PN-ABM-951

ARAB REPUBLIC OF EGYPT
THE MINISTRY OF HOUSING AND RECONSTRUCTION

Alexandria Wastewater Master Plan Study

VOLUME IV
MARINE STUDIES

Camp Dresser & McKee Inc.
International Division

with Chas. T. Main International Inc.
Arab Technical and Economical Consulting Office

October 1978

This Master Plan Consists of Four Volumes:

I SUMMARY REPORT

II TECHNICAL REPORT

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IV MARINE STUDIES

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CHAPTER 1

SUMMARY

This is the final report of a one-year program of marine studies undertaken as part of the Alexandria Wastewater Facilities Development Program. The purpose of the marine studies was to determine the fundamental feasibility of large-scale disposal of sewage from Alexandria into the Mediterranean Sea, and to obtain sufficient engineering data to permit the planning and conceptual design of ocean outfalls for Alexandria. Investigations at sea began in July 1977 and concluded in July 1978.

For engineering planning purposes, measurements were made of water current velocity, temperature, salinity, dissolved oxygen, and wind velocity. Geophysical surveys were made of bottom conditions. Daytime and nighttime bacterial disappearance rates were measured. Hourly water level readings were obtained.

For a baseline measure of present ecological conditions, seawater samples were tested for BOD, SS, P, N, and pesticides; bottom sediment samples were tested for heavy metals content. Phytoplankton and zooplankton were sampled frequently throughout the year. Monthly surveys of the quantity and abundance of fish landed at several principal local fish markets were conducted throughout the year. Benthic biota were sampled at 25 stations.

Geophysical studies included bathymetric surveys, seismic subbottom profiling, side-scan sonar surveys, gravity coring, and sample gathering and visual observations by divers on the sea bottom.

The physical oceanographic data and the bacterial disappearance data obtained are very adequate for engineering planning purposes, and even for outfall design purposes. The geophysical studies have greatly increased the amount of knowledge available concerning seabottom conditions in the area, and permit one to choose outfall alignments which offer the most favorable construction conditions available. However, a much more intensive and detailed program of geophysical sampling and surveying will be required in the outfall design phase. The biological data obtained provide a detailed picture of present marine biological conditions.

Currents, measured by drogues and by moored recording meters, flow mostly parallel to the coastline, although surface waters can be driven towards shore by onshore winds. Current speeds tend to increase with distance from shore and to decrease with depth. The median speed found 10 km from shore, about 10 m beneath the surface, is about 0.10 m/sec. Currents do not flow in one direction only, but change direction with a periodicity ranging from a few hours to several days. The periodicity is great enough that the distance an element of fluid is likely to be convected in any one principal direction has a median value of about 20 km. Astronomical tides appear to be of negligible importance in determining current patterns here.

Density profiles were obtained from measurements of temperature and salinity. Between late September and March, the density in the top 50 m of the sea is nearly uniform. However, from late March through August, there is a thermally-induced stratification sufficiently intense that sewage effluent plumes issuing from properly designed outfalls would not reach the surface of the sea but remain trapped beneath it, at least during June and July, and perhaps during parts of April, May and August as well. It is extremely unlikely that sewage effluent that cannot reach the sea surface will ever recognizably reach the shoreline.

Ambient dissolved oxygen levels are generally high, averaging about 6.4 mg/l.

Fecal coliform bacterial disappearance studies with sewage from Kait Bey pump station mixed with Mediterranean seawater imply a daytime T_{90} value of 1.0 to 1.5 hours, and a nighttime T_{90} value of 40 hours. (The T_{90} value is the time required for bacterial concentrations to decrease by 90 percent due to dieoff, sedimentation and other processes, excluding physical dilution.)

The geophysical studies indicate that the seabottom is characterized by rocky ridges running parallel to the shore, separated by bands of granular material. The rock and sand are largely calcareous. Blasting will most likely be required to prepare a trench or a bed across the rocky regions. Farther than six km from shore, the bottom is largely composed of fine sand and somewhat cohesive silts and clays. Preliminary tests on these soils indicate that they will have adequate bearing capacity to support a properly designed pipeline, provided that the pipeline can tolerate differential settlement of up to 20 to 30 cm from section to section.

After brief reviews of the basic feasibility of discharge to the ocean at Alexandria and of existing and anticipated water quality standards for Egypt and the Eastern Mediterranean Sea, outfall performance standards are developed. These standards, based largely on the results of current research and on practice elsewhere in the world, lead to the specification that the sewage should receive initial dilution to attain a seawater:sewage ratio of 150:1 and secondary or far-field dilution to attain a seawater:sewage ratio of 1000:1. Furthermore, outfalls should be located sufficiently far from beaches to ensure that mean concentrations of fecal coliform bacteria are not increased beyond background levels by more than only a small amount.

In Volume II, the Technical Report[1] of this series, ocean outfalls were proposed to be built at Sidi Bishr and near Kait Bey Fort, to discharge projected year 2000 average flows of 560 megalitres/day (ML/day) and 392 ML/day, respectively. It is herein proposed that the Sidi Bishr outfall extend about 11 km to sea, terminating in a water depth of 55 m with a multiport diffuser 400 m long. It is proposed that the Kait Bey outfall extend 8 km to sea, terminating in a water depth of 40 m with a multiport diffuser 450 m long. According to analysis and interpretation of the oceanographic and bacterial data obtained during the marine studies, these proposed outfalls will meet the adopted water quality standards.

[1] Camp Dresser & McKee Inc., Charles T. Main International Inc., Arab Technical and Economical Consulting Office, Alexandria Wastewater Master Plan Study, Volume II, Technical Report, 1978.

CHAPTER 2

INTRODUCTION

2.1 Rationale for Oceanographic Studies

It was evident from the beginning of the Alexandria wastewater study that one of the most attractive alternatives for the handling of Alexandria's wastewater would be disposal to the sea via long outfalls. Since outfall planning and design should be undertaken only with a thorough understanding of local oceanographic conditions, the contract between CDM and MOHR[1] specified that CDM should, early in the Master Plan study, review the available information about local marine conditions and develop a plan for whatever further studies were deemed necessary.

Accordingly, Special Report No.1, Program for Oceanographic Studies, was submitted to MOHR on 28 February 1977. That report recommended an oceanographic program that should run at least six months, including the summer months when bathing beaches would be frequented; but should preferably continue for a full year. The full 12-month program was approved by MOHR and field work began mid-July 1977.

In the Interim Oceanographic Study report of April, 1978, the oceanographic data collected from July, 1977, through February, 1978, were described, and some of the data analysis and interpretation that established the feasibility of disposal through outfalls and which led to preliminary outfall design were included.

This final report, Marine Studies, is intended to give a complete summary of all the oceanographic data collected from July 1977 through July 1978 and to present preliminary designs and locations for the outfalls at Kait Bey and Sidi Bishr.

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[1] "Agreement for Consulting Engineering Services for Alexandria Wastewater Facilities Development Program," 4 November 1976.

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Chapter 2 of the final report begins with a discussion of present and projected flows and loadings and includes a brief description of the areas affected by present and proposed discharges. In Chapter 3, the basic data are presented and interpreted. In Chapter 4, the water quality criteria adopted herein are described; also included is a brief discussion of overall discharge strategy, and a recognition of the coordinated Mediterranean Pollution Monitoring and Research Program. In Chapter 5, the data gathered and analyzed in earlier sections are applied to the preliminary design of the Kait Bey and Sidi Bishr outfalls.

Appendix A contains biological data. Appendix B contains a description of the field equipment used. Appendix C contains current meter data at an intermediate stage of analysis.

In addition to these printed appendices included herein, an unprinted volume of technical memoranda has been prepared. The interested reader may apply to the Ministry of Housing and Reconstruction for a photocopy of this volume, to be provided at cost.

2.2 Present Conditions

Presently the Alexandria sewerage system serves an area of approximately 4300 hectares and has a population which varies from about 2 million in the winter months to about 2.4 million in the summer. In addition, there is a considerable industrial wastewater flow, estimated to be 870 000 m^3/day. Approximately 25 percent of this flow is considered contaminated with the other 75 percent consisting of single-pass cooling water. As an aggregate, Alexandria industry discharges an estimated daily BOD load of 160 tonnes. Based on a average BOD_5 load of .09 kg per capita per day, the population equivalent of the industrial wastewater is 1 760 000 persons, nearly equal to Alexandria's present population.

Field investigations described in Section 3.4 of the Master Plan Study[1] indicate that the wastewaters of Alexandria are of unusually high strength

[1] Camp Dresser & McKee Inc., Charles T. Main International Inc., Arab Technical and Economical Consulting Office, Alexandria Wastewater Master Plan Study, Volume II, Technical Report, 1978.

when compared to those of most municipalities. To some extent, this can be attributed to the low per capita water use; if adjustment for per capita flow differences is made, Alexandria's domestic wastes could be classified as medium to high strength wastes when compared to a representative number of cities in the U.S[1]. This indicates that wastewater strength will probably decline as water use increases in Alexandria. Analyses also show that high concentrations of bacterial indicator organisms are found in Alexandria's wastewaters. Results of sampling on June 17, 1978 are shown in Table 2-1.

Estimates of present wastewater flow are based on industrial and domestic water use according to the procedures outlined in Chapter 4 of the Master Plan Technical Report. Analysis indicates that the present domestic wastewater flow discharged to sewers averages 238 000 m^3/day. Adding industrial waste flows that discharge to public sewers and estimating present infiltration at a rate of 0.15 litres/sec/hectare throughout the sewered area results in a current average dry weather wastewater flow of 383 000 m^3/day. A resultant overall (sewered and unsewered area) wastewater average dry weather flow of 562 000 m^3/day has been estimated to represent 1977 conditions in Alexandria. This value is equivalent to an overall per capita generation rate of 236 litres of wastewater per day.

The locations of principal discharges of the Alexandria wastewater system are shown in Figure 2-1. A complete inventory of gravity collectors, pump stations and force mains, as well as descriptions of present treatment works is contained in Special Report Number 2, submitted 26 April 1977.

The many shoreline discharges and overflows along the beach present a health hazard and a nuisance. These overflows, shown in Figure 2-1, are intended to pass stormwater discharges to the beach in the winter only; but in fact they have been observed to discharge frequently in the summer and nearly continuously in the winter. Fecal coliform levels measured during the summer

[1] Metcalf and Eddy, Inc., Wastewater Engineering, McGraw Hill Book Company, 1972

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TABLE 2-1

RESULTS OF BACTERIOLOGICAL ANALYSES OF SAMPLES TAKEN ON 17 JUNE 1978[a]

Sampling Stations	Total Coliforms (Presumptive)	Fecal Coliforms (Confirmed)	Total Enterococci (Presumptive)	Fecal Enterococci (Confirmed)
Sidi Bishr Pumping Station	3.5×10^{8}	1.1×10^{8}	2.8×10^{9}	2.2×10^{9}
	5.4×10^{8}	1.1×10^{8}	1.8×10^{9}	1.4×10^{9}
Kait Bey Pumping Station	9.4×10^{8}	1.1×10^{8}	2.2×10^{11}	2.2×10^{11}
	1.40×10^{9}	3.3×10^{8}	3.5×10^{11}	2.4×10^{11}
East Treatment Plant Influent	1.7×10^{8}	1.3×10^{8}	3.3×10^{9}	2.6×10^{9}
	5.4×10^{8}	2.2×10^{8}	3.5×10^{9}	2.6×10^{9}
Outfall from Industries Pumping Station	1.7×10^{9}	1.3×10^{9}	7.0×10^{10}	1.7×10^{10}
	5.4×10^{9}	5.4×10^{9}	1.40×10^{11}	7.0×10^{10}

[a] Analysis was by the Multiple Tube Fermentation Procedure (using 5 tubes) and results are expressed as Most Probably Number per 100 mL. Details of the procedure are contained in Appendix F.

of 1976 at several Alexandria beaches are listed in Table 2-2.

