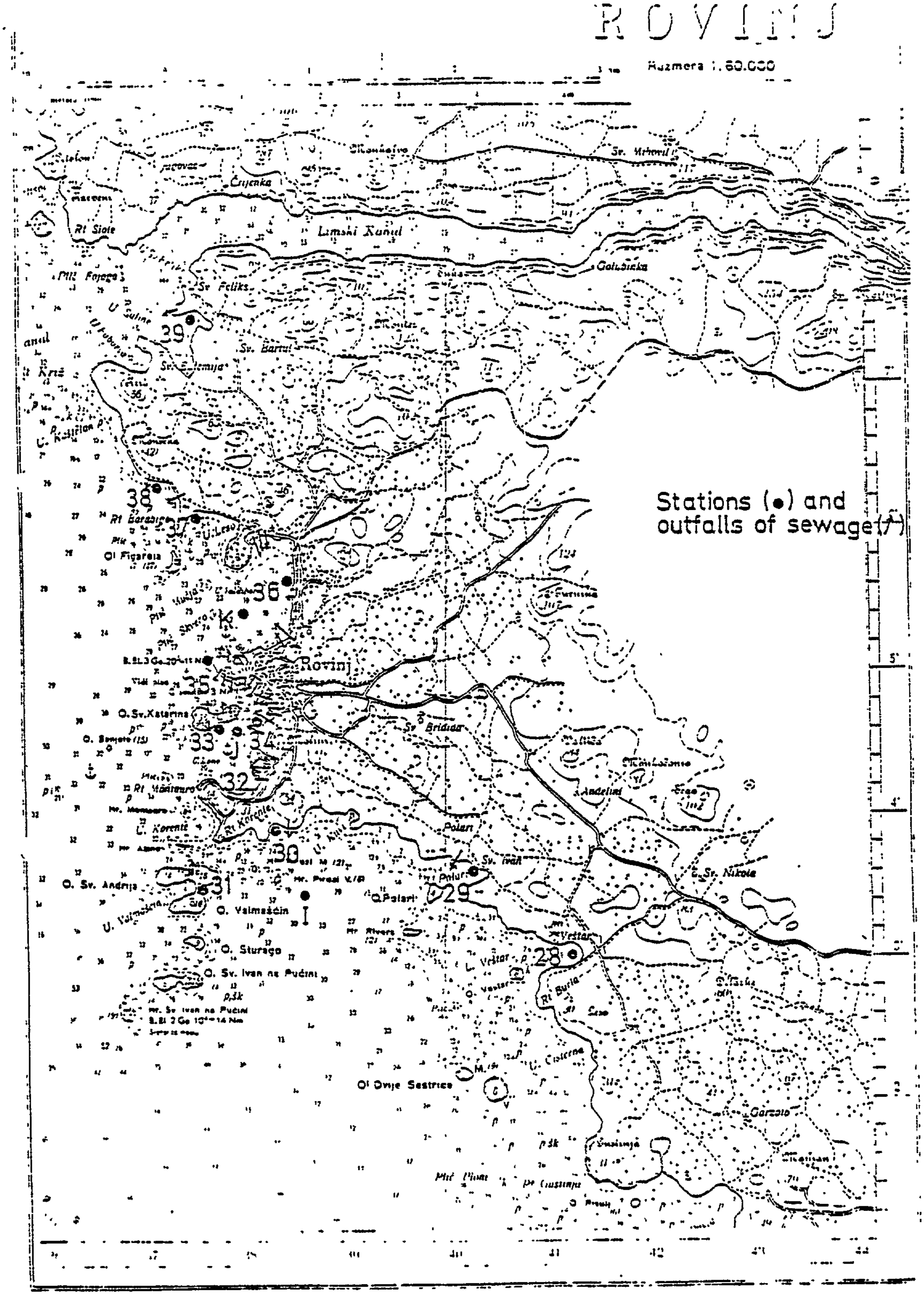

Fig. 2. Rovinj area

Table I: Mean values and their standard deviations for total coliforms, faecal coliforms and faecal streptococci in samples taken at examined stations (data separated in "summer" and "other" (season) columns)

Stations	Total coliforms n/100 ml		Faecal coliforms n/100 ml		Faecal streptococci n/100 ml	
	Summer	Others	Summer	Others	Summer	Others
1	138.9 ± 7.1	289.1 ± 6.7	69.3 ± 6.8	147.4 ± 9.8	35.2 ± 7.0	92.5 ± 8.9
2	94.2 ± 10.5	207.6 ± 8.8	44.7 ± 11.2	112.6 ± 9.8	43.6 ± 9.1	53.1 ± 9.9
3	75.3 ± 5.2	239.3 ± 5.4	27.4 ± 7.0	69.6 ± 6.6	19.7 ± 5.0	39.2 ± 9.7
4	56.6 ± 10.0	58.8 ± 10.4	30.8 ± 10.3	25.1 ± 10.3	41.1 ± 7.2	18.5 ± 11.1
5	72.5 ± 7.3	124.9 ± 4.4	34.0 ± 7.2	98.5 ± 4.2	10.4 ± 7.2	15.7 ± 7.5
6	46.7 ± 6.2	135.4 ± 6.1	21.0 ± 5.9	90.9 ± 6.6	13.2 ± 7.6	47.7 ± 8.3
7	192.0 ± 4.7	257.3 ± 6.1	69.8 ± 5.1	131.5 ± 9.3	25.6 ± 7.8	50.2 ± 12.7
8	315.0 ± 3.3	304.2 ± 4.4	178.9 ± 3.6	113.1 ± 4.2	71.1 ± 5.8	62.8 ± 5.9
A	5.8 ± 10.2	75.5 ± 6.8	1.8 ± 3.3	65.9 ± 6.1	4.2 ± 7.9	49.0 ± 20.2
B	7.9 ± 5.2	91.1 ± 4.7	2.6 ± 3.3	46.1 ± 2.5	2.1 ± 3.2	46.1 ± 6.8
9	7.8 ± 7.2	2.3 ± 7.8	3.6 ± 5.6	1.4 ± 2.4	4.4 ± 7.5	2.7 ± 5.8
10	4.0 ± 4.1	1.4 ± 3.1	2.5 ± 2.8	1.2 ± 1.7	3.0 ± 5.6	2.4 ± 3.8
11	13.4 ± 9.2	2.3 ± 4.7	8.1 ± 6.2	1.8 ± 4.1	8.1 ± 3.9	3.3 ± 6.5
12	33.9 ± 5.4	10.7 ± 5.3	9.7 ± 5.6	4.5 ± 3.7	19.9 ± 7.9	3.3 ± 4.7
13	5.7 ± 5.3	1.1 ± 1.3	3.2 ± 4.3	1.3 ± 2.6	4.3 ± 6.2	2.1 ± 3.5
14	4.7 ± 3.9	1.7 ± 2.6	1.9 ± 2.3	1.0 ± 1.0	3.6 ± 4.4	1.6 ± 2.0
15	2.4 ± 4.5	1.4 ± 2.4	1.5 ± 1.7	1.1 ± 1.4	3.5 ± 3.9	1.7 ± 2.7
C	2.6 ± 5.3	1.0 ± 1.0	2.8 ± 4.9	1.0 ± 1.0	3.2 ± 6.2	1.0 ± 1.0
D	1.9 ± 2.8	1.0 ± 1.0	1.3 ± 5.9	1.0 ± 1.0	1.4 ± 2.2	1.0 ± 1.0
16	110.6 ± 8.4	44.3 ± 8.0	80.0 ± 6.5	30.5 ± 6.9	87.3 ± 5.5	27.4 ± 7.4
17	73.1 ± 16.8	2.7 ± 3.9	39.1 ± 12.2	1.3 ± 2.0	50.7 ± 11.8	3.5 ± 6.2
18	28.9 ± 2.3	2.5 ± 2.9	7.4 ± 6.5	1.3 ± 2.3	38.7 ± 3.9	5.1 ± 4.1
19	13.9 ± 5.5	6.9 ± 8.5	5.2 ± 5.0	2.9 ± 6.9	40.6 ± 3.7	5.3 ± 7.1
20	32.1 ± 6.4	22.4 ± 9.4	8.8 ± 8.9	9.4 ± 11.1	16.9 ± 9.6	21.3 ± 8.6
21	20.0 ± 4.1	9.9 ± 5.4	10.5 ± 3.7	2.7 ± 5.7	14.6 ± 6.4	4.6 ± 4.8
E	1.0 ± 1.0	2.0 ± 4.2	1.0 ± 1.0	1.9 ± 2.8	1.8 ± 1.9	1.2 ± 1.4
F	3.1 ± 5.8	1.2 ± 1.4	2.8 ± 5.0	1.0 ± 1.0	6.4 ± 4.5	1.0 ± 1.0
22	30.0 ± 4.7	3.5 ± 5.9	14.7 ± 6.5	2.3 ± 4.9	15.8 ± 5.1	2.3 ± 2.9
23	6.3 ± 5.1	9.1 ± 5.4	2.5 ± 3.7	5.5 ± 4.4	2.8 ± 3.7	3.7 ± 4.9
24	40.9 ± 17.3	26.0 ± 14.3	22.9 ± 8.1	14.3 ± 7.6	16.6 ± 4.5	30.0 ± 8.8
25	6.3 ± 4.4	15.2 ± 5.1	3.4 ± 3.8	11.9 ± 5.8	2.7 ± 3.9	12.7 ± 3.5
26	10.7 ± 17.6	6.7 ± 3.6	5.8 ± 5.9	3.3 ± 4.4	5.3 ± 4.8	4.3 ± 3.4
27	10.3 ± 6.2	26.6 ± 8.1	4.6 ± 5.8	11.8 ± 7.8	7.9 ± 4.9	17.4 ± 9.5
G	3.2 ± 3.9	1.7 ± 2.5	1.9 ± 3.5	1.0 ± 1.0	1.8 ± 4.0	1.4 ± 1.9
H	3.1 ± 4.9	2.0 ± 3.3	1.3 ± 1.4	1.6 ± 1.7	1.6 ± 1.7	1.4 ± 1.9

* Log transformed data.

Table Ia. Median and deviation factor for total coliforms, faecal coliforms and faecal streptococci in samples taken in coastal waters of Rovinj.

Station	Total coliforms		Faecal coliforms		Faecal streptococci	
	Summer	Others	Summer	Others	Summer	Others
28	1.1 ± 1.5	1.2 ± 1.8	1.0 ± 1.0	1.2 ± 1.7	1.2 ± 1.4	1.1 ± 1.7
29	2.6 ± 4.4	2.0 ± 3.5	2.0 ± 4.0	2.0 ± 3.4	1.8 ± 2.7	1.5 ± 2.4
30	1.9 ± 3.0	1.2 ± 1.5	1.4 ± 2.0	1.1 ± 1.2	1.4 ± 2.1	1.2 ± 1.8
31	1.2 ± 1.6	1.7 ± 2.6	1.1 ± 1.3	1.3 ± 1.9	1.1 ± 1.3	1.4 ± 2.9
32	35.3 ± 8.6	153.9 ± 9.8	26.5 ± 8.9	127.1 ± 9.4	23.6 ± 7.0	77.4 ± 8.2
33	35.2 ± 7.1	17.2 ± 7.9	16.0 ± 5.6	11.9 ± 7.9	13.0 ± 3.6	12.0 ± 7.6
34	105.8 ± 4.9	140.9 ± 10.2	50.2 ± 5.9	90.8 ± 11.3	53.8 ± 7.3	52.6 ± 6.1
35	27.1 ± 5.5	37.1 ± 6.8	10.9 ± 6.3	24.8 ± 7.7	18.3 ± 5.9	13.1 ± 5.6
36	6.7 ± 5.4	3.8 ± 3.0	4.1 ± 4.1	2.4 ± 2.4	8.0 ± 3.8	2.9 ± 5.4
37	8.0 ± 6.3	3.8 ± 3.1	5.6 ± 4.9	3.2 ± 3.9	7.0 ± 5.4	3.2 ± 3.2
38	93.6 ± 21.3	4.5 ± 5.5	61.0 ± 22.3	3.4 ± 5.3	34.5 ± 8.5	1.8 ± 2.2
39	19.7 ± 14.7	2.2 ± 3.0	11.4 ± 15.1	1.9 ± 2.7	18.9 ± 11.2	1.3 ± 1.9
I	1.0 ± 1.0	-	1.0 ± 1.0	-	1.0 ± 1.0	-
J	7.9 ± 1.2	-	1.0 ± 1.0	-	6.3 ± 13.5	-
K	41.9 ± 1.0	-	31.6 ± 1.4	-	60.6 ± 26.3	-

Table II. Distribution of faecal coliforms and evaluation of stations according to interim criteria, FC/FS ratio

Stations	Samples (%) exceeding limits of -				
	100 faecal coliforms/100 ml		1000 faecal coliforms/100 ml		Ratio
	Total	Summer	Total	Summer	FC/FS
1	41.5	37.5	12.2	8.2	3.2
2	43.9	50.0	7.3	0.0	3.1
3	26.8	25.0	9.8	4.2	3.4
4	29.2	33.3	4.9	4.2	2.3
5	28.9	21.7	5.3	4.3	5.4
6	25.0	13.0	5.0	0.0	3.2
7	35.0	26.1	15.0	8.7	5.4
8	62.5	69.6	7.5	4.3	3.5
A	20.0	0.0	0.0	0.0	0.6
B	20.0	0.0	0.0	0.0	0.9
9	4.2	7.7	0.0	0.0	0.6
10	0.0	0.0	0.0	0.0	0.7
11	8.3	15.4	0.0	0.0	1.5
12	4.2	7.7	0.0	0.0	2.3
13	0.0	0.0	0.0	0.0	0.8
14	0.0	0.0	0.0	0.0	0.5
15	0.0	0.0	0.0	0.0	0.6
C	0.0	0.0	0.0	0.0	0.7
D	0.0	0.0	0.0	0.0	0.6
16	30.4	50.0	4.3	0.0	1.7
17	17.4	33.0	0.0	0.0	0.9
18	4.3	8.3	0.0	0.0	0.8
19	4.3	0.0	0.0	0.0	0.7
20	4.3	8.3	4.3	0.0	2.0
21	0.0	0.0	0.0	0.0	1.1
X	0.0	0.0	0.0	0.0	1.0
Y	0.0	0.0	0.0	0.0	0.9
22	10.5	18.2	0.0	0.0	1.3
23	0.0	0.0	0.0	0.0	1.4
24	26.3	36.4	0.0	0.0	1.8
25	5.3	0.0	0.0	0.0	1.6
26	0.0	0.0	0.0	0.0	1.1
27	10.5	9.1	0.0	0.0	0.8
G	0.0	0.0	0.0	0.0	0.7
E	0.0	0.0	0.0	0.0	0.9

Table IIa. Distribution of faecal coliforms and evaluation of stations according to interim criteria.