In Abu Kir Bay the industrial discharges to Abu Kir drain, thence to the Bay via the Tabia pump station, have had a significant impact on the fishery in Abu Kir Bay and probably in Lake Idku.[1]

2.3 Future Conditions

Wastewater Flows

Total projected wastewater flows for the Alexandria area were generated according to the procedures discussed in Chapter 4 of the Technical Report.[2] For the recommended Master Plan (Chapter 8 of the Technical Report) projected wastewater flows for each sewerage zone are shown in Table 2-3. Figure 2-2 shows a plan of the Alexandria area locating the major discharge points and the principal components of the Recommended Master Plan.

Wastewater Loadings

Estimated loading rates for the year 2000 flows are based on the results of a wastewater gauging and sampling program that was conducted from May to July 1977.[2] From the results of the sampling program, the following estimates of future concentrations of BOD, COD, SS, nitrogen and phosphorus were made:

	Domestic	Industrial
BOD (mg/L)	500	700
COD (mg/L)	950	1500
SS (mg/L)	525	1100
NH_3-N(mg/L)	33	9
Albuminoid-N (mg/L)	6	3
PO_4-P (mg/L)	11	2

[1] Ezzat, A., and El-Ghrabawy, M., "Effect of Water Pollution on the Population of Solea Vulgaris in Abu Kir Bay, Alexandria (Egypt)," Bulletin of the Institute of Oceanography and Fisheries, Alexandria, Egypt, 1975.

[2] Camp Dresser & McKee Inc., Charles T. Main International Inc., Arab Technical and Economical Consulting Office, Alexandria Wastewater Master Plan Study, Volume II, Technical Report, 1978.

TABLE 2-2

FECAL COLIFORM CONCENTRATIONS AT ALEXANDRIA BEACHES[a]

Beach	Fecal Coliforms/100 mL[b]	Sewage Outfall
Anfushi	4.7×10^3	present
Chatby	4.4×10^3	present
Camp Caesar & Ibrahimia	3.0×10^3	-
Sporting	9.6×10^4	present
Sidi Gaber & Cleopatra	3.0×10^3	-
Staley	1.1×10^3	-
Glym	1.6×10^4	present
San Stefano	2.9×10^3	-
Sidi Bishr	2.9×10^3	-
Miami	2.7×10^3	-
Mandara	1.1×10^5	present
Montazah	1.4×10^3	-
Maamoura	4.2×10^2	-

[a] Analysis was by the Multiple-Tube Fermentation Procedure. Results are expressed as the log mean of MPN per 100 mL for the summer of 1976.

[b] Hassan and Sharkawi, F.M., The Relation Between the State of Pollution in Alexandria Swimming Beaches and the Occurrence of Typhoid among Bathers, High Institute of Public Health, 1976.

TABLE 2-3

PROJECTED DRY WEATHER WASTEWATER FLOWS

Sewerage Zones	Marine Discharges, ML/day					
	Average Day			Peak Day		
	1980	1990	2000	1980	1990	2000
Eastern,[a] to Sidi Bishr outfall	261	412	560	390	619	838
West/Central, to Kait Bey outfall	263	328	392	401	492	577
Mex-Dekheila, to Noubaria drain	66	113	161	51	131	249
Ameria, to Noubaria drain	32	85	137	51	131	209
	Other Discharges, ML/day					
Nouzha, to Kalaa drain	17	31	45	30	52	74
Abu Kir, to Evaporation Pond	103	127	150	152	189	225
Subtotal, Sewered Areas	742	1096	1445	1127	1659	2172
Unsewered areas	13	18	25	22	26	43
TOTAL ALEXANDRIA	755	1114	1470	1149	6187	2215

Note: (a) Includes Ras el Soda, Siouf Keblia, and Sadat City area.

Applying these concentrations to the estimated future discharges for each sewerage zone resulted in the daily load for each zone. These loads were then reduced according to the removal efficiency expected at each treatment facility. As discussed in Chapter 6 of the Technical Report, the treatment processes are: preliminary treatment which consists of screening, the removal of grit, sand and other inorganic solids larger than 0.15 mm in diameter and the removal of floating materials; secondary treatment which would be accomplished through the use of a conventional activated sludge process; and aerobic/anaerobic lagoons which would be designed for a 30-day detention time

For the preliminary treatment and secondary treatment facilities, removal efficiencies were selected from values reported by Metcalf and Eddy,[1] EPA,[2] and Fair, Geyer, and Okun.[3] For the aerobic/anaerobic lagoons, values of effluent BOD and SS were determined by the use of techniques presented in Metcalf and Eddy[1] which were based on influent loadings of BOD and SS. The removal efficiency for COD was assumed to be the same as that for BOD. Nutrient removal efficiencies were estimated according to the following reasoning:

> In an aerobic/anaerobic lagoon some nitrogen is removed by the assimilation of nitrogen into algal cells. However, when algal harvesting is not practiced, the decay of biological cells will return the nitrogen to the water environment as a nutrient. Some removal of nitrogen is accomplished by denitrification to N_2 gas. Some nitrogen is also removed by ammonia emission to the atmosphere, but this is an inefficient process due to the low surface-volume ratio and the low pH.[2]

Because of these considerations, a low value of nitrogen removal efficiency, 20 percent, was chosen from the literature.[2] This was used to compute the amount of nitrogen removed from an aerobic/anaerobic lagoon system.

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[1]Metcalf and Eddy, Inc., Wastewater Engineering, McGraw Hill Book Company, 1972.

[2]U.S. Environmental Protection Agency, Process Design Manual for Nitrogen Control, 1975.

[3]Fair, Geyer, and Okun, Water and Wastewater Engineering, John Wiley and Sons, Inc., 1968.

Good information is not available for phosphorus removal in an aerobic/anaerobic pond. Where nitrogen is removed through denitrification, no phosphorus will be simultaneously removed. Some phosphorus will be removed by algal assimilation, but most will be returned by biological decay. A value of 5 percent for phosphorus removal has been assumed, which, in comparison, is less than the lowest range of phosphorus removal reported for an activated sludge process.[1]

In summary, the flows and loads to be discharged from each sewerage zone after treatment are presented in Table 2-4. It should be noted that the values for discharges from all zones represent loads before mixing and dilution with receiving waters.

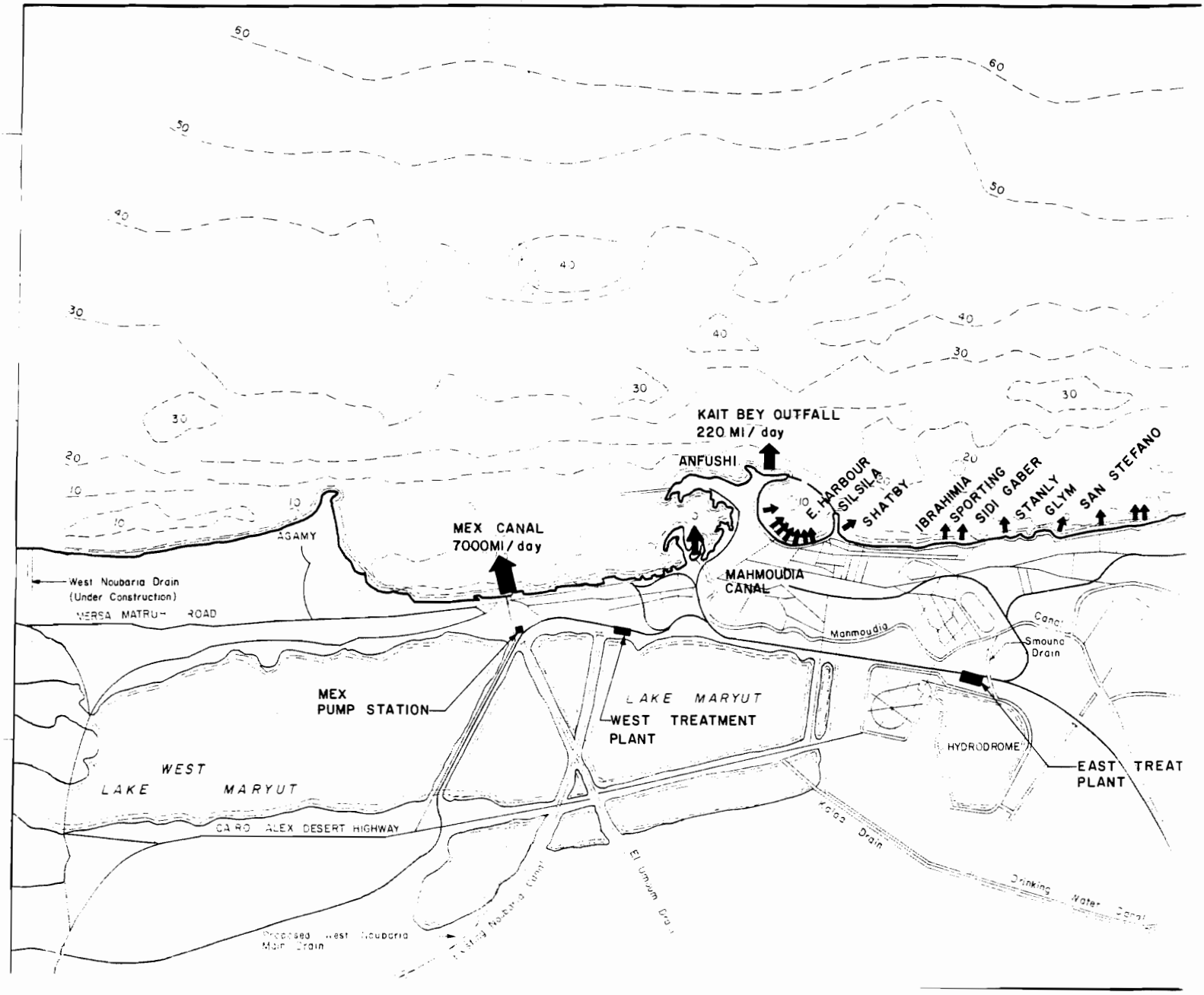
[1] U.S. Environmental Protection Agency, Process Design Manual for Phosphorus Control, 1976.

TABLE 2-4

YEAR 2000 PROJECTED AVERAGE DRY WEATHER FLOWS AND LOADS[a]

Sewerage Zones	Flow[b]	BOD[c]	COD[c]	SS[c]	Ammonia Nitrogen[c]	Albuminoid Nitrogen[c]	Ortho-Phosphate Phosphorus[c]
	Marine Discharge						
Eastern[d], to Sidi Bishr outfall after preliminary treatment	560	270	540	335	12.1	2.5	3.9
West Central, to Kait Bey outfall after preliminary treatment	392	200	400	210	8.8	1.8	2.8
Mex-Dekheila, to Noubaria drain after treatment in aerobic/anaerobic lagoons	159	47.1	100	109	1.4	1.1	0.58
Ameria, to Noubaria after treatment in aerobic/anaerobic lagoons	137	33.6	68.6	77.7	2.2	0.48	0.83
	Other Discharges						
Nouzha, to Kalaa drain after secondary treatment	45	4.3	15.2	6.5	0.47	0.13	0.13
Abu Kir, to evaporation pond with no subsequent discharge	150	105	225	165	1.4	0.45	0.30

Notes:
(a) These values are taken from the Recommended Wastewater Master Plan and represent projected average dry weather flows and loads after receiving treatment as indicated.
(b) Flow is expressed in ML/day.
(c) Loadings are in 1,000 kg per day.
(d) Includes Ras el Soda, Siouf Keblia, and Sadat City areas.


KAIT BEY OUTFALL
220 MI / day
ANFUSHI
E. HARBOUR
SILSILA
SHATBY
IBRAHIMIA
SPORTING
SIDI GABER
STANLY
GLYM
SAN STEFANO
MEX CANAL
7000MI / day
AGAMY
West Noubaria Drain
(Under Construction)
MERSA MATRUH ROAD
MAHMOUDIA
CANAL
Mahmoudia
Canal
Smouna
Drain
MEX
PUMP STATION
LAKE MARYUT
WEST TREATMENT
PLANT
HYDRODROME
EAST TREAT
PLANT
WEST
LAKE MARYUT
CAIRO ALEX DESERT HIGHWAY
Kaab Drain
El Umoum Drain
Drinking Water Canal
Proposed West Noubaria
Main Drain

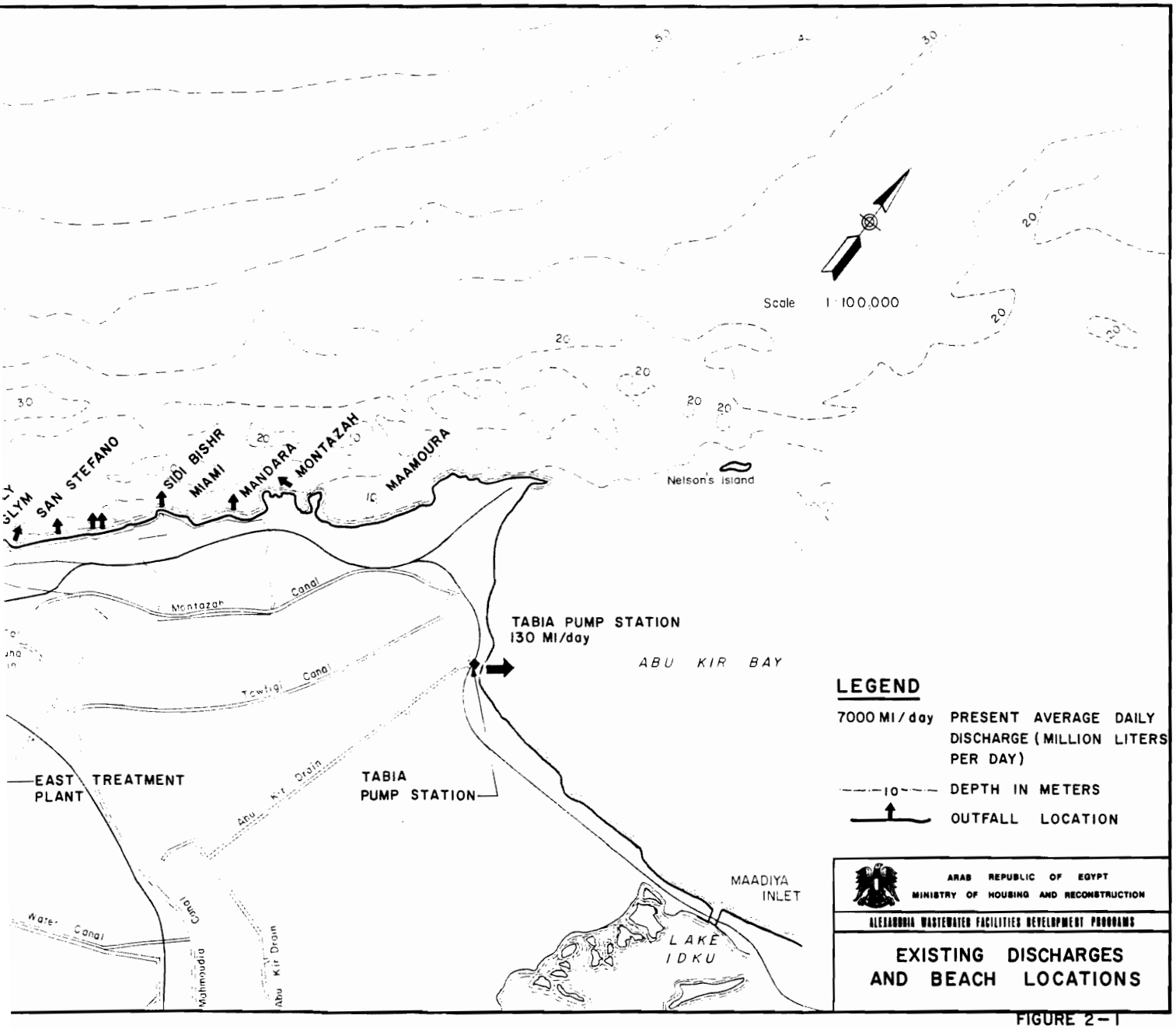
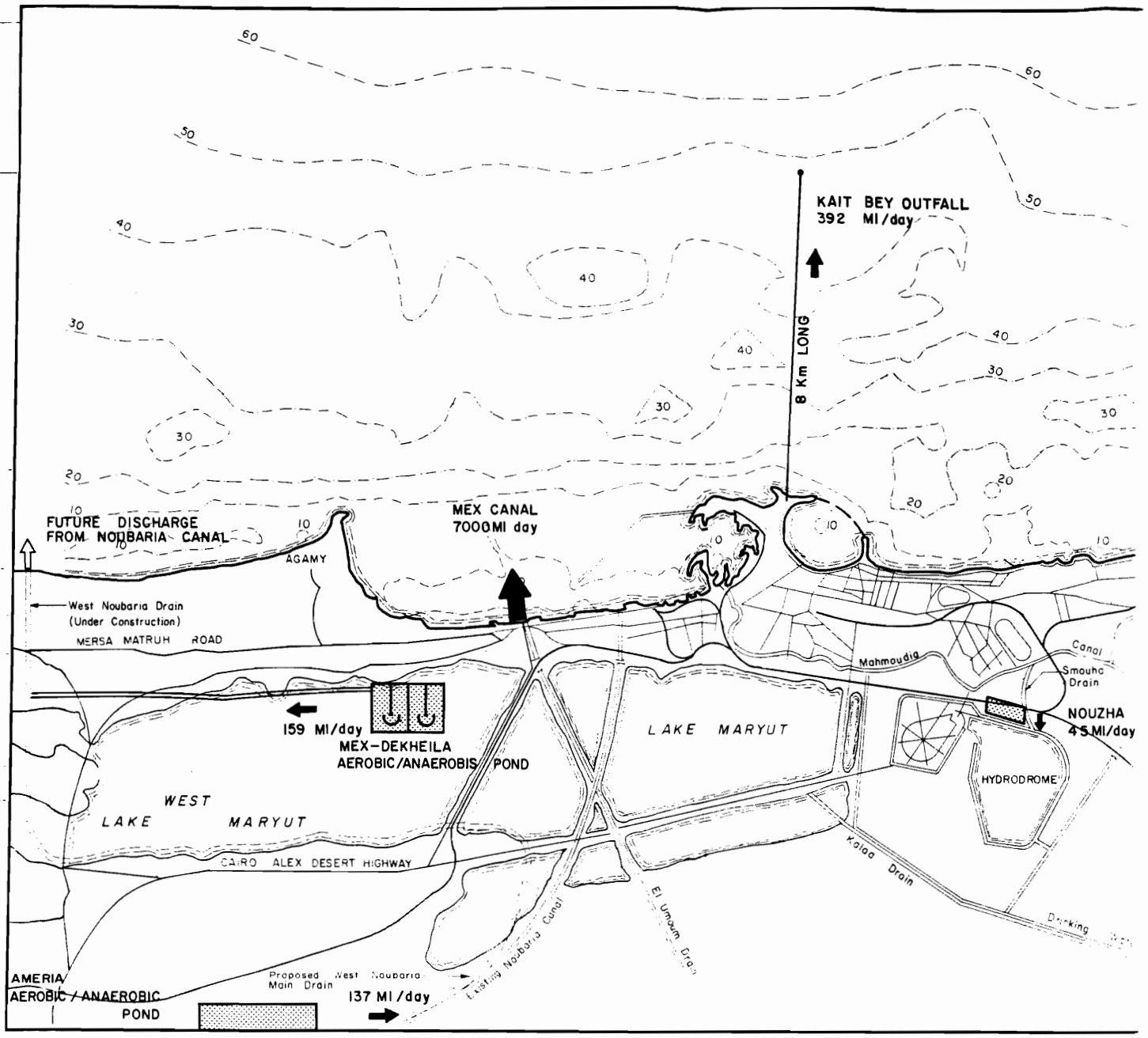

Scale 1 : 100,000
SAN STEFANO
SIDI BISHR
MIAMI
MANDARA
MONTAZAH
MAAMOURA
Nelson's Island
Montazah Canal
Tawfiqi Canal
Abu Kir Drain
Water Canal
Mahmoudia Canal
Abu Kir Drain
TABIA PUMP STATION
130 Ml/day
ABU KIR BAY
EAST TREATMENT PLANT
TABIA PUMP STATION
MAADIYA INLET
LAKE IDKU
LEGEND
7000 Ml/day PRESENT AVERAGE DAILY DISCHARGE (MILLION LITERS PER DAY)
10 DEPTH IN METERS
OUTFALL LOCATION
ARAB REPUBLIC OF EGYPT
MINISTRY OF HOUSING AND RECONSTRUCTION
ALEXANDRIA WASTEWATER FACILITIES DEVELOPMENT PROGRAMS
EXISTING DISCHARGES AND BEACH LOCATIONS

FIGURE 2-1


KAIT BEY OUTFALL
392 Ml/day
8 Km LONG
MEX CANAL
7000Ml day
FUTURE DISCHARGE
FROM NOUBARIA CANAL
AGAMY
West Noubaria Drain
(Under Construction)
MERSA MATRUH ROAD
159 Ml/day
MEX-DEKHEILA
AEROBIC/ANAEROBIS POND
LAKE MARYUT
WEST
LAKE MARYUT
CAIRO ALEX DESERT HIGHWAY
Mahmoudia
Canal
Smouha
Drain
NOUZHA
45 Ml/day
HYDRODROME
Kalaa Drain
Drinking
El Umoum Drain
Existing Noubaria Canal
Proposed West Noubaria
Main Drain
137 Ml/day
AMERIA
AEROBIC / ANAEROBIC
POND