Station	No of samples	Samples (%) exceeding limits of 100 faecal coliforms/100 ml: Total	100 faecal coliforms/100 ml: Bathing season	1000 faecal coliforms/100 ml: Total	1000 faecal coliforms/100 ml: Bathing season
28	32 (42)*	0.0 (0.0)*	0.0 (0.0)*	0.0 (0.0)*	0.0 (0.0)*
29	32 (41)	3.1 (4.8)	5.9 (7.7)	0.0 (0.0)	0.0 (0.0)
30	32 (41)	0.0 (4.9)	0.0 (7.7)	0.0 (0.0)	0.0 (0.0)
31	32 (41)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
32	32 (42)	40.6 (35.7)	29.4 (34.6)	15.6 (11.9)	11.8 (11.5)
33	32 (41)	21.9 (34.2)	23.5 (30.8)	0.0 (2.4)	0.0 (3.9)
34	32 (42)	46.9 (50.0)	35.3 (53.9)	6.3 (11.9)	5.9 (11.5)
35	32 (41)	18.8 (19.5)	17.6 (11.6)	3.1 (0.0)	0.0 (0.0)
36	32 (41)	0.0 (2.4)	0.0 (4.0)	0.0 (0.0)	0.0 (0.0)
37	32 (41)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
38	32 (42)	31.3 (28.6)	52.9 (42.3)	12.5 (11.9)	23.5 (19.2)
39	32 (42)	15.6 (2.4)	29.4 (3.9)	3.1 (0.0)	5.9 (0.0)
I	3 (8)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
J	3 (8)	0.0 (37.4)	0.0 (50.0)	0.0 (25.0)	0.0 (50.0)
K	3 (8)	0.0 (25.0)	0.0 (25.0)	0.0 (0.0)	0.0 (0.0)

( )* values covered by the Progress report, October 1979

Table III. Period of Sampling and Number of Analyses Per Stations in Controlled Areas

Areas	Period of Sampling	Number of Analyses Per Stations
RIJEKA		
Stations:		
Nos. 1-8	June 1976 - August 1978	40
A,B	June 1976 - June 1978	10
PULA		
Stations:		
Nos. 9-15	August 1976 - July 1978	24
C,D	August 1976 - June 1978	10
POREC		
Stations:		
Nos. 16-21	August 1976 - July 1978	23
E,F	August 1976 - June 1978	10
UMAG		
Stations:		
Nos. 22-27	March 1977 - March 1979	23
G,H	March 1977 - March 1979	10
ROVINJ		
Stations:		
Nos. 28-39	March 1978 - March 1980	62
I, J, K	March 1978 - March 1980	9

Table IIIa. Median and deviation factor for total coliforms, faecal coliforms and faecal streptococci in samples taken in coastal waters off Rovinj.

Station	No of samples	Total coliforms n/100 ml	Faecal coliforms n/100 ml	Faecal streptococci n/100 ml
28	10	2.0 ± 2.9	1.3 ± 1.7	1.5 ± 1.8
29	11	3.6 ± 4.3	1.6 ± 2.4	2.8 ± 3.6
30	12	2.4 ± 2.9	1.5 ± 1.9	2.1 ± 3.7
31	12	2.3 ± 2.9	1.5 ± 2.0	2.1 ± 2.8
32	12	95.3 ± 6.6	68.7 ± 8.2	20.5 ± 5.5
33	12	203.1 ± 4.6	123.2 ± 4.4	50.1 ± 3.3
34	12	452.8 ± 3.3	249.3 ± 4.1	81.9 ± 2.5
35	12	193.9 ± 4.1	100.1 ± 3.8	36.2 ± 3.6
36	12	29.8 ± 4.9	13.4 ± 6.1	9.7 ± 3.9
37	12	28.9 ± 2.9	9.4 ± 5.1	6.6 ± 5.4
38	12	15.1 ± 4.5	3.2 ± 4.3	4.1 ± 2.6
39	12	11.5 ± 3.3	2.4 ± 3.3	4.5 ± 2.6
I	3	1.0 ± 1.0	1.0 ± 1.0	1.0 ± 1.0
J	3	26.8 ± 11.3	15.6 ± 13.9	11.3 ± 12.1
K	3	51.1 ± 2.6	32.9 ± 1.8	15.8 ± 1.5

Table IV. Correlation of Total Coliforms Versus Faecal Coliforms

Station	N	r	t	Level of significance
1	39	0.869	10.70	P > 0.001
2	39	0.869	10.71	P > 0.001
3	39	0.827	8.95	P > 0.001
4	40	0.892	7.98	P > 0.001
5	39	0.835	9.23	P > 0.001
6	39	0.934	15.88	P > 0.001
7	39	0.882	11.37	P > 0.001
8	39	0.854	9.97	P > 0.001
9	14	0.268	0.97	0.40 < P > 0.30
10	12	0.825	12.02	P > 0.001
11	15	0.958	12.04	P > 0.001
12	21	0.184	0.82	0.50 < P > 0.40
13	12	0.676	2.90	0.02 < P > 0.01
14	11	0.185	0.56	0.60 < P > 0.50
15	6	0.908	4.33	0.02 < P > 0.01
16	22	0.915	10.15	P > 0.001
17	14	0.951	10.67	P > 0.001
18	16	0.822	5.41	P > 0.001
19	19	0.852	6.71	P > 0.001
20	22	0.805	6.08	P > 0.001
21	21	0.584	3.14	0.01 < P > 0.005
22	14	0.720	3.59	0.005 < P > 0.001
23	16	0.284	1.11	0.30 < P > 0.25
24	17	0.877	7.08	P > 0.001
25	16	0.854	6.14	P > 0.001
26	14	0.861	5.86	P > 0.001
27	16	0.923	8.99	P > 0.001

Table IVa. Distribution of faecal coliforms and evaluation of stations according to interim criteria.

Station	No of samples	Samples (%) exceeding limits of 100 faecal coliforms/100 ml	1000 faecal coliforms/100 ml
28	10	0.0	0.0
29	11	0.0	0.0
30	12	0.0	0.0
31	12	0.0	0.0
32	12	25.0	16.7
33	12	41.7	8.3
34	12	83.3	25.0
35	12	50.0	8.3
36	12	8.3	0.0
37	12	0.0	0.0
38	12	0.0	0.0
39	12	0.0	0.0
I	3	0.0	0.0
J	3	33.3	0.0
K	3	0.0	0.0

Table V. Medians and Deviation Factors of Faecal Coliforms (n/100 ml) According to Meteorological Conditions (NE-Wind, S-Wind)

Station	Summer		Others	
	NE - wind	S - wind	NE - wind	S - wind
1	116.1 ± 2.8	323.6 ± 2.0	168.9 ± 9.4	465.9 ± 2.8
2	75.9 ± 6.7	325.5 ± 2.1	73.3 ± 3.6	486.0 ± 6.0
3	28.4 ± 3.4	58.9 ± 12.3	51.0 ± 4.4	298.5 ± 5.2
4	24.0 ± 4.0	86.1 ± 25.0	-	147.2 ± 5.1
5	158.5 ± 5.2	-	91.7 ± 3.8	228.2 ± 2.8
6	54.3 ± 3.5	67.6 ± 7.5	87.1 ± 5.9	248.9 ± 3.2
7	54.6 ± 2.3	341.5 ± 3.6	45.7 ± 8.0	305.5 ± 5.5
8	102.3 ± 7.3	389.1 ± 2.4	217.5 ± 2.4	269.2 ± 2.8

Table VI. Median and deviation factor for total coliforms, faecal coliforms and faecal streptococci in samples taken in coastal waters of Rovinj.

Stations	Total coliforms n/100 ml		Faecal coliforms n/100 ml		Faecal streptococci n/100 ml	
	Summer	others	Summer	others	Summer	others
28	1.5 ± 1.9	1.3 ± 1.8	1.2 ± 1.7	1.1 ± 1.6	1.3 ± 1.8	1.1 ± 1.4
29	9.2 ± 7.4	2.2 ± 3.8	6.3 ± 7.3	2.0 ± 3.4	4.4 ± 6.0	1.6 ± 2.6
30	5.1 ± 6.6	1.5 ± 2.3	3.2 ± 5.5	1.1 ± 1.4	5.1 ± 6.5	1.4 ± 2.4
31	2.1 ± 2.6	1.7 ± 2.5	1.4 ± 2.1	1.3 ± 1.8	1.7 ± 2.1	1.4 ± 2.4
32	49.5 ± 9.2	95.6 ± 12.9	37.6 ± 11.0	69.9 ± 12.3	19.4 ± 8.9	32.5 ± 9.2
33	49.8 ± 6.9	35.8 ± 5.9	33.0 ± 9.9	23.4 ± 6.1	11.1 ± 5.9	11.2 ± 5.8
34	95.2 ± 9.3	149.9 ± 4.5	88.5 ± 9.1	116.9 ± 5.2	36.7 ± 7.8	38.9 ± 4.4
35	21.9 ± 4.9	84.6 ± 4.8	12.7 ± 4.8	58.5 ± 5.1	7.8 ± 4.9	17.2 ± 4.7
36	7.6 ± 5.2	9.6 ± 5.0	4.4 ± 3.9	7.2 ± 5.6	9.4 ± 6.1	4.4 ± 4.5
37	6.4 ± 4.8	5.9 ± 3.8	3.2 ± 4.1	3.4 ± 3.8	3.3 ± 4.0	3.1 ± 3.2
38	79.9 ± 19.0	8.8 ± 8.6	40.1 ± 25.1	5.4 ± 5.9	30.7 ± 11.2	2.3 ± 2.9
39	8.1 ± 5.3	1.8 ± 2.6	3.6 ± 4.6	1.7 ± 2.6	7.4 ± 5.9	1.3 ± 1.7
I	3.2 ± 10.2	1.8 ± 3.6	2.7 ± 7.4	1.6 ± 3.0	3.7 ± 13.7	1.6 ± 2.9
J	11.6 ± 36.1	9.1 ± 6.0	9.5 ± 25.9	4.4 ± 7.9	7.0 ± 14.8	2.7 ± 3.1
K	5.6 ± 31.6	21.6 ± 10.3	3.2 ± 10.3	14.4 ± 13.3	1.9 ± 3.5	6.9 ± 7.5

Table VII: Median and deviation factor of faecal coliforms (n/100 ml) in polluted stations according to meteorological conditions (S - wind, no wind)

Stations	Summer		Others	
	S-wind	No wind	S-wind	No wind
32	50.9 ± 8.1	111.1 ± 12.4	89.3 ± 15.5	95.7 ± 11.2
33	14.8 ± 7.3	52.5 ± 7.9	24.2 ± 11.4	25.5 ± 2.9
34	66.4 ± 13.0	155.8 ± 4.4	200.8 ± 5.8	55.4 ± 3.2
35	5.6 ± 4.7	34.5 ± 4.3	91.2 ± 6.3	75.8 ± 5.3
36	8.2 ± 4.9	14.1 ± 7.9	9.8 ± 4.1	6.7 ± 5.4
38	343.7 ± 18.4	50.1 ± 26.8	8.2 ± 5.9	3.1 ± 3.8

Research Centre: Marine Biological Station
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INTRODUCTION

Since 1971 the investigations of bacterial indicators of faecal pollution (such as total coliforms, faecal coliforms, etc.) have been performed as part of the pollution research programme, including complex studies on the quality of coastal water, by the Marine Biological Station, Portoroz.

The results obtained by the monitoring programme have been presented at some symposiums, meetings, and in publications and reports.

Since 1976 microbiological quality of shellfish and shellfish growing waters have also been controlled.

We started the new monitoring programme in 1977 as a part of the UNEP/WHO Project MED POL VII.

The programme was slightly reduced in 1979, and continued in 1980.

AREA(S) STUDIED

Our programme on coastal water quality monitoring covered the area of the Yugoslav side of the Gulf of Trieste which is the most northerly part of the Adriatic, i.e. coastal waters along S. R. Slovenia. The length of our coastline is about 35 km, including two shallow and closed bays: Koper Bay and Piran Bay. The average depth is 20 m.

The coastal hinterland, made of flysch sandstone discharges important amounts of fine sediments and nutrients into the coastal sea. Therefore both turbidity and primary productivity are quite high. Koper Bay is the most polluted part of the area. It is polluted directly by domestic waste discharge (non-treated) via outfalls and by the river Rizana (average flow $1m^3$/sec) which is polluted by industrial and domestic wastes. The town of Koper is situated on its coast (20,000 inhabitants) with its port (for chemicals and different cargoes, 2-3 million tonnes/year). On the coast of the same bay is the town of Izola (17,000 inhabitants) with its food industry (Figure 1).

Piran Bay is practically unpolluted. It receives the river Dragonja (average flow 0.5 m^3/sec) which is slightly polluted by domestic wastes. The town of Piran is situated there (10,000 inhabitants). The shores of Piran Bay are intensively used as recreational areas and sorrounded by many hotels (15,000 beds). Domestic waste-waters treated by a primary treatment plant are discharged through the underwater outfall 3,450 m offshore (0.1 m^3/sec average flow) plus two small outfalls which are located 100-200 m offshore (Figure 2).

To monitor the sanitary quality of coastal waters used for bathing, twenty-seven representative coastal stations (10 m offshore in surface waters - 0.5 m) were selected in the recreational waters along the coastline. Seven additional open water stations at different distances offshore were also monitored as reference stations (at different depths - 5 m, 10 m, 15 m, 20 m). The main sources of pollution (rivers Dragonja and Rizana), and main outfalls were included in the programme and twelve stations selected. (Table I)

The shell-fish (*Mytilus galloprovincialis*) culture at Strunjan was chosen for monitoring (see Figure 2), during the whole period of the programme.

The programme was slightly modified during February 1979 and continued in this reduced form.

During that period, 21 representative coastal stations instead of 27 were selected in the recreational waters along the coastline and six additional open water stations instead of seven (7) at different offshore distances were monitored as reference stations (at different depths - 5, 10, 15, 20m). The pollution sources such as the Rizana and Dragonja rivers and the submarine outfall in Piran Bay were investigated but not other smaller pollution sources (Figures 1a and 2a, and Table Ia).

MATERIALS AND METHODS

The membrane filtration technique and media, as described in Guidelines for Health Related Monitoring of Coastal Water Quality, WHO/UNEP, Copenhagen 1977, were used to identify the bacteriological parameters.