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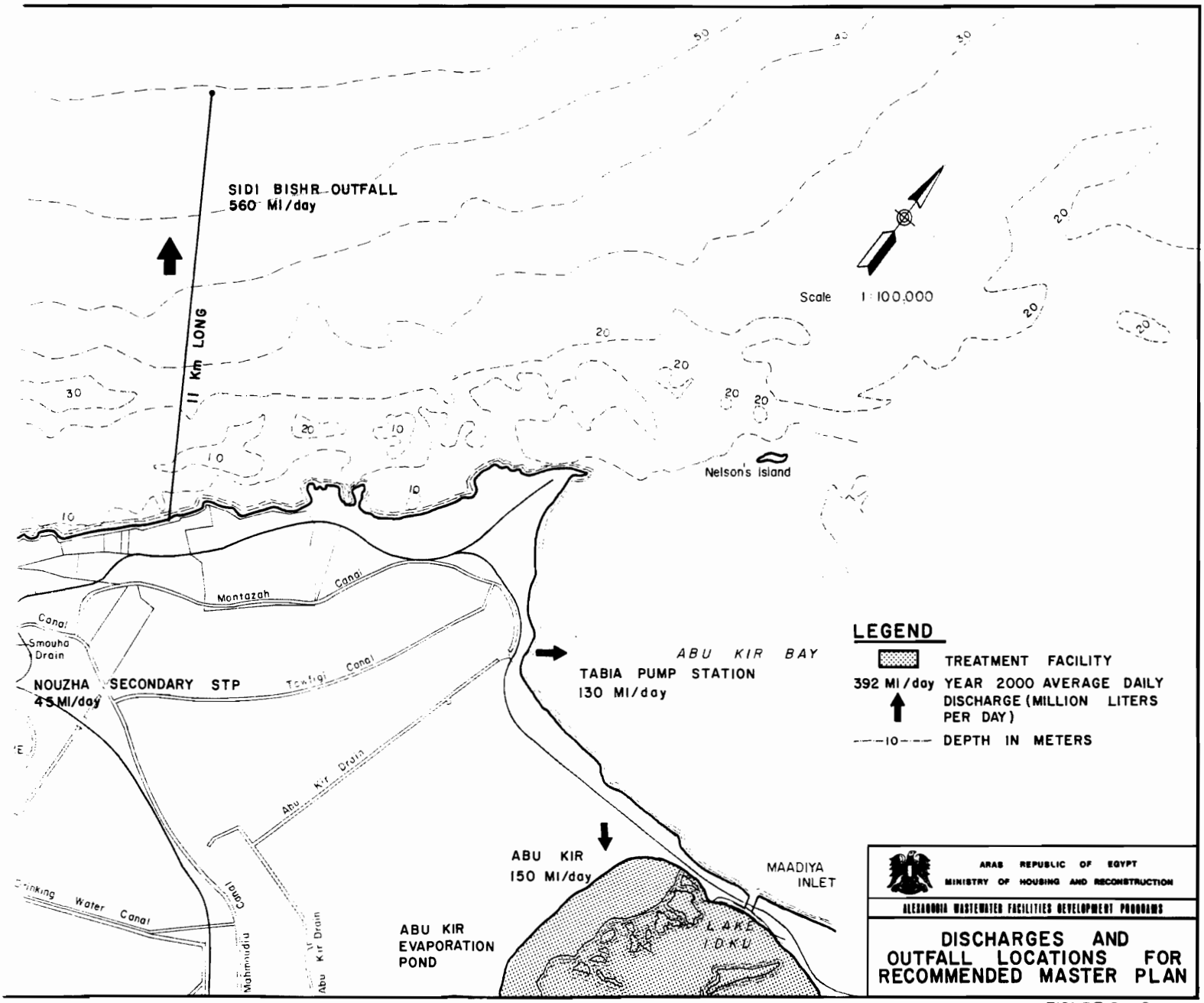

FIGURE 2 – 2

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CHAPTER 3

FIELD STUDIES

3.1 Physical Oceanography

Introduction

The scope and method of measurements for wind, water level, salinity, temperature, density, dissolved oxygen, and ocean currents are described below. Application and interpretation of the data follow, occasionally with comparison of the findings with those of others. Instruments used to gather all data for the oceanographic study are described in Appendix B. A description of the Alexandria climate is given in the Technical Report[1]. Full listings of the wind, salinity, temperature, density, dissolved oxygen, current meter, and drogue data are presented in unpublished Memoranda Nos. 5, 6, 7, 8, and 9.

Data derived and presented in this chapter are applied, in Chapters 4 and 5, to the derivation of water quality criteria and to outfall planning and preliminary design.

Wind

From July 1977 until June 1978, a weather station recorded wind speed and direction and air temperature at the project office staff house at 477 El Guish Street, Sidi Bishr. The station, manufactured by Meteorology Research Inc., was mounted on a 5 m high mast on the roof, at about 21 m above sea level. Average hourly wind speeds and directions were obtained from the continuous records, and have been preserved in Memorandum 5. While records for this station are largely complete, there are occasional gaps due to instrument malfunction.

---

[1] Camp Dresser & McKee Inc., Charles T. Main International Inc., Arab Technical and Economical Consulting Office, Alexandria Wastewater Master Plan Study, Volume II--Technical Report, 1978.

Weather data for the study period from the government weather stations at Ras el Tin and Dekheila were made available to the project. Wind direction and speed, barometric pressure, relative humidity, air temperature, and cloudiness were reported every three hours; since November, the reportage was every hour from Ras el Tin. From December 1977 to June 1978, data from the government station at Abu Kir, reported every three hours, was provided as well. The location of all weather stations is shown on Figure 3-3.

On drogue study days wind speed was recorded aboard the survey vessel, using an anemometer mounted about 5 m above the sea surface. Concurrent wind directions were measured using a hand-held compass.

Wind data collected from shipboard observations in the Alexandria area over an eleven-year period (1956 to 1967) were also obtained for this project from the report by Western Egypt Petroleum Co. (WEPCO) to Arab Petroleum Pipelines Co. (SUMED), completed in 1975. These relatively long-term wind data are presented as seasonally averaged speed-direction frequency distributions in Tables 3-1 to 3-4. They indicate that the predominant wind speeds are 5 to 15 knots (2.5 to 7.5 m/sec) year round, and are principally from the north to northwest. In winter and spring, wind direction is variable, although predominantly from 270° to 330°. In the summer and autumn, the wind direction is less variable; winds from 300° are strongly predominant.

Wind data gathered during the project period (July 1977 to June 1978) from Ras el Tin, Dekheila and CDM at Sidi Bishr are similarly presented, in Tables 3-5 to 3-16, to provide a comparison of winds during the project period with long-term conditions. The project period may be said to have been a typical wind year, in that the direction and speed distributions during the project period, as determined from records at all three stations, showed the same seasonal variations described for the long-term data.

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TABLE 3-1

AVERAGE FREQUENCY(%) OF WINDS IN ALEXANDRIA[a]

Location: Offshore Date: Feb/Apr 56-67

Beaufort Scale	Knots	m/sec	Degrees from North 150	180	210	240	270	300	330	0	030	060	090	120	All Directions
0	1	1													3.7
1	1-3	1	0.2	0.1	0.3	0.3	0.4	0.4	0.5	0.2	0.2	0.2	0.3	0.3	3.6
2	4-6	2-3	1.1	1.0	1.1	1.2	1.6	2.0	1.3	1.9	0.7	0.7	0.9	0.5	14.0
3	7-10	4-5	2.1	1.7	1.3	1.5	4.0	3.8	3.8	2.5	1.5	0.8	1.5	2.0	26.5
4	11-16	6-8	1.8	1.6	1.0	1.7	3.7	7.2	4.5	1.9	0.9	0.7	1.1	2.3	28.4
5	17-21	9-11	0.8	0.4	0.7	0.8	2.3	3.8	2.7	0.8	0.2	0.1	0.7	0.9	14.1
6	22-27	12-14	0.2	0.1	0.2	0.7	1.0	1.8	1.6	0.3	0.1	<0.1	0.1	0.4	6.7
7	28-33	15-17	0.1			0.1	0.3	0.8	0.7	0.1	0.1	0.1		0.1	2.3
8	34-40	18-21			0.1			0.1	0.3				<0.1		0.6
9	41-47	22-24					<0.1								<0.1
10	48-55	25-28													
11	56-63	29-32													
12	63	33													
Each Direction			6.4	4.9	4.9	6.3	13.2	19.9	15.4	7.7	3.7	2.7	4.6	6.5	

[a] Data were based on 2037 ship wind observations taken offshore Alexandria in Marsden Square 142 (subsquare 17/19, 27/29) at Lat 31° to 33° and Long. 27° to 30° E as reported in the WEPCO Report to SUMED on Wind and Wave data, 1956-1967.

TABLE 3-2

AVERAGE FREQUENCY (%) OF WIND IN ALEXANDRIA[a]

Location: Offshore Date: May/Jul 56-67

Beaufort Scale	Knots	m/sec	Degrees from North 150	180	210	240	270	300	330	0	030	060	090	120	All Directions
0	1	1													4.2
1	1-3	1	0.1	0.2	0.2	0.3	0.6	0.7	1.0	1.0	0.7	0.1	0.3	0.2	5.2
2	4-6	2-3	0.4	0.6	0.3	0.5	2.6	5.5	4.3	2.5	0.6	0.5	0.6	0.3	18.8
3	7-10	4-5	0.2	0.4	0.2	0.6	4.2	12.2	9.4	2.9	0.9	0.4	0.9	0.6	33.0
4	11-16	6-8	0.4	0.2	0.1	0.3	3.0	14.1	6.8	2.0	0.2	0.4	1.0	0.7	29.2
5	17-21	9-11	0.2	0.1	0.1		0.9	2.8	2.6	0.8	0.1		0.2	0.1	7.7
6	22-27	12-14					0.1	0.5	0.8	0.1			0.1	0.1	1.6
7	28-33	15-17					0.1	0.1	0.1	0.1					0.2
8	34-40	18-21						0.1							<0.1
9	41-47	22-24													
10	48-55	25-28													
11	56-63	29-32													
12	63	33													
Each Direction			1.3	1.4	0.9	1.7	11.3	35.9	25.1	9.3	2.6	1.4	3.0	1.9	

[a] Data were based on 2037 ship wind observations taken offshore Alexandria in Marsden Square 142 (subsquare 17/19, 27/29) at Lat 31° to 33° and Long. 27° to 30° E as reported in the WEPCO Report to SUMED on Wind and Wave data, 1956-1967.

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TABLE 3-3

AVERAGE FREQUENCY (%) OF WINDS IN ALEXANDRIA[a]

Location: Offshore Date: Aug/Oct 56-67

Beaufort Scale	Knots	m/sec	Degrees from North 150	180	210	240	270	300	330	0	030	060	090	120	All Directions
0	1	1													4.7
1	1-3	1	0.1	0.2	0.3	0.1	0.4	1.1	1.0	1.	0.8	0.5	0.5	0.1	6.2
2	4-6	2-3	0.3	0.2	0.3	0.5	1.5	4.6	5.2	4.0	2.2	0.8	0.6	0.3	20.7
3	7-10	4-5	0.6	0.3	0.5	0.5	2.8	9.5	11.6	5.0	2.5	1.0	0.6	0.3	35.2
4	11-16	6-8	0.2	0.2	0.3	0.1	1.2	8.6	8.6	3.1	1.3	0.5	0.2	0.2	24.6
5	17-21	9-11	0.1		0.1		0.3	1.5	3.2	1.0	0.3	0.1			6.5
6	22-27	12-14						0.3	0.9	0.2	0.1	0.1			1.7
7	28-33	15-17					<0.1		0.1	0.2					0.3
8	34-40	18-21							0.1						0.1
9	41-47	22-24													
10	48-55	25-28													
11	56-63	29-32													
12	63	33													
Each Direction			1.3	1.0	1.5	1.2	6.3	25.6	30.6	14.7	7.2	3.0	1.9	1.0	

[a] Data were based on 2037 ship wind observations taken offshore Alexandria In Marsden Square 142 (subsquare 17/19, 27/29) at Lat 31° to 33° and Long. 27° to 30° E as reported in the WEPCO Report to SUMED on wind and Wave Data, 1956-1967.