The standard methods as described in Strickland and Parsons (1968) and Grasshoff (1976) manuals were used for other parameters.

The multiple test tube method was used for shellfish flesh and shellfish culture water analyses.

RESULTS AND THEIR INTERPRETATION

The following parameters were monitored at all stations:

- total coliforms;
- faecal coliforms;
- faecal streptococci;
- salinity; and
- water and air temperatures.

At the reference stations (which are also the points of the Marine Biological Station's systematic monitoring programme) complex investigations into the whole pelagic ecosystem and its bioproductivity were performed. The parameters are:

- hydrographic: temperature, salinity, oxygen, pH;
- bioproductivity: nutrients, phytoplankton biomasses (chlorophylls).

Period November 1977 to September 1979:

Surface-sea temperature measured in waters along S. R. Slovenia varied between 7.99°C (January 1978), - 23.75°C (July 1978) and at the bottom temperature 9.03°C (January 1978), 19.80°C (August 1978).

Oxygen values were in the range of 6.90 mg/ml (October 1978) and 9.51 mg/ml (March 1979) at the surface sea-water, and at the bottom 5.85 mg/ml (November 1978) and 9.48 mg/ml (March 1979).

Salinity ranges were 33.52°/oo (July 1978) - 37.29°/oo (January 1979) at the surface and 36.04°/oo (October 1978), 38.17°/oo (January 1979) at the bottom.

pH variations were in the range of 8.24 (in the summer) to 8.52 (in the winter) at the surface and 8.18 - 8.52 at the bottom. In the estuaries of the rivers Rizana and Dragonza values were in the range of 8.15 - 8.58 at the bottom and 7.75 - 8.32 at the surface.

In a one-year period (March 1978-March 1979) nutrient concentration values were in the range: 5.06 - 37.72 mg NO_3/m^3, 0.92-30.36 mg NO_2/m^3, 8.50 - 100.64 NH_3/m^3, 5.80 - 66.50 mg $PO_4/m^3$and 5.27 - 27.59 mg P-tot/m^3 at the surface and 31.00-261.02 mg NO_3/m^3, 2.76 - 57.50 mg NO_2/m^3, 10.03-80.75 mg NH_3/m^3, 2.85 - 37.05 mg PO_4/m^3, 2.17 - 27.28 mg P-tot/m^3 at the bottom.

The minimal concentrations of NO_2 and NO_3 were recorded in the summer and the maximal concentrations recorded in winter, but maximal NH_4 concentrations were measured in the winter and minimal NH_4 concentrations in spring. Maximal concentrations of PO_4 were detected in the winter.

The nutrients concentrations were higher in the Bay of Koper, close to the main outfall area and in the estuaries of Rizana and Dragonza. The measurements varied in the Bay of Koper: 0.00 - 2194.80 mg NO_3/ m^3, 4.60 - 69.00 mg NO_3/m^3, 27.20 - 460.70 mg NH_3/m^3 and up to 228.70 mg PO_4/m^3 and at the surface of the Rizana up to 2322.52 mg NO_3/m^3 and the Dragonja up to 2366.54 mg NO_3/m^3.

The horizontal distribution of dissolved organic nitrogen was uniformly in the range of 11.20-722.40 mg N/m^3. The highest concentrations were detected in the Bay of Koper, close to the main outfall area (up to 1733.40 mg N/m^3).

Chlorophyll concentrations varied from 0.00 (below detection of the method) up to 6.51 ug/l, registered during the bloom of Sceletonema costatum in March 1978. In general, three sharper peaks were recorded from March to April 1978, from May to June 1978 and from November to December 1978.

Sampling and analysing were done fifteen times during November 1977 to April 1979- six months in the winter season (November, February, April 1977/78 and 1978/79) and ten times in the summer season (every month from May to September for 1978 and from June to September for 1979).

Altogether 701 sea-water samples were collected as follows:

388 samples were taken at points chosen as coastal stations (recreational water, public beaches), at a distance approximately 10 m offshore.

168 samples were taken near the main sources of pollution (38 samples at rivers Rizana and Dragonza), and 130 samples at main outfalls.

145 samples were taken at reference stations which were selected at a relatively unpolluted site, 1 - 2 Nm offshore.

Results obtained by all bacteriological analyses (number of total coliforms, faecal coliforms, faecal streptococci) were evaluated as mean values for winter and summer months, respectively for two periods separately.

Period November 1977 to February 1979:

The results of the first period November 1977 to February 1979 (see Table II) show that serious faecal pollution in the coastal sea along S. R. Slovenia is confined to only one zone in the Bay of Koper, exactly at the main direct outfall- Stations A, A1, A2 (load 20,000 - 30,000 eqv. units), where high concentrations of bacteria were found (max. 310,000 faecal coliforms/100 ml). But their number decreased rapidly with distance from the source of pollution towards the open sea.

There are some other smaller direct outfalls in the Bay of Koper but they have little effect on public beaches their influence limited in time and place.

In Piran Bay there is an underwater outfall discharging primarily treated domestic waste-waters. The investigations at the outfall (3,450 m offshore), Station C, show almost no influence, except at the bottom (depth 20 m) near the diffuser.

There is another small outfall 200 m offshore in the town of Piran (Station E) which is near a public beach (Station 17) but this also has little influence on the water quality.

Another slight factor contributing to the pollution is the river Rizana flowing into the Bay of Koper and the Dragonza flowing into the Bay of Piran.

The counts at all stations showed lower values than 1000 faecal coliforms/100 ml except at the stations Zusterna (Station 5), Izola (Station 8), Valdoltra (Station 2) and Ankaran (Station 3). As to station 5, the values obtained could be attributed to the effect of the main outfall from Koper as described above, and most probably to the influence of the smaller outfall near the station. The results from Stations 2, 3 and 8 could be attributed to the effect of the smaller outfall of sewage a few metres offshore (Table III).

The ratios of total coliforms and faecal coliforms and of faecal coliforms and faecal streptococci are shown in Table IV. The computed ratios are varied dependent on the distances of the stations from direct sources of contamination.

Period March 1979 to September 1979:

The results (see Table V) of the second period show that coastal waters along S.R. Slovenia are not significantly affected by faecal pollution. Generally, low densities for total and faecal coliforms and for streptococci were found. The counts at all stations showed lower values than 1000 faecal coliforms/100 ml. There is only one exception, Station No. 5 in the Bay of Koper, where high concentration of faecal indicators (max. 68,000 faecal coliforms/100 ml) were noted. It is most probably the effect of the main direct outfall from Koper, which is located 750 m from the station and the influence of the smaller outfall near the beach.

Besides the effect of the main outfall from Koper there is also the effect of the river Rizana, which is also a slight factor contributing to the faecal pollution of the Bay of Koper (max. 2,940 faecal coliforms/100 ml).

The public-beaches in the Bay of Piran are very "clean" and almost all stations can be considered as "highly satisfactory bathing areas". Also the investigations at the underwater outfall (3,450 m offshore, station PI) show almost no influence, except a slight effect at the bottom (max. 168 faecal coliforms/100 ml).

On the whole, higher mean values of faecal coliforms were noted during the winter months, with some exceptions (where the counts were slightly increased during summer months).

The correlation between the mandatory parameters is shown in Table VI. With some exceptions we found the best correlation between total coliforms and faecal coliforms. But the correlation between total and faecal coliform and faecal streptococci was noted only at some stations. On the other hand a good correlation between all three indicator organisms was found at certain stations (1, 5, A, 13, 18, D).

In accordance with the recommended interim criteria (WHO document ICP/CEP 209/A(2)I, Athens, 1977) the results are shown in Table VII.

Monitoring of shellfish and culture areas:

Our monitoring programme also included investigations on shellfish grown in the experimental shellfish aquaculture farm of mussels Mytilus galloprovincialis in Strunjan Bay (see attached map - Figures 2 and 2a).

Shellfish and shellfish growing water sampling was done at the same time. Frequency of sampling was monthly. The parameters measured were: total coliforms and faecal coliforms. The multiple test tube method was used in shellfish flesh and shellfish growing water analyses (see Guidelines for Health Related Monitoring of Coastal Water quality, WHO/UNEP, 1977).

The results of these investigations for a period of two years (from July 1977 to August 1979) are shown in Table IVa and on Figure 3.

Generally the levels of faecal contamination of culture water are very low (10 faecal coliforms/100 ml). In spite of that, the counts of faecal coliforms in mussels is sometimes very high (the average is 843 faecal coliforms/100 g. The concentration factor for faecal coliforms is about 50.

The correlation between the total coliforms and faecal coliforms for samples of water and shellfish flesh was calculated. There is a good correlation for water samples ($r = 0.9$) but there is no correlation for shellfish flesh samples.

The results based on the recommended interim criteria (Report on WHO/UNEP UNEP Seminar, Rome 4-7 April 1978) are shown in Table Va.

Period September 1979 to September 1980:

Sampling and analysis were carried out nine times from September 1979 to September 1980 - four times in the winter (November, December 1979, February, April 1980) and five times in the summer (September 1979; May, July, August, September 1980).

Altogether, 248 sea-water samples were collected as follows:

186 samples were taken at stations chosen as coastal ones (recreational waters, public beaches) at a distance approximately 10 m offshore;

21 samples were taken near the sources of pollution (the river Rizana and at the submarine outfall);

41 samples were taken at reference and background stations which were selected at relatively unpolluted sites, 1 - 2 Nm offshore.

Results obtained by bacteriological analyses (number of total coliforms, faecal coliforms, faecal streptococci) were evaluated as mean values and their variances for winter and summer months, respectively (Table IIa).

These results show that recreational waters along S.R. Slovenia are not significantly affected by faecal pollution. Generally, at all stations low densities for total and faecal coliforms and for faecal streptococci were found.

The counts of mentioned bacteria indicate lower faecal contamination at station No. 5 during the year 1980 compared to the results from a period 1977-1979. All samples from this year contained less than 1000 faecal coliforms/100 ml.

It is necessary to mention that since October 1979 the main direct sewage outfall from Koper has been located at the river Rizana (cca 300 m far from the outflow) and consequently the high counts of bacterial indicators were estimated at the outflow of Rizana (station rR) during this period. All counts were higher than 1000 faecal coliforms/100 ml (max. 98,000 faecal coliforms/100 ml). The influence of this fact was not found in the middle of the Bay (1 Nm from offshore, station A).

Bathing waters in the Bay of Piran are "clean" and almost all stations can be considered as "highly satisfactory bathing areas".

In accordance with the recommended interim criteria (Health Criteria and Epidemiological Studies Related to Coastal Water Pollution, WHO 1977), the results are listed in Table IIIa.

The results of bacteriological quality control of mussels (*Mytilus galloprovincialis*) and shellfish growing water during a period of three years (from July 1977 to September 1980) are shown in Table IVa and in Figure 3a. Shellfish and shellfish growing water sampling were done at the same time. The frequency of sampling and analysing was monthly.

Generally, the levels of faecal contamination of culture water is very low (less than 10 faecal coliforms/100 ml). In spite of that, the count of faecal in mussels is sometimes very high (max. = 24,000 faecal coliforms/100 ml). The concentrations factor for faecal coliforms is about 50. The correlation between concentration of total coliforms and faecal coliforms for samples of water and mussels were calculated. There is a good correlation for water samples (r = 0.9), but there is no correlation for mussel samples.

The results, in accordance with the recommended interim criteria (WHO, document ICP/RCE 206(8) Rome, April 1978) are shown in Table Va.

DISCUSSION OF RESULTS

For the period November 1977 to February 1979:

Taking into consideration the recommended interim criteria for recreational water (Report of a WHO/UNEP working group Athens, 1-4 April 1977, it can be underlined in the conclusions that only 9 out of 262 samples taken at public beaches contained more than 1000 coliforms/100 ml while 203 samples were in the range of 0-100 faecal coliforms/100 ml. That means that most of the public beaches in the areas under investigation could be considered as highly satisfactory bathing places.

For the period February 1979 to September 1979:

Only one public beach exceeded 1000 faecal coliforms/100 ml in 50% of the samples in that situation and was not acceptable for bathing. All other samples contained less than 1000 faecal coliforms/100 ml and most of them, especially those from the bay of Piran had less than 100 faecal coliforms/100 ml. This means that these are of a high quality for bathing and recreational activities (Table VII).

The observations of mussel-culture do not show very high sanitary quality: only 46% of the values are smaller than 2 faecal coliforms/g - which means that sale is permitted, and 27% values are between 3 - 10 faecal coliforms/g - sale temporarily prohibited and 27% values are higher than 10 faecal coliforms/g - sale prohibited. However 80% of samples of water of culture area was less than 10 faecal coliforms/100 ml.

The programme is continuing; however, no further statistical analysis could be carried out at this stage due to insufficient data. Preliminary evaluations indicate that faecal contamination in coastal waters along S.R. Slovenia is very similar to previous results, with one exception at the out-flow of the river Rizana where a higher number of bacterial indicators was found. The results based on the recommended interim criteria (report by WHO/UNEP Seminar, Rome 4-7 April 1978) are shown in Table IVa.

Period September 1979 to September 1980:

Taking into consideration the WHO's recommended interim criteria for recreational waters we can stress in our conclusions that all public beaches are acceptable for bathing and most of them can be considered as "highly satisfactory bathing areas" (Table IIIa).

The observation of mussels-culture do not show very high sanitary quality: only 51.1% of the values are smaller than 2 faecal coliforms/g - which means that sale is permitted; 24.3% of the values are between 3 - 10 faecal coliforms/g - sale temporarily prohibited, and 24.3% of the values are higher than 10 faecal coliforms/g - sale prohibited.

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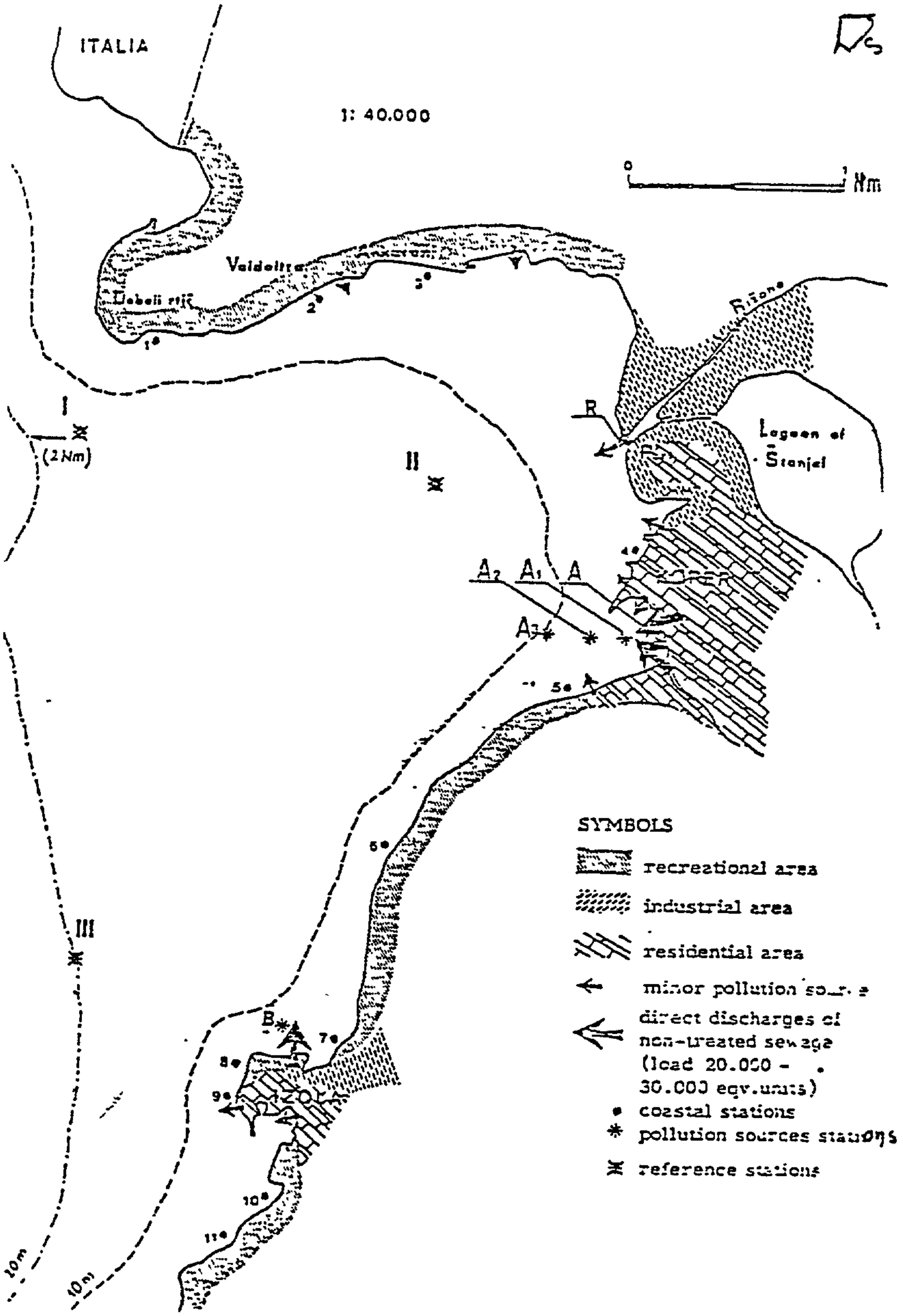