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TABLE 3-4

AVERAGE FREQUENCY (%) OF WINDS IN ALEXANDRIA[a]

Location: Offshore Date: Nov/Jan 56-67

Beaufort Scale	Knots	m/sec	Degrees from North 150	180	210	240	270	300	330	0	030	060	090	120	All Directions
0	1	1													6.6
1	1-3	1	0.3	0.4	0.1	0.2	0.7	0.4	0.4	0.7	0.4	0.4	0.3	0.2	4.5
2	4-6	2-3	0.9	1.1	1.1	1.3	1.7	1.5	1.6	1.8	2.1	1.1	1.3	1.5	16.9
3	7-10	4-5	1.1	1.3	2.1	2.7	3.4	2.7	3.1	3.3	2.8	1.8	1.3	1.1	26.6
4	11-16	6-8	1.3	1.1	1.6	2.8	3.1	4.4	3.2	1.9	1.4	1.3	0.9	1.1	24.2
5	17-21	9-11	0.5	0.4	0.9	1.5	2.3	1.7	2.0	0.6	0.3	0.3	0.1	0.5	11.1
6	22-27	12-14	0.1	0.1	0.8	1.0	1.3	0.9	1.2	0.4	0.1	0.1	<0.1	<0.1	5.9
7	28-33	15-17			0.3	0.6	0.4	0.7	0.7	0.1	<0.1				2.8
8	34-40	18-21	0.1		0.2	0.3	0.1	0.3	0.2	0.1					1.3
9	41-47	22-24													
10	48-55	25-28						<0.1	<0.1						0.1
11	56-63	29-32													
12	63	33	<0.1												<0.1
Each Direction			4.3	4.3	6.9	10.6	12.8	12.6	12.4	8.9	7.2	5.1	3.9	4.4	

[a] Data were based on 2037 ship wind observations taken offshore Alexandria in Marsden Square 142 (subsquare 17/19, 27/29) at Lat 31° to 33° and Long. 27° to 30° E as reported in the WEPCO Report to SUMED on wind and Wave Data, 1956-1967.

TABLE 3-5

AVERAGE FREQUENCY (%) OF WINDS IN ALEXANDRIA[a]

Location: Sidi Bishr Date: Feb/Apr 78

Beaufort Scale	Knots	m/sec	Degrees from North 150	180	210	240	270	300	330	0	030	060	090	120	All Directions
0	1	1													
1	1-3	1	0.14		0.14		0.14					0.28			0.70
2	4-6	2-3	4.80	2.40	0.70	1.27	1.98	1.13	1.98	1.83	3.25	2.40	5.50	6.63	33.87
3	7-10	4-5	2.82	1.84	0.56	0.70	3.67	2.83	2.40	4.23	2.54	0.70	2.96	7.76	33.01
4	11-16	6-8		0.28	0.14	0.98	6.63	6.21	3.11	0.99		0.14		0.56	19.04
5	17-21	9-11				0.28	2.96	4.23	0.56	0.14					8.17
6	22-27	12-14					1.83	1.55	0.14						3.52
7	28-33	15-17					0.99	0.28							1.27
8	34-40	18-21					0.42								0.42
9	41-47	22-24													
10	48-55	25-28													
11	56-63	29-32													
12	63	32													
Each Direction			7.76	4.52	1.54	3.23	18.62	16.23	8.19	7.19	5.79	3.52	8.46	14.95	

[a] Data based on observations at Camp Dresser & McKee weather station at Sidi Bishr.

TABLE 3-6

AVERAGE FREQUENCY (%) OF WINDS IN ALEXANDRIA[a]

Location: Sidi Bishr Date: May/Jun 78 and Jul 77

Beaufort Scale	Knots	m/sec	Degrees from North 150	180	210	240	270	300	330	0	030	060	090	120	All Directions
0	1	1													
1	1-3	1	1.17	0.84	0.17	0.17	0.17	0.34	1.34	1.17	2.34	2.85	2.18	2.34	15.08
2	4-6	2-3	0.66	1.17	0.17	0.17	2.34	12.20	9.86	6.19	6.52	6.86	2.34	0.17	48.65
3	7-11	4-5					0.67	13.20	16.88	3.34	1.51				35.60
4	11-16	6-8						0.50	0.17						0.67
5	17-21	9-11													
6	22-27	12-14													
7	28-33	15-17													
8	34-40	18-21													
9	41-47	22-24													
10	48-55	25-28													
11	56-63	29-32													
12	63	33													
Each Direction			1.83	2.01	0.34	0.34	3.18	26.24	28.25	10.70	10.37	9.71	4.52	2.51	

(a) Data based on observations at Camp Dresser & McKee weather station at Sidi Bishr

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TABLE 3-7

AVERAGE FREQUENCY (%) OF WINDS IN ALEXANDRIA[a]

Location: Sidi Bishr Date: Aug/Oct 77

Beaufort Scale	Knots	m/sec	Degrees from North 150	180	210	240	270	300	330	0	030	060	090	120	All Directions
0	1	1													
1	1-3	1	0.29	0.29											0.58
2	4-6	2-3	3.45	2.87		0.29		1.15	4.60	5.75	3.74	1.15	2.01	1.72	26.73
3	7-10	4-5	1.72	2.30			0.58	5.46	6.33	5.46	4.88		0.29	0.29	27.31
4	11-16	6-8		1.72			1.43	13.21	15.81	3.16	1.72				37.05
5	17-21	9-11		0.29			0.57	3.16	2.87						6.89
6	22-27	12-14						1.44							1.44
7	28-33	15-17													
8	34-40	18-21													
9	41-47	22-24													
10	48-55	25-28													
11	56-63	29-32													
12	63	32													
	Each Direction		5.46	7.47	-	0.29	2.58	24.42	29.61	14.37	10.34	1.15	2.30	2.01	

[a] Data based on observations at Camp Dresser & McKee weather station at Sidi Bishr.

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TABLE 3-8

AVERAGE FREQUENCY (%) OF WINDS IN ALEXANDRIA[a]

Location: Sidi Bishr Date: Nov/Dec 77 and Jan 78

Beaufort Scale	Knots	m/sec	Degrees from North 150	180	210	240	270	300	330	0	030	060	090	120	All Directions
0	1	1													
1	1-3	1											0.49		0.49
2	4-6	2-3	8.35	5.89	0.98	1.48	1.23	1.23	1.96	2.45	2.95	5.90	5.66	10.56	48.64
3	7-10	4-5	3.67	4.43	3.20	1.96	3.94	1.96	2.70	0.99	1.96	0.49	0.74	2.46	28.50
4	11-16	6-8	0.25	0.25	2.21	2.21	2.94	1.96	1.23						11.05
5	17-21	9-11				0.74	2.70		0.25						3.69
6	22-27	12-14				0.25	2.94	1.23							4.42
7	28-33	15-17					1.23	0.74	0.49						2.46
8	34-40	18-21					0.25								0.25
9	41-47	22-24				0.25			0.25						0.50
10	48-55	25-28													
11	56-63	29-32													
12	63	32													
Each Direction			12.27	10.57	6.39	6.89	15.23	7.12	6.88	3.44	4.91	6.39	6.89	13.02	

[a] Data based on observations at Camp Dresser & McKee weather station at Sidi Bishr.

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TABLE 3-9

AVERAGE FREQUENCY (%) OF WINDS IN ALEXANDRIA[a]

Location: Ras el Tin Date: Feb/Apr 78

Beaufort Scale	Knots	m/sec	Degrees from North 150	180	210	240	270	300	330	0	030	060	090	120	All Directions
0	1	1													1.97
1	1-3	1	1.12	0.56	0.14	0.42	1.27	1.12	0.56	0.84	1.41	0.98	0.42	0.84	9.68
2	4-6	2-3	2.11	1.55	0.56	0.84	2.27	1.99	3.54	2.25	2.69	0.98	2.53	1.27	22.58
3	7-10	4-5	2.82	1.96	1.12	1.82	3.70	4.82	4.68	2.26	4.66	2.26	2.39	4.36	36.85
4	11-16	6-8	2.40	0.56	1.68	2.10	2.38	5.07	3.10	0.28	1.26	0.70	1.82	1.97	23.32
5	17-21	9-11		0.28	1.12	0.56	1.26	0.98					0.28		4.48
6	22-27	12-14			0.42	0.14	0.42							0.14	1.12
7	28-33	15-17													
8	34-40	18-21													
9	41-47	22-24													
10	48-55	25-28													
11	56-63	29-32													
12	63	32													
Each Direction			8.45	4.91	5.04	5.88	11.30	13.98	11.88	5.63	10.02	4.92	7.44	8.58	

[a] Data based on observations at government weather station at Ras el Tin.

TABLE 3-10

AVERAGE FREQUENCY (%) OF WINDS IN ALEXANDRIA[a]

Location: Ras el Tin Date: May/Jun 78 and Jul 77

Beaufort Scale	Knots	m/sec	Degrees from North 150	180	210	240	270	300	330	0	030	060	090	120	All Directions
0	1	1													1.09
1	1-3	1	0.41	0.41		0.14	1.63	4.62	8.69	1.22	0.68	0.41	0.41	0.27	18.89
2	4-6	2-3		0.28	0.14	0.14	1.00	8.82	10.57	2.72	1.63	1.09	1.08	0.28	27.84
3	7-10	4-5	0.68		0.14	0.14	1.22	9.35	17.64	2.86	3.94	1.76	0.14	0.27	38.14
4	11-16	6-8	0.28			0.14	0.28	3.53	4.89	0.41	3.13	0.83		0.27	13.76
5	17-21	9-11						0.14				0.14			0.28
6	22-27	12-14													
7	28-33	15-17													
8	34-40	18-21													
9	41-47	22-24													
10	48-55	25-28													
11	56-63	29-32													
12	63	33													
Each Direction			1.37	0.69	0.28	0.56	4.22	26.46	41.79	7.21	9.38	4.23	1.63	1.09	

[a] Data based on observations at government weather station at Ras el Tin.