Fig. 1. Bay of Koper

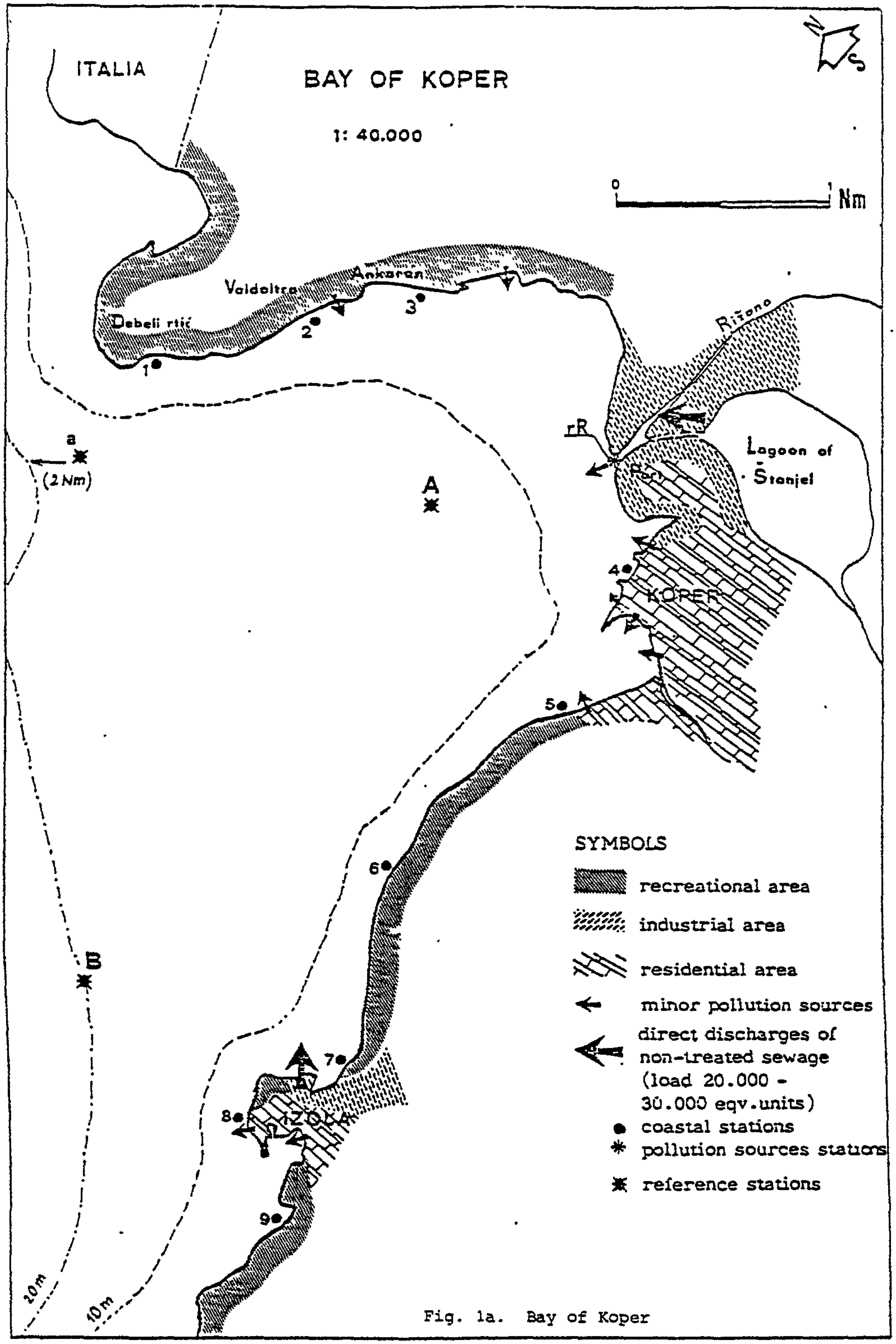

Fig. 1a. Bay of Koper

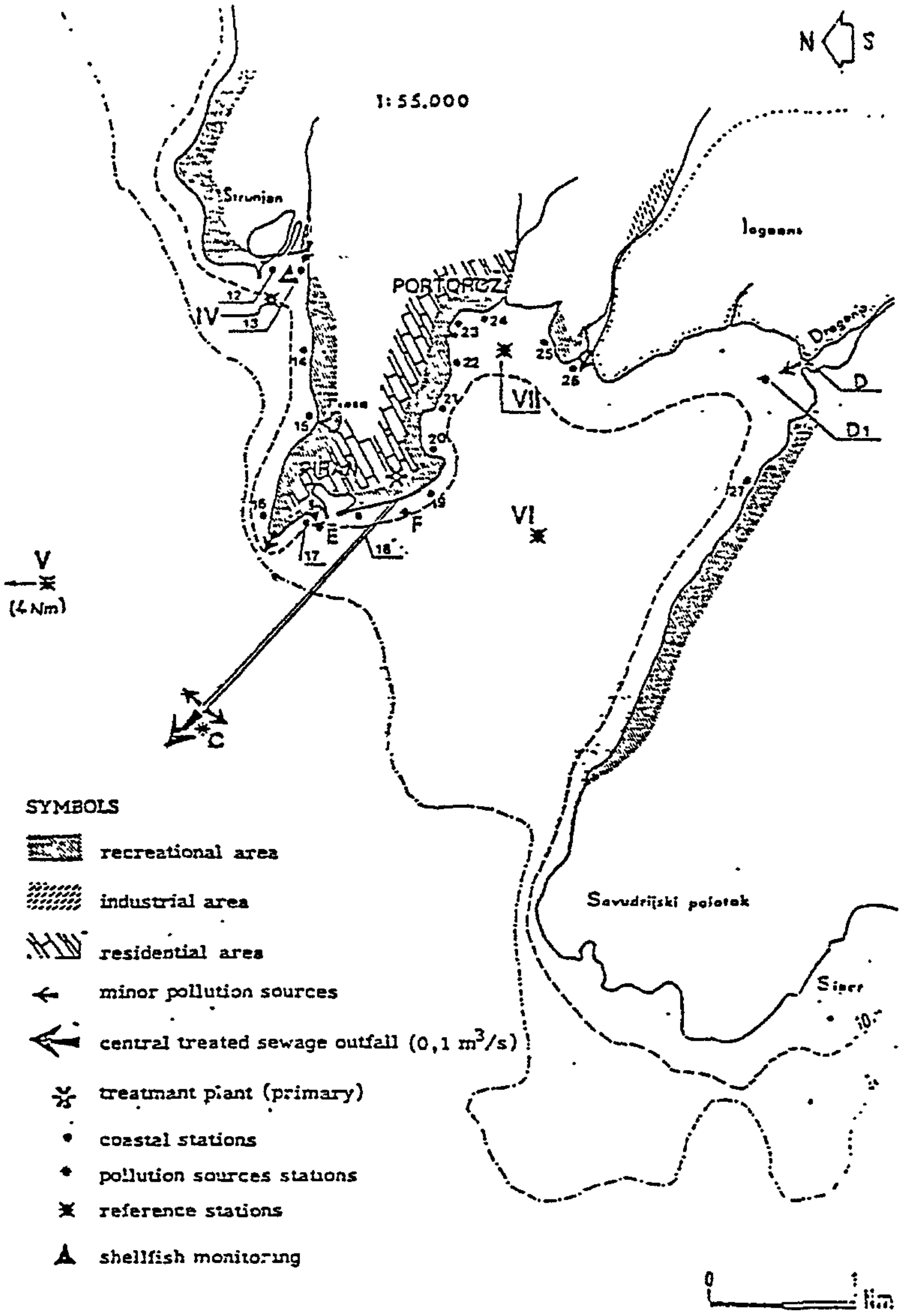

Fig. 2. Bay of Piran

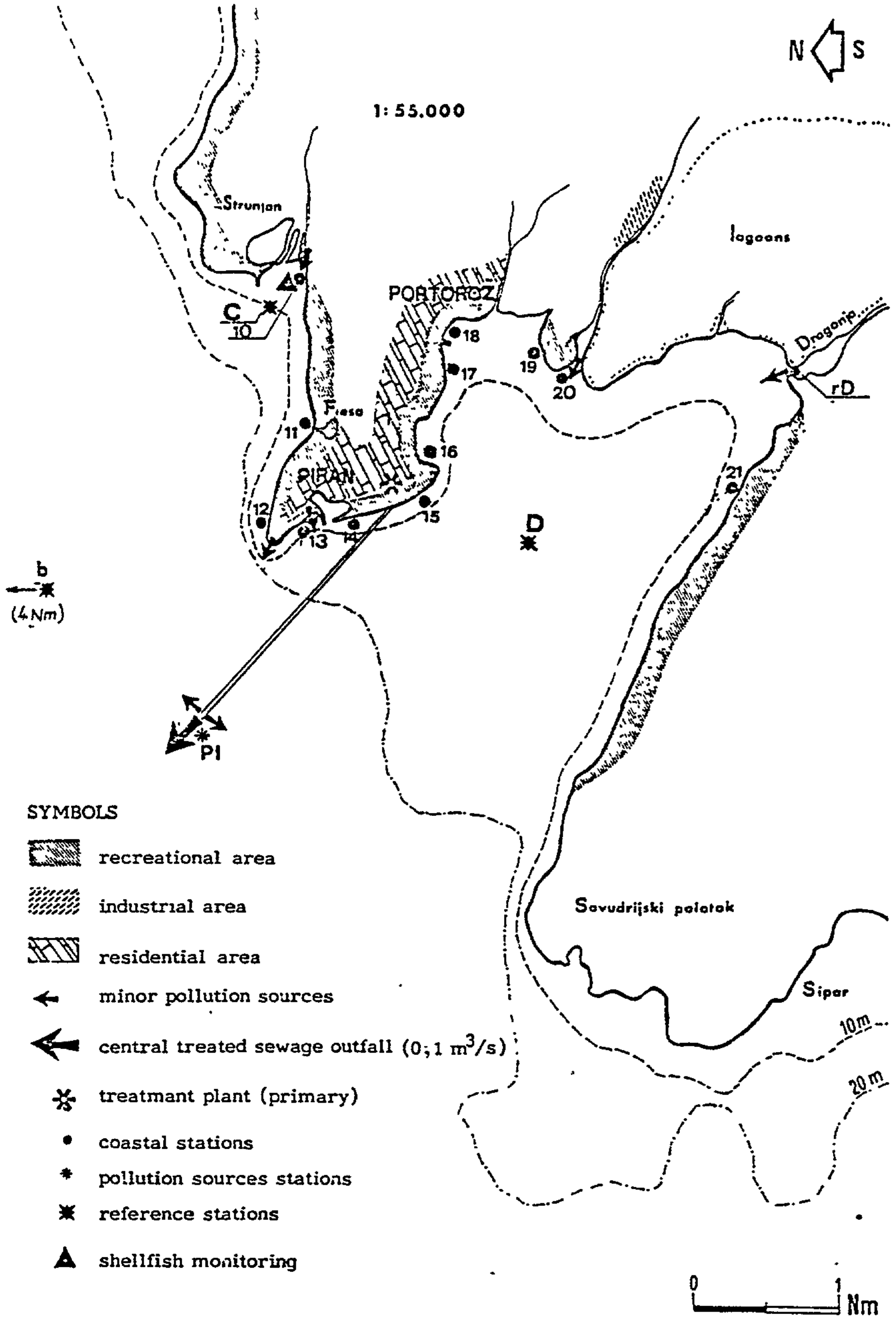

Fig. 2a. Bay of Piran

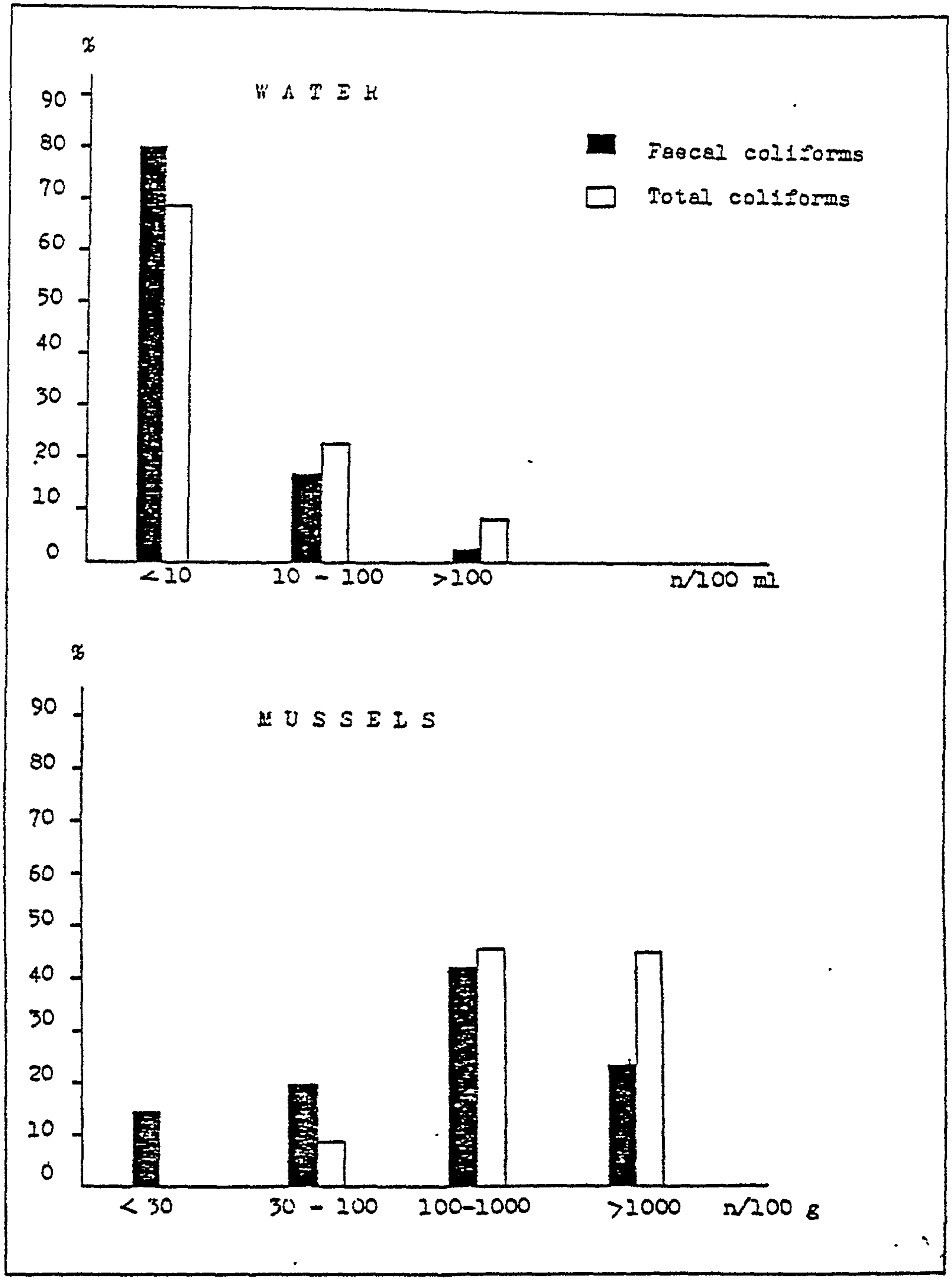

Fig. 3. The relative frequencies of the values of total coliforms and faecal coliforms in samples of mussels and water of culture area

Table I

List of monitoring stations in the coastal sea along S.R.Slovenija (Yugoslavia), Gulf of Triest (North Adriatic) , for the period November 1977 to February 1979.

Recreational waters

(swimming areas, coastal stations, 10 - 20 m from shoreline)

Station symbols	Locality Terms
1	Debeli rtič
2	Valdoltra
3	Ankaran
4	Koper
5	Žusterna
6	Rex
7	Izola - camping
8	Izola - public beach
9	Izola - light house
10	Simonov zaliv
11	Belveder
12	Strunjan - public beach
13	Strunjan - -"- -"-
14	Pacug
15	Fiesa
16	Piran - hotel "Punta"
17	Piran - hotel "Piran"
18	Piran - public beach
19	Bernardin - hotel "Emona"
20	Bernardin - public beach
21	Portorož - store-house
22	Portorož - hotel "Riviera"
23	Portorož - public beach
24	Lucija
25	Seča - camping
26	Seča - "Ribič"
27	Kanegra

Pollution point sources

Rivers

R	Rižana - outflow
D	Dragonja - outflow
D1	Dragonja - estuary - 500 m from outflow

Outfalls

A	Koper - main direct discharge of non-treated sewage, at the point of discharge
A1	100 m off the point of discharge
A2	250 m off -"- -"- (0.5 m, 5 m)
A3	1000 m off -"- -"- (0.5 m, 10 m)
B	Izola - main direct discharge of non-treated sewage
C	Piran - UW outfall of treated sewage (0.5 m, 10 m, 20 m)
E	Piran - outfall at "Punta" (0.5 m, 10 m)
F	Piran - outfall at "Salvetti" (meteoric waters only)

Table I (continued)

Reference stations off-shore

Station symbols	Coordinates	Station Depth (m)
I	45° 36,2' 13° 39,8'	20 m
II	45° 33,6' 13° 43,7'	13 m
III	45° 33,3' 13° 39,3'	18 m
IV	45° 30,3' 13° 32,8'	10 m
V	45° 35,4' 13° 27,0'	20 m
VI	45° 30,3' 13° 34,0'	16 m
VII	45° 30,6' 13° 35,0'	10 m

Table Ia.

List of monitoring stations in the coastal sea along S.R. Slovenija (Yugoslavia), Gulf of Triest (North Adriatic), from February 1979

Recreational Waters

(Swimming areas, coastal stations, 10 m from shoreline.)

Station Symbols	Locality Terms
1	Debeli rtič
2	Valdoltra
3	Ankaran
4	Koper
5	Zusterna
6	Rex
7	Izola - camping
8	Izola - light house
9	Simonov zaliv
10	Strunjan - public beach
11	Fiesa
12	Piran - Hotel "Punta"
13	Piran - Hotel "Piran"
14	Piran - public beach
15	Bernardin - Hotel "Emona"
16	Portorož - store-house
17	Portorož - Hotel "Riviera"
18	Portorož - public beach
19	Seča - camping
20	Seča - "Ribič"
21	Kanegra

Pollution Point Sources

rR	River Rizana - outflow
rD	River Dragonja - outflow
PI	Underwater outfall of treated sewage (0.5 m, 10 m, 20 m)

Background and Reference Station

Station symbols	Coordinates	Station Depth (m)
A	45° 33.6' 13° 43.7'	13
B	45° 33.3' 13° 39.3'	18
C	45° 30.3' 13° 32.8'	10
D	45° 30.3' 13° 34.0'	16
a	45° 36.2' 13° 39.8'	20
b	45° 34.7' 13° 26.1'	21

Table II Bacterial indicators of faecal pollution expressed in mean values for winter and summer months
(First Period Nov 1977 - Feb 1979)

Station depth/m	SUMMER mean values/100* Total coliforms	Faecal coliforms	Faecal streptococci	WINTER mean values/100 ml* Total coliforms	Faecal coliforms	Faecal streptococci
1	17.8 ± 8.2	8.6 ± 9.4	6.4 ± 6.5	23.3 ± 3.0	19.0 ± 5.3	17.8 ± 3.4
2	62.6 ± 14.6	19.8 ± 15.7	14.3 ± 14.8	13.8 ± 7.2	9.6 ± 8.5	4.9 ± 3.3
3	73.1 ± 2.2	56 2 ± 6 B	13.1 ± 13.1	24.4 ± 6.1	12.7 ± 4.6	3.2 ± 3 6
4	55.5 ± 3.1	33.9 ± 2.5	31.3 ± 2.5	72 8 ± 4.3	30.5 ± 3 2	3.7 ± 1.4
5	502.6 ± 8.1	347.0 ± 6.4	161.6 ± 5.5	439.2 ± 35.3	174.4 ± 51.3	157.1 ± 24.5
6	n.d.	n.d.	n.d.	43.3 ± 2 2	14.5 ± 1.7	8.7 ± 2.2
7	26.4 ± 9.7	11.3 ± 4.4	23.3 ± 4.0	40.6 ± 1.8	35.5 ± 3.3	80.5 ± 2.5
8	1665.5 ± 13.2	932.9 ± 14.6	468.3 ± 4.2	89.1 ± 9.0	42.0 ± 14.8	35.6 ± 2.6
9	41.5 ± 9.2	16.9 ± 17.1	18.0 ± 5.4	107.0 ± 14.1	64.8 ± 12.1	56.8 ± 4.9
10	5.4 ± 10 1	2.7 ± 6.6	3.8 ± 5.5	12.3 ± 5.6	4.2 ± 5.3	10.2 ± 5.9
11	5.0 ± 5.0	1.8 ± 1.7	1.3 ± 1.5	16.3 ± 3.0	4.8 ± 2.3	5.5 ± 1.7
12	7.5 ± 9.0	4.2 ± 4.7	5.1 ± 3.1	27.0 ± 8.6	10.7 ± 7.6	15.5 ± 2.7
13	8.8 ± 5.6	3.6 ± 4.4	2.4 ± 3.3	31.1 ± 12.1	6.7 ± 5.9	5.8 ± 2.5
14	8.8 ± 1.4	2.8 ± 2.8	1.4 ± 1.6	n.d.	n.d.	n.d.
15	3.9 ± 4.2	3.3 ± 4.4	3.1 ± 3.5	5.9 ± 6.5	1.5 ± 2.1	1.8 ± 2.6
16	3.1 ± 4.8	2.2 ± 3.1	2.5 ± 2.6	6.0 ± 2.4	2.0 ± 3.3	2.3 ± 6.6
17	3.0 ± 2.7	1.8 ± 2.8	1.5 ± 2.4	43.2 ± 4.6	17.1 ± 5.7	11.4 ± 9.6
18	3.0 ± 9.4	3.1 ± 9.6	5.1 ± 7.3	2.4 ± 3.5	4.9 ± 3.5	3.9 ± 1.4
19	17.4 ± 21.8	15.4 ± 15.7	12.5 ± 11.6	12.5 ± 3.4	3.7 ± 5.3	6.7 ± 4.4
20	16.0 ± 3.7	6.5 ± 6.0	3.8 ± 4.1	50.3 ± 2.9	10.5 ± 5.0	9.5 ± 3.7
21	9.5 ± 6.7	7.4 ± 8.1	7.5 ± 7.1	46.1 ± 3.1	7.1 ± 7.8	6.5 ± 5.3
22	263.7 ± 2.4	125.4 ± 1.3	35.9 ± 2.4	22.7 ± 2.7	8.3 ± 2.6	8.2 ± 3.5
23	7.4 ± 5.2	6.3 ± 6.3	6.5 ± 5.8	10.0 ± 8.7	13.5 ± 11.1	14.7 ± 6.5
24	n.d.	n.d.	n.d.	n.d	n.d.	n.d.
25	15.3 ± 5.5	12.1 ± 5.6	6.1 ± 5.6	12.5 ± 4.8	4.2 ± 6.2	4.2 ± 3.6
26	17.2 ± 3.8	6.4 ± 7.2	3.9 ± 4.9	38.9 ± 11.5	12.1 ± 5.7	3.6 ± 2.2
27	3.3 ± 5.3	2.1 ± 2.9	1.7 ± 1.8	6.7 ± 5.2	1.2 ± 1.6	0.0 ± 0.0
I/0.5	1.1 ± 1.4	0.0 ± 0.0	0.0 ± 0.0	3.9 ± 5.4	1.6 ± 2.2	2.0 ± 2.7
I/20	1.3 ± 1.5	0.0 ± 0.0	0.0 ± 0.0	2.3 ± 2.5	1.1 ± 1.4	1.3 ± 1.5
II/0.5	3.7 ± 2.8	1.6 ± 1.6	5.3 ± 6.0	71.5 ± 23.2	35.2 ± 36.8	27.0 ± 29.4
II/15	4.0 ± 4.0	0.0 ± 0.0	4.6 ± 4.9	4.3 ± 2.9	1.7 ± 2.8	1.8 ± 2.1
III/0.5	1.4 ± 2.0	1.2 ± 1.6	1.4 ± 2.0	8.3 ± 39.0	14.3 ± 22.1	11.1 ± 19.6
III/18	2.9 ± 4.4	2.0 ± 4.9	2.3 ± 4.4	3.8 ± 2.7	1.5 ± 2.2	2.3 ± 2.3
IV/0.5	1.7 ± 2.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
V/0.5	1.1 ± 1.4	0.0 ± 0.0	1.4 ± 1.7	2.4 ± 2.7	1.1 ± 1.4	0.0 ± 0.0
V/20	1.3 ± 1.9	0.0 ± 0.0	1.1 ± 1.4	1.3 ± 1.5	0.0 ± 0.0	0.0 ± 0.0
VI/0.5	0.0 ± 0.0	0.0 ± 0.0	1.5 ± 2.3	3.4 ± 1.7	1.4 ± 1.8	2.0 ± 2.0
VI/15	3.0 3.7	1.7 3.4	1.6 2.9	2.7 1.8	0.0 0.0	2.4 2.3
VII/0.5	2.1 3.5	0.0 0.0	0.0 0.0	105.8 5.4	4.0 2.7	10.6 4.0
B/0.5	5628.6 2.3	841.6 2.4	276.6 2.1	1293.6 1.9	274.0 1.6	171.6 1.6
D/0.5	33.1 2.9	15.7 4.6	8.4 5.3	38.4 3.9	9.8 8.6	5.1 3.0
D1/0.5	6.5 4.3	2.4 3.5	5.0 6.4	12.9 5.9	2.8 4.2	6.2 5.1
A/0.5	111837.6 4.1	44410.2 9.4	21213.8 7.7	200045.4 4.7	62783.6 6.3	23201.7 5.3
A1/0.5	4580.1 4.5	2519.9 4.3	1724.2 2.4	23342.5 2.5	8062.1 3.5	4187.0 2.3
A2/0.5	131.1 12.9	15.8 12.4	92.1 4.7	323.1 10.1	213.2 14.0	97.4 13.9
A2/5	25.7 4.4	18.1 5.2	11.6 1.8	80.1 2.2	50.9 2.0	52.7 1.5
A3/0.5	40.4 34.1	17.0 23.0	56.4 10.1	407.9 6.5	140.0 9.4	217.7 5.3
A3/10	117.3 10.0	11.3 13.6	14.0 2.7	17.1 13.2	7.9 11.3	14.6 4.2
C/0.5	0.0 0.0	0.0 0.0	0.0 0.0	3.0 4.5	1.8 3.8	2.0 2.2
C/10	1.6 2.0	0.0 0.0	1.6 2.0	1.6 1.7	1.2 1.4	1.8 2.8
C/20	151.0 8.3	71.8 5.8	28.0 6.1	52.9 3.9	19.8 12.2	18.0 3.6
E/0.5	3.2 3.4	2.6 3.1	6.4 5.7	49.2	12.2 9.4	13ʜ9 7.1
E/10	262.7 6.6	160.1 4.9	89.2 3.0	102.9 3.3	51.8 5.1	22.1 4.7
F/0.5	37.4 159.9	20.2 57.8	38.1 39.6	123.6 106.8	80.5 88.4	43.8 45.4

* mean values and standard deviation expressed as antilog.

N.d. = not determined.

Table IIa Bacterial indicators of faecal pollution expressed in mean values and their variances for winter and summer months (during September 1979 to September 1980)

Station	SUMMER						WINTER					
	Total coliforms/100 ml		Faecal coliforms/100 ml		Faecal streptococci/100 ml		Total coliforms/100 ml		Faecal coliforms/100 ml		Faecal streptococci/100
	mean[x]	variance[x]	mean[x]	variance[x]	mean[x]	variance[x]	mean[x]	variance[x]	mean[x]	variance[x]	mean[x]	variance
1	0.90	0.42	0.55	0.31	0.52	0.55	2.18	0.90	1.97	0.27	2.02	0.06
2	1.01	0.95	0.61	0.36	0.75	0.50	2.01	0.56	1.83	0.49	1.52	0.71
3	1.08	0.81	0.80	1.10	0.99	0.75	2.15	0.31	1.63	0.69	1.39	0.96
4	1.84	1.42	1.45	1.21	1.31	0.86	1.72	0.51	1.70	0.28	1.78	0.31
5	1.64	3.73	1.18	4.23	1.34	3.11	2.59	0.24	2.39	0.37	2.19	0.09
A	0.37	0.26	0.26	0.15	0.18	0.16	1.93	0.61	1.49	0.52	1.09	0.50
a	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.39	0.23	0.16	0.71	0.47
6	1.78	1.82	0.74	1.19	1.31	1.06	2.15	0.19	1.95	0.22	1.88	0.01
7	2.21	0.67	0.47	0.38	2.24	0.11	1.75	0.42	1.32	0.61	1.20	0.54
8	1.22	0.84	0.70	0.46	1.42	0.54	2.99	0.88	2.77	0.89	2.30	0.79
9	0.17	0.14	0.22	0.04	0.47	0.08	1.18	0.51	0.85	0.46	0.87	0.58
B	0.23	0.16	0.00	0.00	0.00	0.00	0.62	1.16	0.47	0.65	0.49	0.37
10	0.81	0.45	0.36	0.65	0.47	0.53	1.33	2.06	1.06	1.59	0.92	0.83
11	0.34	0.29	0.24	0.11	0.37	0.31	0.85	0.54	0.62	0.53	0.80	0.29
C	0.18	0.03	0.10	0.05	0.26	0.15	0.99	0.83	0.83	0.66	0.82	0.31
12	1.03	0.67	0.78	0.65	0.91	0.59	1.43	0.21	1.34	0.36	1.35	0.04
13	0.87	0.77	0.64	0.37	1.00	0.85	1.95	1.44	1.38	1.69	1.65	0.42
14	1.09	0.83	0.71	0.94	0.66	0.83	2.43	2.80	1.49	1.70	1.58	0.98
15	0.56	0.65	0.30	0.27	0.62	0.81	1.85	1.30	1.58	1.35	1.72	0.46
16	0.70	0.44	0.40	0.06	0.79	0.50	1.61	0.52	1.33	0.83	1.26	1.30
17	1.32	0.67	1.13	0.36	1.08	0.45	1.76	0.60	1.39	1.26	1.14	0.76
18	0.79	0.75	0.59	0.57	1.07	0.03	1.49	1.01	1.31	0.77	1.18	0.68
19	1.20	0.20	0.65	0.10	0.69	0.01	1.35	1.27	0.99	1.37	0.98	0.68
20	0.99	1.15	0.66	0.92	0.45	0.48	1.70	1.53	1.48	1.09	1.30	0.81
21	0.27	0.36	0.00	0.00	0.16	0.05	0.51	0.69	0.29	0.35	0.56	0.51
D	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.79	0.10	0.03	0.23	0.16
b	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
rR	4.32	0.61	4.13	0.42	3.28	0.78	4.95	0.22	4.32	0.39	3.77	0.16
PI	0.00	0.00	0.00	0.00	0.00	0.00	1.74	2.32	1.65	2.09	2.32	0.12

[x] Log transformed data

Table III Relative frequencies (%) of the counts of faecal coliforms listed in accordance with interim criteria, i.e., less than 100 faecal coliforms/100 ml and more than 100 faecal coliforms/100 ml.
(First Period, November 1977 to February 1979)

Stations depth/m	less than 100		more than 1000	
	All samples	Bathing season samples (1978)	All samples	Bathing season samples (1978)
1	81.8	80.0	0.0	0.0
2	77.8	80.0	9.1	20.0
3	81.3	80.0	9.1	20.0
4	80.0	80.0	0.0	0.0
5	45.4	40.0	36.4	20.0
6	100.0	100.0	0.0	0.0
7	90.9	100.0	0.0	0.0
8	33.3	20.0	33.3	60.0
9	63.6	80.0	0.0	0.0
10	100.0	100.0	0.0	0.0
11	100.0	100.0	0.0	0.0
12	90.9	100.0	0.0	0.0
13	100.0	100.0	0.0	0.0
14	100.0	100.0	0.0	0.0
15	100.0	100.0	0.0	0.0
16	100.0	100.0	0.0	0.0
17	72.7	100.0	0.0	0.0
18	100.0	100.0	0.0	0.0
19	90.0	80.0	0.0	0.0
20	100.0	100.0	0.0	0.0
21	100.0	100.0	0.0	0.0
22	50.0	20.0	0.0	0.0
23	90.9	100.0	0.0	0.0
24	n.d.	n.d.	n.d.	n.d.
25	100.0	100.0	0.0	0.0
26	90.9	100.0	0.0	0.0
27	100.0	100.0	0.0	0.0
I/0.5	100.0	100.0	0.0	0.0
I/20	100.0	100.0	0.0	0.0
II/0.5	70.0	100.0	0.0	0.0
II/15	100.0	100.0	0.0	0.0
III/0.5	77.8	100.0	0.0	0.0
III/18	100.0	100.0	0.0	0.0
IV/0.5	100.0	100.0	0.0	0.0
V/0.5	100.0	100.0	0.0	0.0
V/20	100.0	100.0	0.0	0.0
VI/0.5	100.0	100.0	0.0	0.0
VI/15	100.0	100.0	0.0	0.0
VII/0.5	100.0	100.0	0.0	0.0

Table IIIa

Evaluation of faecal coliform counts according to interim criteria, i.e. less than 100 faecal coliforms/100 ml and more than 1000 faecal coliforms/100 ml

Station	less than 100		more than 1000	
	All samples %	Bathing season samples (1980) %	All samples %	Bathing season samples (1980) %
1	66.7	100.0	0.0	0.0
2	77.8	100.0	0.0	0.0
3	66.7	75.0	0.0	0.0
4	66.7	75.0	0.0	0.0
5	55.6	100.0	11.1	0.0
A	87.5	100.0	0.0	0.0
a	100.0	100.0	0.0	0.0
6	55.6	75.0	0.0	0.0
7	77.8	75.0	0.0	0.0
8	62.5	100.0	37.5	0.0
9	100.0	100.0	0.0	0.0
B	100.0	100.0	0.0	0.0
10	88.9	100.0	0.0	0.0
11	100.0	100.0	0.0	0.0
C	100.0	100.0	0.0	0.0
12	88.9	100.0	0.0	0.0
13	77.8	100.0	0.0	0.0
14	66.7	100.0	0.0	0.0
15	100.0	100.0	0.0	0.0
16	77.8	100.0	0.0	0.0
17	88.9	100.0	0.0	0.0
18	100.0	100.0	0.0	0.0
19	88.9	100.0	0.0	0.0
20	66.7	75.0	0.0	0.0
21	100.0	100.0	0.0	0.0
D	100.0	100.0	0.0	0.0
b	100.0	100.0	0.0	0.0
rR	100.0	0.0	100.0	100.0
PI	66.7	100.0	0.0	0.0

Table IV. The Correlation Between Total Coliforms and Faecal Coliforms (TC/FC) and Between Faecal Coliforms and Faecal Streptococci (FC/FS).

(First Period, November 1977 to February 1979)

Stations	Ratio TC/FC	Ratio FC/FS	Stations depth/m	Ratio TC/FC	Ratio FC/FS
1	1.58	0.94	I/0.5	4.67	0.82
2	3.58	1.44	I/20	6.00	0.67
3	0.66	14.55	II/0.5	1.14	5.14
4	2.27	1.10	II/15	5.64	0.17
5	1.73	2.79	III/0.5	2.25	0.93
6	n.d.	n.d.	III/18	1.50	0.86
7	5.34	0.26	IV/0.5	5.00	0.00
8	1.44	5.09	V/0.5	6.00	0.43
9	1.58	2.63	V/20	8.00	0.00
10	2.09	0.60	VI/0.5	2.71	0.37
11	4.26	1.15	VI/15	2.88	0.59
12	2.40	1.46	VII/0.5	35.64	0.33
13	7.59	1.98	R/0.5	5.89	2.73
14	4.83	3.00	D/0.5	1.64	2.71
15	1.38	1.25	D1/0.5	3.65	0.33
16	2.76	0.40	A/0.5	2.44	2.36
17	2.55	0.10	A1/0.5	1.91	2.62
18	0.90	1.41	A2/0.5	1.97	1.59
19	1.49	1.80	A2/5	1.66	1.46
20	2.60	1.61	A3/0.5	2.70	1.25
21	1.69	1.42	A3/10	2.61	3.24
22	2.63	2.44	C/0.5	1.38	2.62
23	1.54	0.37	C/10	4.00	0.21
24	n.d.	n.d.	C/20	2.63	3.97
25	1.50	1.85	E/0.5	2.03	0.90
26	5.46	4.16	E/10	2.27	2.88
27	8.39	1.64	F/0.5	7.39	2.90

Table IVa

Data on faecal contamination of mussel-cultures in Strunjan from 1977 to 1980

		WATER OF CULTURE AREA		MUSSEL	
Date of sampling	Temp. °C	Total coliforms n/100 ml	Faecal coliforms n/100 ml	Total coliforms n/100 g	Faecal coliforms n/100 g
27.7.77	24.5	9	< 3	430	150
16.8.77	25.2	<3	< 3	230	< 30
8.9.77	23.5	9	4	430	<30
6.10.77	17.5	< 3	< 3	430	90
25.11.77	14.3	<3	< 3	930	430
27.12.77	12.0	<3	< 3	40	<30
29.1.78	8.0	93	21	4600	430
17.2.78	7.8	460	150	1500	< 30
11.4.78	11.1	23	< 3	90	<30
9.5.78	17.4	<3	< 3	390	230
9.5.78	17.4	<3	< 3	4600	430
14.6.78	17.5	<3	< 3	2400	230
14.6.78	17.5	<3	< 3	430	430
11.7.78	21.6	240	93	≥ 24000	≥ 24000
25.7.78	23.7	<3	< 3	46000	2300
2.8.78	23.6	15	15	2300	2300
18.9.78	21.7	4	< 3	930	90
6.10.78	18.6	<3	< 3	11000	4600
7.11.78	15.5	<3	<3	150	150
8.12.78	11.1	4	4	930	930
9.1.79	9.2	<3	< 3	90	90
6.2.79	9.2	43	15	≥ 24000	4600
6.3.79	8.8	<3	< 3	230	90
5.4.79	11.0	<3	<3	1500	1500
30.5.79	22.0	430	43	1100000	2100
23.8.79	24.0	<3	< 3	230	40
9.10.79	19.7	23	9	4600	750
6.11.79	13.9	<3	< 3	2400	930
4.12.79	13.1	<3	< 3	1500	430
29.1.80	9.1	21	< 3	930	110
14.2.80	9.1	11	< 3	4600	230
12.3.80	9.2	<3	<3	150	90
16.4.80	12.1	<3	< 3	150	40
20.6.80	10.0	<3	< 3	210	150
3.7.80	21.0	15	15	2400	2400
9.9.80	22.0	<3	<3	2400	930
28.10.80	17.0	<3	<3	11000	4600

Table V. Bacterial Indicators of Faecal Pollution Expressed in Mean Values and Their Variances for Winter and Summer Months (Second Period, February 1979 - September 1979)