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TABLE 3-11

AVERAGE FREQUENCY (%) OF WINDS IN ALEXNADRIA[a]

Location: Ras el Tin Date: Aug/Oct 77

Beaufort Scale	Knots	m/sec	Degrees from North 150	180	210	240	270	300	330	0	030	060	090	120	All Directions
0	1	1													1.90
1	1-3	1	1.76	1.10	0.96	0.14	1.49	4.89	12.76	4.75	2.71	0.67	0.82	0.68	32.73
2	4-6	2-3	0.14		0.14	0.28	0.82	6.65	14.63	4.61	2.58	0.55	0.55	0.41	31.36
3	7-10	4-5	0.41		0.14	0.14	0.28	5.30	15.18	3.26	1.78	0.28		0.14	26.91
4	11-16	6-8			0.14	0.14	0.14	1.77	2.99	0.82	0.96	0.14			7.10
5	17-21	9-11													
6	22-27	12-14													
7	28-33	15-17													
8	34-40	18-21													
9	41-47	22-24													
10	48-55	25-28													
11	56-63	29-32													
12	63	32													
Each Direction			2.31	1.10	1.38	0.70	2.73	18.61	45.56	13.44	8.03	1.64	1.37	1.23	

[a] Data based on observations at government weather station at Ras el Tin.

TABLE 3-12

AVERAGE FREQUENCY (%) OF WINDS IN ALEXANDRIA[a]

Location: Ras el Tin Date: Nov/ Dec 77 and Jan 78

Beaufort Scale	Knots	m/sec	Degrees from North 150	180	210	240	270	300	330	0	030	060	090	120	All Directions
0	1	1													3.39
1	1-3	1	6.77	3.51	0.96	1.62	1.35	2.42	3.52	1.08	1.76	2.04	1.22	2.31	28.56
2	4-6	2-3	1.63	2.31	1.49	1.35	1.22	1.49	2.70	2.72	1.90	1.09	1.23	1.09	20.22
3	7-10	4-5	1.49	2.17	2.15	1.63	1.63	1.49	3.65	2.71	1.23	0.41	1.22	0.55	20.33
4	11-16	6-8	1.09	0.96	4.73	1.77	2.05	2.85	2.85	0.56	0.27				17.13
5	17-21	9-11		0.55	2.04	1.49	0.82	1.22	0.54	0.14					6.80
6	22-27	12-14		0.41	1.36	0.82	0.28	0.42	0.28						3.57
7	28-33	15-17													
8	34-40	18-21													
9	41-47	22-24													
10	48-55	25-28													
11	56-63	29-32													
12	63	32													
	Each Direction		10.98	9.91	12.73	8.68	7.35	9.89	13.54	7.21	5.16	3.54	3.67	3.95	

[a] Data based on observations at government weather station at Ras el Tin.

TABLE 3-13

AVERAGE FREQUENCY (%) OF WINDS IN ALEXANDRIA[a]

Location: Dekheila Date: Feb/Apr 78

Beaufort Scale	Knots	m/sec	Degrees from North 150	180	210	240	270	300	330	0	030	060	090	120	All Directions
0	1	1													2.26
1	1-3	1	0.14			0.42	0.28	0.42	0.42	0.42	0.42	0.56	0.14	0.28	3.50
2	4-6	2-3	1.83	0.42	0.28	1.12	0.56	0.56	1.12	1.12	1.26	0.70	0.70	1.40	11.07
3	7-10	4-5	5.21	1.27	1.26	1.26	2.53	1.97	3.64	3.80	4.66	2.40	1.26	4.21	33.47
4	11-16	6-8	3.38	1.26	0.84	1.82	1.68	2.67	6.75	5.92	3.66	2.38	1.40	3.37	35.13
5	17-21	9-11	0.56	0.28	0.14		1.26	1.68	2.39	1.40	0.42	0.14	0.28	0.98	9.53
6	22-27	12-14				0.28	1.12	1.40	1.68				0.14		4.62
7	28-33	15-17							0.42						0.42
8	34-40	18-21													
9	41-47	22-24													
10	48-55	25-28													
11	56-63	29-32													
12	63	32													
Each Direction			11.12	3.23	2.52	4.90	7.43	8.70	16.42	12.66	10.42	6.18	3.92	10.24	

[a] Data based on observationsat government weather station at Dekheila.

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TABLE 3-14

AVERAGE FREQUENCY (%) OF WINDS IN ALEXANDRIA[a]

Location: Dekheila Date: May/Jun 78 and Jul 77

Beaufort Scale	Knots	m/sec	Degrees from North 150	180	210	240	270	300	330	0	030	060	090	120	All Directions
0	1	1													0.68
1	1-3	1					0.14	0.27	0.83	0.81	0.69	0.14	0.95	0.28	4.11
2	4-6	2-3	0.27		0.41	0.28	0.55	1.24	4.37	2.19	0.96	0.41	0.28	0.68	11.64
3	7-11	4-5	0.28		0.14	0.28	0.55	3.55	16.13	9.42	4.93	1.10	1.10	0.28	37.76
4	11-16	6-8	0.14				0.28	4.10	21.03	10.93	5.75	0.55	0.28	0.42	43.48
5	17-21	9-11		0.14		0.14	0.14	0.14	0.95	0.41	0.27	0.14			2.33
6	22-27	12-14													
7	28-33	15-17													
8	34-40	18-21													
9	41-47	22-24													
10	48-55	25-28													
11	56-63	29-32													
12	63	33													
Each Direction			0.69	0.14	0.55	0.70	1.66	9.30	43.31	23.76	12.60	2.34	2.61	1.66	

[a] Data based on observations at government weatehr station at Dekheila.

TABLE 3-15

AVERAGE FREQUENCY (%) OF WINDS IN ALEXANDRIA[a]

Location: Dekheila Date: Aug, Sep, Oct 77

Beaufort Scale	Knots	m/sec	Degrees from North 150	180	210	240	270	300	330	0	030	060	090	120	All Directions
0	1	1													3.99
1	1-3	1	0.26	0.13	0.26	0.40		0.67	1.20	1.60	1.07		0.39	0.13	6.11
2	4-6	2-3	0.70	0.40	0.53	0.54	0.67	2.66	3.60	4.54	0.94	0.27	1.20		16.14
3	7-10	4-5	0.26	0.40		0.26	0.40	3.06	13.86	14.51	2.93	0.40	0.53	0.40	37.01
4	11-16	6-8				0.13	0.93	2.52	16.67	9.73	2.01	0.92	0.13		33.04
5	17-21	9-11					0.13	0.13	1.06	0.93	1.33	0.13			3.71
6	22-27	12-14													
7	28-33	15-17													
8	34-40	18-21													
9	41-47	22-24													
10	48-55	25-28													
11	56-63	29-32													
12	63	32													
Each Direction			1.31	0.93	0.79	1.33	2.13	9.04	36.39	31.31	8.28	1.72	2.25	0.53	

[a] Data based on observations at government weather station at Dekheila.

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TABLE 3-16

AVERAGE FREQUENCY (%) OF WINDS IN ALEXANDRIA[a]

Location: Dekheila Date: Nov, Dec 77 & Jan 78

Beaufort Scale	Knots	m/sec	Degrees from North 150	180	210	240	270	300	330	0	030	060	090	120	All Directions
0	1	1													5.71
1	1-3	1	1.09	1.09	1.77	0.54	1.08	0.14	0.41	1.37	0.28	0.14	0.55	0.68	9.14
2	4-6	2-3	1.63	1.09	3.39	1.90	0.82	0.28	1.89	2.44	1.08	1.22	1.23	1.36	18.33
3	7-10	4-5	1.23	1.63	5.13	3.80	2.43	1.64	1.89	3.78	2.57	1.09	1.90	1.90	28.99
4	11-16	6-8	0.68	0.82	2.31	5.14	3.53	0.82	2.97	3.81	2.84	0.14	0.82	0.14	24.02
5	17-21	9-11		0.14	0.82	1.91	1.76	1.09	2.31	0.95	0.14				9.12
6	22-27	12-14			0.14	0.69	1.22	0.69	0.41	0.56					3.71
7	28-33	15-17				0.14	0.56		0.14	0.14					0.98
8	34-40	18-21													
9	41-47	22-24													
10	48-55	25-28													
11	56-63	29-32													
12	63	32													
Each Direction			4.63	4.77	13.56	14.12	11.40	4.66	10.02	13.05	6.91	2.59	4.50	4.08	

[a] Data based on observations at government weather station at Dekheila.

One difference noted between the project wind data and the long term data was the existence of light offshore winds (2 to 3 m/sec from 100° to 150°) during the project period. This trend was clearly seen in the Sidi Bishr and the Ras el Tin data during the entire year and in the Dekheila data during the spring.

The variation in wind direction, averaged monthly rather than seasonally, is presented in Tables 3-17 and 3-18 for Ras el Tin and Dekheila. Again, predominance of winds from 270° to 330° is shown for the entire year on these tables.

Speed frequency distributions were prepared for monthly wind data from the government weather stations and the CDM-operated station. Wind speeds not exceeded 20 percent, 50 percent and 80 percent of the time, referred to as V_{20}, V_{50}, and V_{80}, are shown in Table 3-19. There is not a high degree of agreement among the three stations, except in that December, January, and February were windier than October and November, and that for most months the median (50 percentile) speed ranged between 4 and 6 m/sec (yet Ras el Tin shows lesser speeds for July through November). The differences among the stations may be attributed to differences in geographical location, and differing circumstances in interference by nearby structures.

It is of interest to know whether nighttime wind speeds are significantly different from daytime wind speeds. For selected months, the wind speed data were analyzed separately for the day period (hours 6 a.m. to 6 p.m.) and the night period (hours 6 p.m. to 6 a.m.). The results of the day/night wind speed analyses are shown in Table 3-20 in terms of V_{20}, V_{50}, and V_{80} values. In nearly every case, the nighttime value is less than the corresponding daytime value. Averaging all values of day and night wind speeds for the months of September, December, March, and June indicates that the night values are about 15 percent less than day values. The night values were as much as 20 percent less than the day values in September and about 12 percent less than day values in March. Table 3-20

TABLE 3-17

DIRECTIONAL FREQUENCY DISTRIBUTION OF SURFACE WINDS

Location: Ras el Tin Date: Jul 77 - Jun 78

	Degrees From North							
	135	180	225	270	315	0	45	90
July	0.0	0.0	0.0	17.7	77.1	5.1	0.0	0.0
August	0.4	0.8	0.0	3.2	65.7	27.0	1.2	0.4
September	2.5	1.6	1.2	7.1	44.7	29.6	5.0	4.6
October	4.0	4.0	1.6	2.4	37.1	38.3	6.4	3.2
November	12.9	15.0	5.8	4.2	14.6	27.0	7.1	7.9
December	4.8	18.9	17.2	12.4	24.9	9.6	3.2	6.0
January	9.6	18.4	24.3	17.2	8.8	6.0	5.6	7.6
February	11.1	13.7	13.9	14.7	12.0	10.3	4.4	17.0
March	8.0	8.0	5.2	20.8	22.8	12.8	6.4	13.6
April	12.1	6.3	3.8	12.5	30.8	15.8	8.3	8.8
May	3.6	2.0	0.4	2.4	29.6	28.4	22.4	8.0
June	0.4	2.0	0.4	7.0	65.5	20.8	2.5	0.0