Station	SUMMER						WINTER					
	Total coliforms/100 ml		Faecal coliforms/100 ml		Faecal streptococci/100 ml		Total coliforms/100 ml		Faecal coliforms/100 ml		Faecal streptococci/100	
	mean*	variance*	mean*	variance*	mean*	variance*	mean*	variance*	mean*	variance*	mean*	variance*
1	1.17	0.24	0.34	0.07	0.55	0.64	2.28	0.30	1.98	0.36	1.65	0.46
2	2.53	0.27	2.06	0.60	2.02	0.47	1.75	0.00	1.45	0.01	1.52	0.41
3	1.75	0.19	0.67	0.63	0.93	0.45	1.92	1.41	1.33	1.06	1.06	0.42
4	2.32	0.15	1.69	0.21	1.62	0.27	2.56	0.02	2.27	0.12	1.61	0.70
5	3.33	1.98	2.92	2.51	2.71	1.40	3.32	1.42	2.90	2.53	2.66	0.87
A	2.00	0.55	1.17	0.78	1.67	0.97	3.02	0.16	2.86	0.40	2.86	0.45
a	0.92	0.83	0.00	-	0.87	0.74	1.25	0.13	0.85	0.05	0.65	0.49
6	1.44	0.31	1.06	0.68	1.55	0.33	1.31	0.01	0.96	0.08	0.83	0.49
7	1.81	0.16	1.13	0.84	1.29	0.88	2.23	0.69	2.09	0.44	2.35	0.01
8	2.15	0.71	1.66	0.96	1.79	0.99	2.26	1.10	1.93	1.25	2.16	0.54
9	0.96	0.72	0.39	0.07	0.86	0.44	1.37	0.59	0.82	1.33	0.63	0.46
B	0.51	0.46	0.00	-	1.88	0.85	2.63	0.19	2.31	0.08	2.09	0.79
10	1.86	0.42	1.20	0.83	1.09	0.83	1.23	1.71	0.69	0.98	1.13	0.32
11	1.87	0.45	0.90	0.71	0.96	0.68	1.17	0.06	0.89	0.02	0.48	0.46
C	0.61	0.57	0.85	0.61	0.68	0.02	1.16	0.02	0.93	0.05	0.83	0.24
12	1.98	1.20	1.03	0.78	0.92	0.76	1.46	0.01	1.26	0.01	1.58	0.34
13	1.56	0.10	0.96	0.42	1.47	0.00	1.74	1.09	1.50	0.50	0.98	1.38
14	1.78	0.28	1.68	0.07	1.30	0.08	0.56	0.79	0.45	0.05	0.24	0.34
15	1.24	0.74	0.55	1.19	1.61	0.77	0.65	0.07	0.74	0.14	0.70	0.99
16	1.84	0.11	0.46	0.21	1.31	0.38	1.41	0.02	0.87	0.02	0.76	0.40
17	1.92	0.28	1.63	0.34	1.44	0.29	1.12	0.73	1.02	0.21	1.35	0.24
18	1.79	0.47	1.53	0.38	1.62	0.06	1.51	2.14	1.89	1.26	1.79	1.01
19	1.29	0.43	1.14	0.89	1.18	0.58	1.91	0.00	1.59	0.01	1.33	0.05
20	1.30	0.58	0.40	0.22	0.45	0.27	1.83	0.37	1.13	0.06	1.06	0.16
21	1.70	1.02	1.32	2.02	0.90	2.04	1.12	1.35	0.74	0.14	0.00	-
D	1.59	1.29	0.00	-	0.00	-	1.33	2.13	1.68	0.93	1.01	2.06
b	0.00	-	0.00	-	1.19	1.54	0.00	-	0.00	-	0.00	-
rR	4.12	0.85	2.88	0.88	2.56	0.40	3.49	0.00	2.94	0.12	2.71	0.51
rD	1.29	0.23	0.98	0.37	1.28	0.07	1.91	0.00	1.29	0.05	1.47	0.30
PI/10 m	0.00	-	0.00	-	0.00	-	1.21	0.09	1.15	0.09	0.59	0.02
PI/20 m	1.74	1.56	1.80	0.48	1.35	0.23	1.43	0.21	0.95	0.85	0.94	0.90

* Log transformed data.

Table Va

Percentage of samples of mussel and water within the proposed limits on the basis of faecal coliform values

		MUSSELS			WATER		
Year	No. of samples	0-2/g	3-10/g	> 10/g	< 10/100 ml	10-100/100 ml	> 100/100 ml
1977	6	83.3 %	16.7 %	0.0 %	100.0 %	0.0 %	0.0 %
1978	14	28.6 %	42.9 %	28.6 %	71.4 %	21.4 %	7.1 %
1979	9	33.3 %	33.3 %	33.3 %	77.7 %	22.2 %	0.0 %
1980	8	62.5 %	12.5 %	25.0 %	87.5 %	12.5 %	0.0 %
Total	37	51.4 %	24.3 %	24.3 %	81.1 %	16.2 %	2.7 %

Table VI. The Correlation Between the Mandatory Parameters

(Second Period, February 1979 - September 1979)

Station	r TC : FC	r TC : FS	r FC : FS
1	1.00	0.99	0.99
2	0.38	0.76	0.40
3	0.95	0.32	0.57
4	0.80	- 0.35	- 0.39
5	1.00	1.00	1.00
A	0.99	1.00	1.00
a	0.99	0.42	0.43
6	- 0.34	0.10	0.73
7	0.99	0.34	0.42
8	0.99	0.86	0.93
9	0.83	0.49	0.01
B	0.99	0.86	0.94
10	- 0.30	- 0.06	0.83
11	- 0.31	- 0.30	0.19
- C	0.65	0.22	0.06
12	0.64	- 0.01	0.41
13	0.96	0.95	0.96
14	0.92	0.89	0.94
15	0.97	0.92	0.81
16	0.50	0.30	0.43
17	0.94	0.39	0.66
18	1.00	0.96	0.95
19	0.90	0.87	1.00
20	0.97	0.97	0.89
21	0.86	- 0.16	0.36
D	1.00	1.00	1.00
rR	0.36	0.50	0.61
rD	0.69	0.59	0.60
PI/0 m	1.00	0.82	0.83
PI/20 m	0.99	0.67	0.76

Table VII. Relative frequencies (%) of the counts of faecal coliforms listed in accordance with interim criteria, i.e., less than 100 faecal coliforms/100 ml and more than 1000 faecal coliforms/100 ml. (Second Period, February 1979 - September 1979)

Stations depth/m	less than 100 All samples	less than 100 Bathing season samples (1979)	more than 1000 All samples	more than 1000 Bathing season samples (1979)
1	83.3	100.0	0.0	0.0
2	83.3	75.0	0.0	0.0
3	83.3	100.0	0.0	0.0
4	50.0	75.0	0.0	0.0
5	33.3	25.0	50.0	50.0
A	66.7	100.0	16.7	0.0
a	100.0	100.0	0.0	0.0
6	100.0	100.0	0.0	0.0
7	88.3	100.0	0.0	0.0
8	50.0	50.0	0.0	0.0
9	100.0	100.0	0.0	0.0
B	66.7	100.0	0.0	0.0
10	100.0	100.0	0.0	0.0
11	100.0	100.0	0.0	0.0
C	100.0	100.0	0.0	0.0
12	100.0	100.0	0.0	0.0
13	83.3	100.0	0.0	0.0
14	100.0	100.0	0.0	0.0
15	83.0	75.0	0.0	0.0
16	100.0	100.0	0.0	0.0
17	66.7	50.0	0.0	0.0
18	66.7	75.0	0.0	0.0
19	83.3	75.0	0.0	0.0
20	100.0	100.0	0.0	0.0
21	100.0	100.0	0.0	0.0
D	83.3	100.0	0.0	0.0
b	100.0	100.0	0.0	0.0
rR	16.7	25.0	66.7	75.0
rD	100.0	100.0	0.0	0.0
PI/0 m	100.0	100.0	0.0	0.0
PI/20 m	60.0	33.3	0.0	0.0

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INTRODUCTION

The rather wide range of activities of the Institute for Oceanography and Fisheries in Split covers research into the pollution problem of the coastal water of the central and southern parts of the Adriatic Sea. This report gives the results of the activities carried out within the pilot project MED POL VII programme for the period November 1976 till the end of March 1981. During that period 20 cruises were carried out.

The activities of our Institute relevant to the MED POL VII programme have consisted of a continuation of the project "Monitoring of the Coastal Water Quality (Vir - Konavle)" and a few smaller projects of local interest.

AREA(S) STUDIED

Under the MED POL VII programme, the Institute for Oceanography and Fisheries undertook monitoring studies in four areas (Zadar, Split, Ston and Dubrovnik) (Figures 1, 2, 3 and 4). As the quality of the coastal water itself was the object of this programme, it was carried out in zones of intensive recreational activities, extensive shipping traffic, discharges of waste-waters and shellfish-breeding areas. In most cases these zones are surrounded by limestone mountains. The shoreline is mainly rocky and intensively used for recreation.

The Zadar (approximately 50,000 inhabitants) and the Split areas (approximately 200,000 inhabitants) are under the influence of industrial and domestic waste-waters, while the Dubrovnik area (approximately 40,000 inhabitants) is more or less affected by domestic waste-waters only. The Ston area (approximately 200 inhabitants) is slightly influenced by the Mali Ston waste-waters. Usually the waste-waters of these areas are untreated before their discharge into the sea and they are taken out to sea by submarine pipes to a greater or lesser distance from the coast.

MATERIALS AND METHODS

The methods recommended by MED POL VII were applied (operational document, EHE/76.1, WHO, Geneva 1976). Nutrients were measured by autoanalyser; both salinity and temperature were determined by the conductivity method and oxygen was determined by the standard Winkler method.

RESULTS AND THEIR INTERPRETATION

The following parameters have been monitored:

Total coliforms; faecal coliforms; faecal streptococci; total heterotrophic bacteria; meteorological conditions; hydrographic conditions; dynamic conditions; structure of sediment; nutrients; density of phytoplankton, and visual observation.

The degree of pollution with regard to the bacteria varied a great deal in different areas as well as in different seasons. However this is much the same as was revealed by earlier data.

In the Zadar area, the town itself is being polluted heavily, especially the town port (stations 2, 3, 4 and 5). Distribution of faecal coliforms (Table I) shows the largest values in the course of a NE wind (45°C), but at the town port (station 2) in the course of a SE wind (135°C). Results of the study on the correlation between total coliforms and faecal coliforms (TC/FC) and between faecal coliforms and streptococci (TC/FC) in the Zadar area is given in Table II.

In Split, as well as in Zadar, the town itself is again heavily polluted (town port).

Slight decrease of faecal coliforms as compared to earlier data were noticed in the Split area. Further, the town port is a main source of faecal pollution and threatens the adjoining seaside resorts (stations 1 and 3). Other zones are still suitable for recreation. As we found earlier, the highest values of faecal coliforms occur at NE and SE wind directions (Table III). The correlation between total coliforms and faecal coliforms (TC/FC) and between faecal coliforms and faecal streptococci (FC/FS) in this area are given in Table IV.

The recreational zone in the Ston area (station 1) is under the slight influence of faecal contaminated water (seaside resort Klek-Neum). Distribution of faecal coliforms with regard to the wind direction is given in Table V, and the correlation between total coliforms and faecal coliforms (TC/FC) and between faecal coliforms and streptococci (FC/FS) are given in Table VI.

Sea-water quality at the shellfish-breeding area is mainly adequate for the purpose. Bacteriological analyses of shellfish have confirmed this.

In the Dubrovnik area the results support earlier circumstances that the influence of faecal contaminated water was observed in the vicinity of the port of Gruz and town port (stations 2 and 5). Most of the stations show larger numbers of faecal coliforms at NW wind directions and when there is no wind (Table VIII). Correlations between total coliforms and faecal coliforms (TC/FC) and between faecal coliforms and faecal streptococci (FC/FS) are given in Table IX.

In the course of the research period hydrographic parameters showed high variability. The current measurements mainly confirmed the conclusions from the previous report with regard to the speed, direction, and vertical velocity distributions. The fastest currents were for the most part in winter periods, and the slowest ones in the spring-summer periods. As to the layers, the currents were found to be faster in the bottom layers than in the surface layers. Current directions are rather variable, but circulation often flows in a north-west direction.

In the course of a year, variations of temperature are normal having minimum values in winter periods and maximum ones in summer periods. For the most part, minimum salinity values were found in winter periods and maximum ones in summer periods.

Aeration of the whole region is good, and saturation of oxygen values range from 81,6 to 177.7%.

DISCUSSION OF RESULTS

The results obtained so far indicate that most of the analysed recreational waters are within the accepted interim microbiological quality criteria, but the sites near the harbour are to a certain extent affected by faecal pollution. Thus some recreational zones near Split and Zadar are affected by the faecal water from the town ports. An improvement of coastal water quality near the main towns of the study areas is necessary. Quality of sea-water and shellfish in Ston is satisfactory.