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TABLE 3-18

DIRECTIONAL FREQUENCY DISTRIBUTION OF SURFACE WINDS

Location: Dekheila Date: Jul 77 - Jun 78

	Degrees From North							
	135	180	225	270	315	0	45	90
July	0.0	0.0	0.0	4.1	65.7	30.2	0.0	0.0
August	0.0	0.4	0.0	1.2	47.5	45.5	2.0	0.0
September	1.2	1.6	2.1	5.1	30.8	44.1	7.2	5.0
October	3.2	2.0	3.6	4.4	12.5	55.6	9.7	2.8
November	10.4	8.3	12.9	5.9	6.7	30.9	10.5	5.9
December	2.4	8.8	26.4	14.4	12.8	22.8	2.0	5.6
January	6.8	9.6	30.0	20.8	9.2	6.4	4.8	6.8
February	7.4	10.6	8.9	17.3	12.9	14.7	8.5	6.7
March	15.6	5.6	4.8	10.8	18.0	24.8	13.2	4.4
April	15.0	6.3	2.1	5.8	22.5	28.8	6.7	11.3
May	4.4	1.6	0.8	1.2	14.0	40.0	23.2	11.2
June	0.0	0.0	1.3	2.5	25.8	63.8	3.8	0.8

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TABLE 3-19

MONTHLY DISTRIBUTIONS OF WIND SPEEDS
m/sec

Month	CDM at Sidi Bishr			Ras el Tin			Dekheila		
	V_{20}	V_{50}	V_{80}	V_{20}	V_{50}	V_{80}	V_{20}	V_{50}	V_{80}
July 1977	5.4	6.7	8.1	1.1	2.7	4.7	3.5	4.9	6.5
August 1977	3.3	6.5	8.3	1.5	3.2	4.4	3.2	5.0	6.6
September 1977	3.1	5.0	6.8	0.9	2.1	3.5	3.1	4.8	6.3
October 1977	2.7	4.5	6.1	0.9	2.4	4.6	3.0	4.9	7.2
November 1977	2.2	3.0	4.1	0.5	1.5	3.8	1.8	3.7	6.3
December 1977	2.7	4.3	8.1	1.5	4.3	8.0	2.7	5.0	8.6
January 1978	2.6	3.9	6.5	2.1	4.2	7.9	3.4	5.2	8.7
February 1978	2.8	4.0	6.8	2.3	4.0	6.3	4.0	5.6	8.0
March 1978	3.1	4.5	8.8	2.5	4.1	6.4	3.5	5.5	7.6
April 1978	2.7	4.2	6.3	3.1	4.4	6.2	3.4	5.2	7.6
May 1978	3.0	4.7	7.0	2.6	4.0	5.4	3.8	5.3	7.2
June 1978	4.3	6.0	7.8	2.1	3.4	4.9	3.7	5.3	6.9
Average	3.2	4.8	7.1	1.8	3.4	5.5	3.3	5.0	7.3

TABLE 3-20

COMPARISON OF DAY AND NIGHT WIND SPEEDS

Month	Condition	Ras el Tin			Dekheila			CDM at Sidi Bishr		
		V_{20}	V_{50}	V_{80}	V_{20}	V_{50}	V_{80}	V_{20}	V_{50}	V_{80}
September 1977	Full Day	0.9	2.1	3.5	3.1	4.8	6.3	3.1	5.0	6.8
	Day	1.1	2.3	3.7	3.8	5.4	6.9	3.3	5.4	7.0
	Night	0.8	1.9	3.3	2.6	4.1	5.8	2.5	4.5	6.3
	Night/Day	0.72	0.83	0.89	0.68	0.76	0.84	0.76	0.83	0.90
	Night/Full Day	0.89	0.90	0.94	0.84	0.85	0.92	0.81	0.90	0.93
December 1977	Full Day	1.5	4.3	8.0	2.7	5.0	8.6	2.7	4.3	8.1
	Day	1.7	4.8	8.4	3.0	5.1	9.5	3.0	4.9	8.4
	Night	1.4	4.0	7.2	2.8	5.1	8.0	2.5	3.7	7.2
	Night/Day	0.82	0.83	0.86	0.93	1.00	0.84	0.83	0.76	0.86
	Night/Full Day	0.93	0.93	0.90	1.00	1.02	0.93	0.93	0.86	0.89
March 1978	Full Day	2.3	4.0	6.3	3.5	5.5	7.6	3.1	4.5	8.8
	Day	2.9	4.1	6.2	4.7	6.0	8.0	3.3	5.0	8.9
	Night	1.7	3.8	6.5	3.0	5.2	7.5	2.8	4.3	8.2
	Night/Day	0.59	0.93	1.05	0.64	0.87	0.94	0.85	0.86	0.92
	Night/Full Day	0.74	0.95	1.03	0.86	0.95	0.99	0.90	0.96	0.93
June 1978	Full Day	2.1	3.4	4.9	3.7	5.3	6.9	4.3	6.0	7.8
	Day	2.4	3.7	5.1	4.3	6.2	7.4	4.5	6.0	7.8
	Night	1.6	3.1	4.5	3.2	4.9	6.3	4.0	5.9	7.8
	Night/Day	0.67	0.84	0.88	0.74	0.79	0.85	0.89	0.98	1.00
	Night/Full Day	0.76	0.91	0.92	0.86	0.92	0.91	0.93	0.98	1.00

also shows that average night speeds are less than the diurnal mean speeds by less than 10 percent.

Correlations of wind velocity with relative surface current velocity are discussed in the subsection below on drogue studies.

Water Level

Hourly readings of the Alexandria Harbor tide gauge, beginning in July 1977, were made available to the project.

Variations in water level were not great. For example, the highest level recorded in August 1977 was only 34 cm above the lowest recorded in that month. On the central part of Figure 3-1, the monthly means of daily highs and the monthly means of daily lows are plotted for each month of the study period (for July, the record is only 20 to 31 July, inclusive). In any given month, the range between mean high and mean low is about 20 cm. Over the course of the year, the mean high level ranged from near 70 cm in July to 53 cm in March, in approximately the pattern described by Sharaf El Din and Rifat.[1]

The difference in elevation between the Alexandria tide gauge datum and the datum used on the Admiralty charts is 33.8 cm, according to a note on the charts. Therefore, 33.8 cm has been added to the elevations given on the charts for mean spring high and low levels and mean neap high and low levels, to express them in terms of the tide gauge datum. These values, plotted on the left hand side of Figure 3-1, appear to be comparable, if slightly lower, than values for monthly mean high and low recorded during the 1977-78 study period.

On the right hand side of Figure 3-1 are plotted the twenty annual maximum water levels measured between 1957 and 1976, inclusive. The greatest

[1]Sharaf El Din, S.H., and Rifat, E.M., "Variation in the Sea Level at Alexandria," International Hydrographic Review, Vol. 45, No. 2, July 1968.

value recorded in those 20 years, 102 cm, is only about 60 cm above the mean low water levels recorded in 1977-78.

An extreme value analysis was carried out on these twenty annual maxima as follows: each maximum was assigned a rank, m, according to size (m = 1 for the least, m = 20 for the greatest). The quantity $P = m/(20+1)$ is the probability that the associated value of water level, H, will not be exceeded in any given year. The quantity $R = 1/(1-P)$ is the return period in years for the associated value of H. An extreme value analysis consists of plotting R against H for all recorded values (twenty in this case), then fitting a curve to the plotted points to determine R for any H.

Extreme value distributions are often used to stretch the R and/or the H scales so that the plotted points are well fitted by a straight line. De Young and Pfafflin[1] note that recorded water levels above the astronomical tides are well described by a distribution of the type

$$P = \exp\left[-\exp\left(-a \ln\left[H/H_f\right]\right)\right]$$

where a is a constant and H_f is the modal (most frequent) value of H. This may be applied by defining the probability function Y such that

$$P = \exp\left[-\exp\left(-Y\right)\right];$$

then determining Y for each of the twenty values of m; then plotting Y (on an arithmetic ordinate scale) against H (on a logarithmic abscissa scale); then constructing scales for P and $R = 1/(1-P)$ parallel to the Y- coordinate.

This was done for the data at hand. However, it was found that a straight line fit the data better when an arithmetic scale, rather than a logarithmic scale, was used for H. The corresponding distribution is

$$P = \exp\left[-\exp(-\exp\left(-aH-b\right)\right]$$

[1] De Young, R.K., and Pfafflin, J.R., "Recurrence Intervals of Abnormally High Tides by Superposition of Storm Surges over Astronomical Tides," Proceedings, Civil Engineering in the Oceans III, 9-12 June 1975, ASCE, New York.

where a and b are constants. This is the basis of the scale stretching in Figure 3-2.

Salinity, Temperature, Density, Dissolved Oxygen

Salinity, temperature, and dissolved oxygen profiles at a given station are composed of individual readings taken at a series of depths between the surface and the bottom. The depth interval between measuring points, which generally varied between 1 m and 10 m, was usually 1 m near the surface and every 5 m below 5 m depth. Density profiles are composed of individual values determined from the temperature and salinity values for each depth and location, using standard seawater density tables[1].

On days devoted solely to obtaining salinity, temperature and dissolved oxygen measurements, profiles were obtained at stations arrayed at 1 km intervals on four principal alignments, as shown on Figure 3-3. Usually, all stations on one alignment were visited on one day. (These alignments, off Agamy, Kait Bey, Ramleh, and Abu Kir, were the geographical framework for current measurements as well, as will be discussed in the next section.)

In addition, spot profiles (i.e., vertical profiles in one location only, not in an alignment) were obtained at plankton sampling stations (Figure 3-3) and occasionally at drogue deployment locations (Figure 3-9). A complete listing of all salinity, temperature, and dissolved oxygen measurements, with locations indicated, is provided in unpublished memorandum 9.

In-situ salinity and temperature measurements were made with a Hydrolab Model TC-2 conductivity-temperature meter in 1977, and with a Beckman RS5-3 portable salinometer in 1978. Occasionally, water samples were obtained for conventional thermometric readings taken immediately and for later salinometric readings ashore, as a check on performance of the field instruments, and on a few occasions when the field probes were not

[1] U.S. Navy Hydrographic Office, Tables for Sea Water Density, U.S. Navy, 1952.

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available. In-situ dissolved oxygen and temperature measurements were made with a Hydrolab Model TDO-2 Dissolved Oxygen-Temperature Meter with remote probe. Usually, two temperature measurements for each station and depth were thereby obtained, one from the salinometer and one from the DO meter. (In late September, the dissolved oxygen probe snagged on a bottom rock and the cable broke so there are no DO data for October and November. The probe was subsequently recovered, but the cable was not restored to working order until December.)

Salinity and temperature data were obtained primarily to determine annual patterns in horizontal and vertical density gradients, important considerations for outfall design. However, some interesting points may be observed by reviewing the salinity and temperature profiles.

Often, stations within 5 km of shore have considerably reduced salinity values in the top 5 to 10 m of depth; this is attributed to freshwater discharges, such as the Mex Canal and wastewater overflow points, spreading out over the ocean surface. An example of the reduced salinity is shown on Figure 3-4. The pattern of the isohalines (points of equal salinity) clearly show lenses of reduced salinity near the surface. This type of contour plot can be used to determine the extent of these less saline water lenses. Additional discussion of salinity is contained in a subsequent subsection, Salinity Deficit. Occasionally, salinities may be greater at the surface than below it; this may be attributed to high rates of evaporation at the surface, especially during summer.

Seasonal warming and cooling patterns may be observed by studying temperature variations with location, depth, and time. In general, it appears that areas within 5 km of shore precede the areas farther than 5 km from shore both in autumn cooling and spring warming. Warming occurs by the downward progression of the thermocline between February and August, and cooling occurs homogeneously throughout an overturning, well-mixed water column (at least in the upper 50 m) measured between September and January.