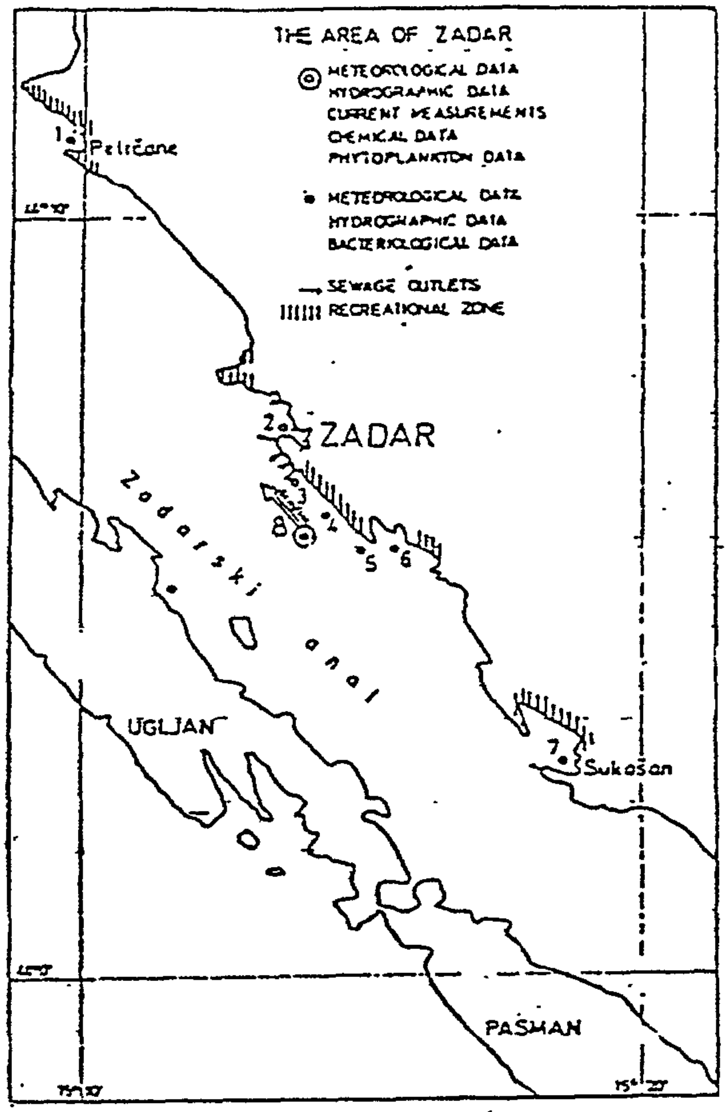

Fig. 1. The area of Zadar

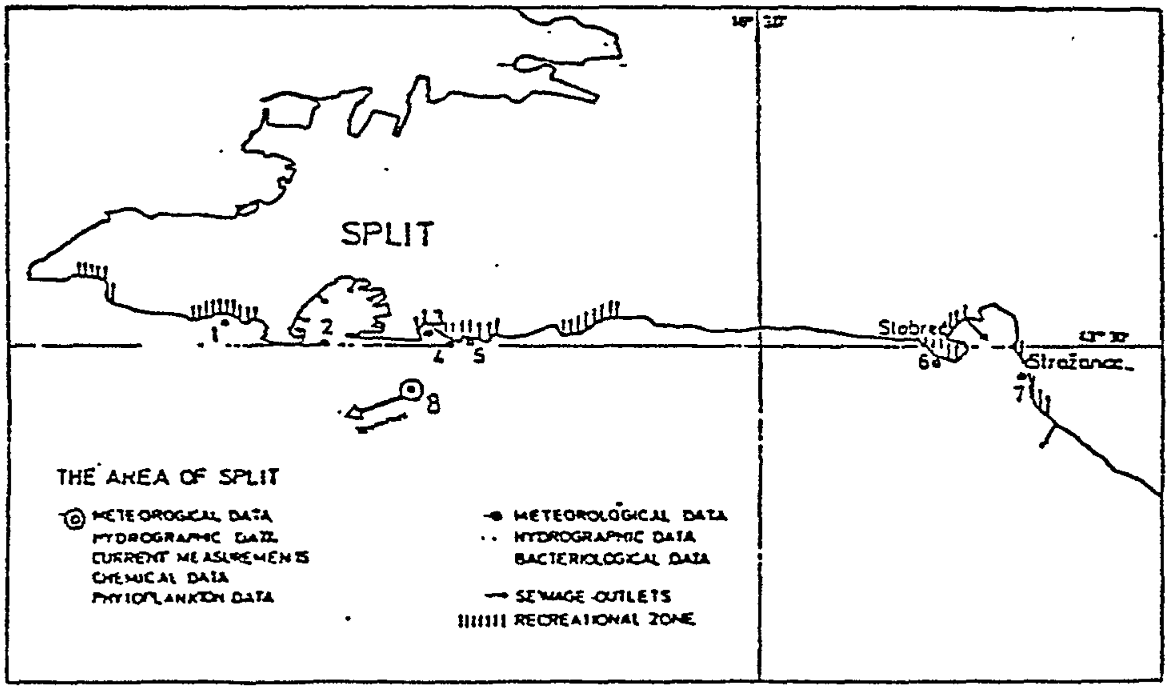

Fig. 2. The area of Split

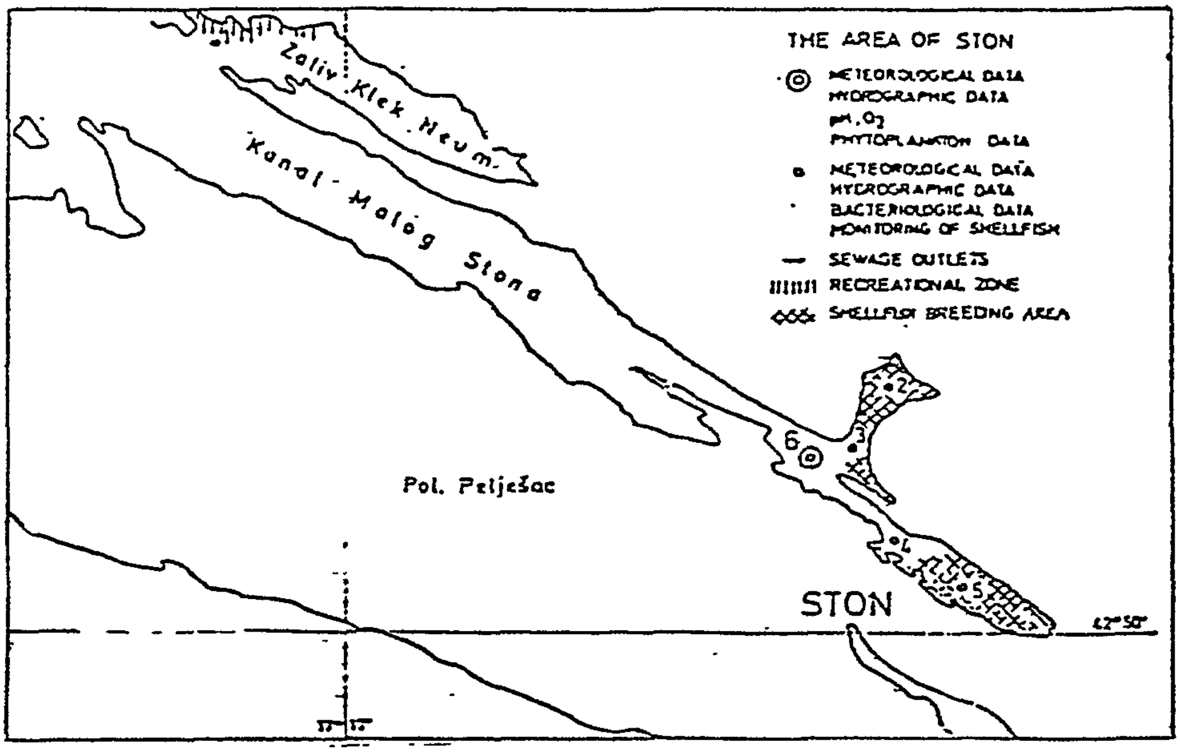

Fig. 3. The area of Ston

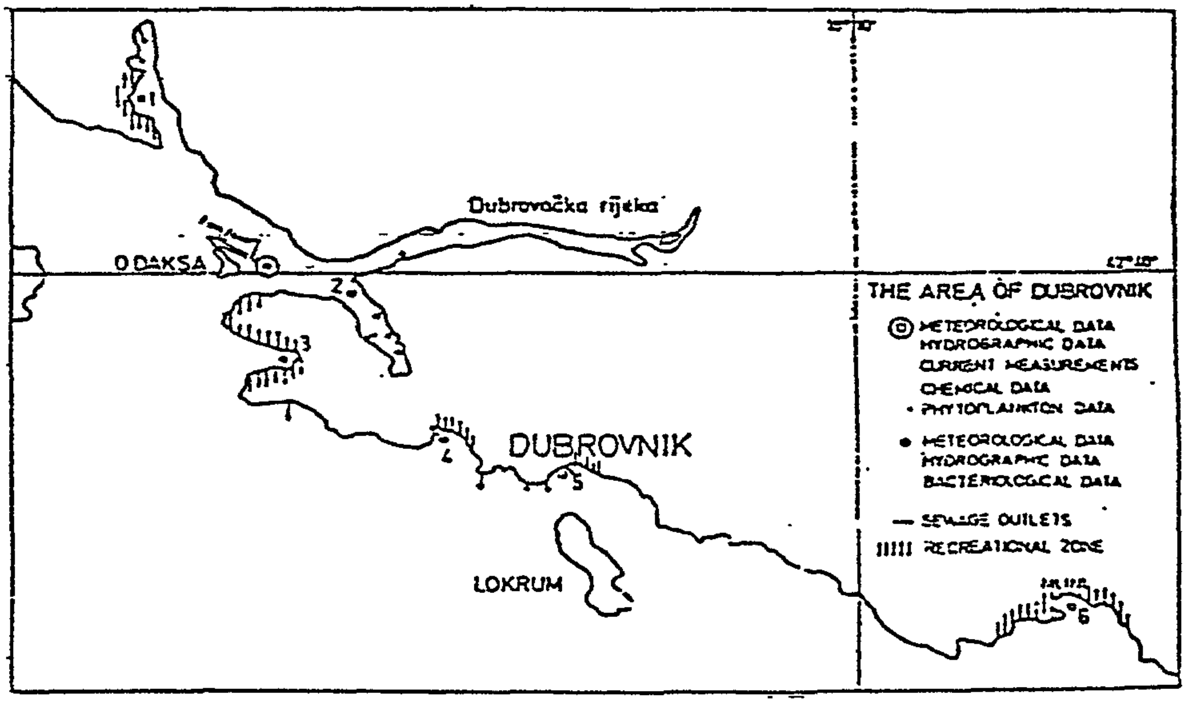

Fig. 4. The area of Dubrovnik

Table I. Mean values and standard deviations (MF/100 ml) for E. coli - ZADAR area
(Period November 1976 - March 1981)

Station		Wind direction in degrees				
		0-90	90-180	180-270	270-360	no wind
1	$\bar{x}$	7,227	7,095	3,079	8,078	
	s	4,008	2,142	3,863	7,053	
2	$\bar{x}$	66,940	242,660	38,018	159,710	158,489
	s	3,55	3,222	1,297	2,833	4,395
3	$\bar{x}$	32,608	36,069	3,464	12,686	52,722
	s	1,100	5,644	2,174	2,429	2,142
4	$\bar{x}$	31,988	18,620	15,684	4,897	8,609
	s	12,050	5,500	3,892	1,339	5,024
5	$\bar{x}$	13,069	8,455	3,464	4,786	4,340
	s	10,749	3,774	2,174	2,140	1,770
6	$\bar{x}$	10,292	3,488	4,899	7,943	1,300
	s	7,180	3,953	1,332	2,664	1,690
7	$\bar{x}$	1,851	1,864		1,637	2,000
	s	2,310	2,417		1,685	1,633

Table II. The correlation between total coliforms and faecal coliforms (TC/FC) and between facal coliforms and faecal streptococci (FC/FS) - ZADAR area
(Period November 1976 - March 1981)

Station	Depth/m	Ratio TC/FC	Ratio FC/FS
1	0,5	4,11	1,76
	10,0	6,52	2,71
2	0,5	4,30	1,70
	15,0	4,55	2,04
3	0,5	4,40	1,34
	6,0	9,17	1,22
4	0,5	5,57	1,91
	7,0	5,41	1,34
5	0,5	9,69	1,67
	10,0	9,59	1,58
6	0,5	10,88	6,46
	12,0	15,79	2,58
7	0,5	17,26	0,67
	6,0	15,33	1,15

Table III. Mean values and standard deviation (MF/100 ml) for E. coli - SPLIT area
(Period November 1976 - March 1981)

Station		Wind directions in degrees				
		0-90	90-180	180-270	270-260	no wind
1	$\bar{x}$	59,330	19,349	14,847		17,218
	s	1,380	11,114	5,831		4,970
2	$\bar{x}$	344,720	183,263	199,041		50,759
	s	2,478	5,589	3,791		6,478
3	$\bar{x}$	17,413	31,311	15,539		15,535
	s	3,034	7,760	6,371		5,030
4	$\bar{x}$	7,033	15,310	18,362		3,375
	s	3,834	8,968	3,045		2,925
5	$\bar{x}$	16,180	8,750	6,780		4,677
	s	9,348	5,074	3,751		3,286
6	$\bar{x}$	5,870	11,234	5,318	9,475	2,655
	s	4,329	5,813	3,649	9,054	4,112
7	$\bar{x}$	5,718	14,531	7,473	8,124	11,306
	s	6,388	11,726	5,221	4,091	4,230

Table IV. The correlation between total coliforms and faecal coliforms (TC/FC) and between faecal coliforms and faecal streptococci (FC/FS) - SPLIT area
(Period November 1976 - March 1981)

Station	Depth/m	Ratio TC/FC	Ratio FC/FS
1	0,5	7,42	1,99
	11,0	11,41	1,50
2	0,5	7,39	1,94
	20,0	9,96	1,42
3	0,5	14,57	1,87
	8,0	23,43	0,84
4	0,5	8,23	1,61
	6,0	10,30	1,14
5	0,5	7,93	2,14
	7,0	22,93	0,71
6	0,5	10,64	2,01
	24,0	11,06	1,45
7	0,5	4,80	4,14
	20,0	9,92	1,94

Table V. Mean values and standard deviations (MF/100 ml) for *E. coli* - STON area
(Period November 1976 - March 1981)

Station		Wind direction in degrees				
		0-90	90-180	180-270	270-360	no wind
1	$\bar{x}$	2,778	3,160	1,258	4,255	3,390
	s	2,824	5,094	1,490	3,550	3,620
2	$\bar{x}$	1,189		1,189	1,260	
	s	1,414		1,414	1,430	
3	$\bar{x}$	1,149		1,188	1,422	1,258
	s	1,363		1,412	1,853	1,490
4	$\bar{x}$	1,319		8,660	1,660	8,163
	s	1,858		2,174	1,800	2,061
5	$\bar{x}$	1,149		1,414	1,490	
	s	1,363		1,632	2,094	

Table VI. The correlation between total coliforms and faecal coliforms (TC/FC) and between feacal coliforms and faecal streptococci (FC/FS) - STON area

(Period November 1976 - March 1981)

Station	Depth/m	Ratio TC/FC	Ratio FC/FS
1	0,5	11,68	2,97
	22,0	18,74	1,28
2	0,5	26,43	3,50
	8,0	33,50	2,00
3	0,5	19,20	2,86
	10,0	26,43	1,17
4	0,5	10,95	2,37
	6,0	15,61	2,30
5	0,5	13,14	4,67
	10,0	15,54	2,17

Table VII. . Relation between E. coli values in shellfish and water in STON area (in %)

(Period November 1976 - March 1981)

Station	Shelifish			Water	
	0-2/g	3-10/g	>10/g	0-10/100 ml	11-100/100 ml
2	93,8	6,2	-	100	-
3	73,3	22,1	4,6	96,2	3,8
4	59,2	32,5	8,3	89,4	11,6
5	84,5	15,5	-	96,6	3,4

Table VIII. Mean values and standard deviations (MF/100 ml) for *E.coli* - DUBROVNIK area

(Period November 1976 - March 1981)

Station		Wind direction in degrees				
		0-90	90-180	180-270	270-360	no wind
1	$\bar{x}$	4,069	1,945		5,843	13,207
	s	4,649	2,213		2,535	3,085
2	$\bar{x}$	45,814	13,634			30,000
	s	2,784	1,915			2,617
3	$\bar{x}$	4,030	1,642		6,487	1,859
	s	5,196	1,620		5,139	1,577
4	$\bar{x}$	4,097	1,318		6,694	7,952
	s	3,423	1,459		11,080	4,613
5	$\bar{x}$	11,166	11,141		67,684	18,033
	s	5,884	6,862		3,382	12,267
6	$\bar{x}$	5,855	9,324		8,358	3,804
	s	1,953	4,231		4,920	2,015

Table IX. The corelation between total coliforms and faecal coliforms (TC/FC) and between faecal coliforms and faecal streptococci (FC/FS) - DUBROVNIK area

(Period November 1976 - March 1981)

Station	Depth/m	Ratio TC/FC	Ratio FC/FS
1	0,5	11,23	1,32
	20,0	18,53	6,12
2	0,5	10,10	1,27
	20,0	27,38	0,73
3	0,5	12,55	0,87
	14,0	13,64	1,03
4	0,5	9,36	0,86
	22,0	10,85	0,45
5	0,5	6,06	1,04
	10,0	6,46	1,16
6	0,5	10,57	0,57
	12,0	18,68	0,58

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Publié et imprimé par:

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