Figure 3-5 is an example of temperature profiles along a sampling station alignment. The thermocline can be clearly observed on Figure 3-7 at stations 6000 m to 9000 m at a depth of about 38 m. The salinity and dissolved oxygen profiles, which will be discussed in other sections, are also shown on Figure 3-5.

Examples of density profiles obtained along various alignments during the project are shown on Figure 3-6 through 3-8. Quite often, especially in the summer, the stations 1 to 5 km offshore and occasionally the stations 6 to 10 km offshore show a pycnocline (strong density gradient) in the upper layers. This pycnocline can be attributed to the occurrence of the thermocline (strong temperature gradient) and the presence of less saline surface waters. The level of the density gradient changes with the seasons, moving upwards during autumnal cooling, and downwards as the effect of surface heating penetrates the water column during spring and summer. In late summer, the pycnocline has been observed as deep as 40 m. At other times of the year, there is a weak, nearly linear density gradient of zero to 0.3 sigma-t units per 30 m, below 10 m depth.

To aid in the outfall design, density differences between the 10 m and 40 m depths, and between the surface and 40 m depth for stations more than 5 km from shore were plotted against calendar dates on Figure 5-5. Between October and March, the density difference between the surface and the bottom is 0.4 sigma-t units or less; at other times, it is significantly greater. This figure will be used in the chapter on outfall planning and design in consideration of wastewater plume submergence. Density throughout the water column is also considered in calculating excess hydraulic head in the outfall pipe.

Dissolved Oxygen. The Mediterranean Sea is considered to be generally one of the well-aerated oceans of the world. The "Ichthyolog"[1] studies showed the waters of the southeastern Mediterranean to be well-aerated

[1] Al Kholy, A.A., and Wakeel, S.K., Fisheries of the Southeastern Mediterranean Sea Along the Egyptian Coast, Soviet-Egyptian Expedition 1970-1971, General Organization for Government Printing, 1975.

throughout the top 1200 m at all seasons. There is, therefore, little doubt that the Mediterranean has great assimilative capacity as far as oxygen-demanding wastes are concerned. Nevertheless, because dissolved oxygen (DO) is a very important parameter, CDM decided to measure dissolved oxygen in the proposed outfall area.

The DO values obtained are summarized in Table 3-21. Within a given month, data from all alignments are classed as "inshore" or "offshore", depending on whether they are from stations less or more than 5 km from shore. Within each category, all data for the month, irrespective of data, precise location, or depth, are averaged and the five highest and five lowest values are noted.

Additional dissolved oxygen data are listed in the plankton tables in Appendix A-1.

The CDM studies have confirmed that there is generally sufficient oxygen in the ocean off Alexandria to assimilate the anticipated wastewater discharges in year 2000. The lowest value of DO was 3.5 mg/L found in a region near a shoreline sewer overflow in a subsurface zone of poor mixing. A more complete discussion of how the dissolved oxygen affects marine life and the design of the outfall is included in Chapter 4.

Currents

A thorough understanding of local current patterns is essential for satisfactory planning and design of outfalls. Previously available data[1] indicated that offshore currents in the eastern Mediterranean consist of a generally counter-clockwise geostrophic circulation (hence easterly off the Egyptian coast) with mean speeds of the order of 0.20 to 0.25 m/sec. Occasionally, there is a westerly current near Alexandria. However, the movement of nearshore waters is dependent in a complex fashion on bathmetry,

[1] United States Naval Oceanographic Office, Pilot Chart of the North Atlantic Ocean (Mediterranean inset), Defence Mapping Agency Hydrographic Center, 1975, 1976.

TABLE 3-21

SUMMARY OF MEASURED DISSOLVED OXYGEN VALUES[a]

Month	Range	Average Value, mg/L	Five Highest Values, mg/L	Five Lowest Values, mg/L
July 1977	Inshore[b]	7.0	7.5, 7.5, 7.0, 6.9, 6.9	6.6, 6.8, 6.8, 6.9, 6.9
	Offshore[c]	7.9	8.4, 8.4, 8.4, 8.4, 8.1	6.9, 7.1, 7.2, 7.2, 7.3
August 1977	Inshore	6.4	7.7, 7.6, 7.5, 7.4, 7.3	3.5, 5.0, 5.1, 5.3, 5.5
	Offshore[c]	6.4	7.3, 7.0, 6.9, 6.9, 6.8	4.8, 5.8, 6.0, 6.0, 6.3
September 1977	Inshore	6.4	9.3, 9.2, 7.4, 7.2, 6.7	4.3, 5.2, 5.3, 5.3, 5.4
	Offshore	6.4	7.7, 7.7, 7.4, 7.2, 7.1	5.9, 6.1, 6.1, 6.1, 6.2
December 1977	Inshore	7.0	7.5, 7.2, 7.2, 7.1, 7.1	6.8, 6.9, 6.9, 7.0, 7.0
	Offshore	7.0	7.3, 7.3, 7.3, 7.0, 6.9	6.6, 6.7, 6.8, 6.8, 7.6
January 1978	Inshore	6.9	11.4, 9.7, 9.6, 8.2, 7.5	5.8, 6.0, 6.1, 6.2, 6.4
	Offshore	6.5	7.8, 6.9, 6.8, 6.8, 6.8	5.7, 5.8, 5.8, 6.1, 6.2
February 1978	Inshore	8.4	9.8, 9.6, 9.0, 8.8, 8.2	7.2, 7.3, 8.0, 8.6, 8.8
	Offshore	7.2	7.7, 7.7, 7.7, 7.6, 7.6	6.9, 7.1, 7.1, 7.1, 7.1
March 1978	Inshore	7.5	9.3, 9.2, 9.2, 9.0, 8.8	6.9, 7.0, 7.0, 7.1, 7.1
	Offshore	7.7	8.9, 8.8, 8.8, 8.8, 8.8	6.8, 6.9, 6.9, 6.9, 7.0
April 1978	Inshore	7.8	8.7, 8.7, 8.6, 8.6, 8.6	7.1, 7.1, 7.1, 7.1, 7.1
	Offshore	7.5	8.8, 8.7, 8.7, 8.6, 8.5	6.8, 6.9, 6.9, 6.9, 6.9
May 1978	Inshore	7.4	9.6, 9.6, 8.6, 8.6, 8.4	6.6, 6.7, 6.7, 6.7, 6.7
	Offshore	7.4	8.8, 8.8, 8.7, 8.5, 8.4	6.2, 6.4, 6.8, 6.8, 6.9
June 1978	Offshore	7.0	7.6, 7.2, 7.1, 7.0, 7.0	6.8, 6.8, 6.8, 6.8, 6.9

[a] Measured off Agamy, Kait Bey, Ramleh, and Abu Kir, using Hydrolab Model TDO-2 Dissolved Oxygen Temperature meter with remote probe.

[b] Inshore stations are those 5 km or less from the coast.

[c] Offshore stations are those farther than 5 km from the coast.

wind, and horizontal and vertical density gradients. To better understand the current regime off Alexandria, the oceanographic program included current meter deployments and drogue studies.

Current Meters. Endeco Model 105 tethered, ducted-impeller current meters measured and recorded current speed and direction at half-hour intervals. The recorded speed values, being proportional to the number of impeller revolutions within each half-hour, can be said to be half-hourly averages rather than half-hourly spot readings. These data are tabulated in unpublished Memorandum No. 6.

The current meter deployment locations are shown on Figure 3-9. Deployments were limited to four principal sites on the two control data-gathering alignments. Two sites were on the Ramleh alignment [1A (1), 1A (2), 1B] and two were on the Kait Bey alignment [2A, 2B (1), 2B (2)]. On the Ramleh alignment, location 1A (1) was used in 1977, and location 1A (2) was used in 1978. On Kait Bey alignment, location 2B (1) was supplanted by 2B (2) in May 1978.

Two current meters were installed at each deployment location, one about 10 m beneath the surface and the other about one quarter to one third the depth above the sea bed. The letters U and L denote these upper and lower meters, respectively; for example, 2BL denotes the lower meter at location 2B. The details of meter deployment, meter specifications and data format are discussed in Appendix B.

A log of current meter deployments is shown on Figure 3-10. Solid horizontal bars indicate continuous periods for which current meter data were successfully obtained. Accompanying numbers indicate the start dates, finish dates, and dates on which film packs were changed with minimum interruption of the record. Finish dates indicate when the meter was recovered or malfunctioned.

It was originally intended to deploy current meters on the Abu Kir and Agamy alignments, as well as the Kait Bey and Ramleh alignments. However,

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this was not done because (1) concurrent Master Plan activities eliminated consideration of outfalls at Agamy and Abu Kir early in the oceanographic studies program, and (2) serious problems in current meter operation were encountered, forcing a cutback in the deployment schedule to the minimum level required to provide necessary and sufficient data.

A brief description of deployment problems, and of successive deployment designs, is presented in Appendix B.

The records were divided into data analysis periods, as shown on Figure 3-10. These periods are arbitrarily chosen segments of time for which the various analyses of current data were conducted. The periods are approximately two weeks long, and represent the first and second halves of each month. Assigning data to such segments permits synoptic comparison of data from several meters, or comparison of data from one meter for several time periods, on a bimonthly basis.

Current meter data were analyzed in several ways:

1. Speed and direction frequency distributions of current were prepared for each meter for the data analysis periods of record. The half-hourly speeds were categorized into intervals of 0.05 m/sec (e.g., 0 to 0.05 and 0.05 to 0.10 m/sec) while the corresponding directions were categorized in 10-degree direction segments. The percent frequency for currents in each speed and direction category were calculated and presented in tabular form. A graphical presentation of current speed and directions was prepared by placing contour lines, enclosing points of equal speeds, on the tables. Table 3-22 is one example of the frequency distribution of currents for the data period. The complete set of frequency distribution tables is included in Appendix C.

   Study of the speed and direction frequency tables indicates the following:

   a. The principal current directions were between 40° and 70°, and between 230° and 260°, i.e., northeasterly parallel to

TABLE 3-22

TYPICAL SPEED-DIRECTION FREQUENCY DISTRIBUTION

Meter: 1 AL Date: 21 Jul 77 - 31 Jul 77

Direction	Speed, m/sec x 10^{-2} 0-5	6-10	11-15	16-20	21-25	26-30	31-35	Total
10	-	-	0.20	-	-	-	-	0.20
20	-	1.63	-	0.61	-	-	-	2.24
30	0.81	2.44	0.41	0.81	0.20	-	-	4.67
40	1.22	3.46	1.02	1.22	0.41	-	-	7.33
50	1.83	5.70	4.47	5.08	1.42	0.20	-	18.70
60	0.61	2.03	4.67	5.08	1.63	0.41	-	14.43
70	1.02	2.03	3.05	2.44	1.22	0.20	-	9.96
80	1.02	0.81	0.61	0.20	0.20	-	-	2.84
90	1.22	1.42	-	-	-	0.20	-	2.84
100	0.41	0.61	-	-	-	-	-	1.02
110	0.41	-	-	-	-	-	-	0.41
120	0.20	0.41	-	-	-	-	-	0.61
130	0.20	0.20	-	-	-	-	-	0.40
140	0.41	-	-	-	-	-	-	0.41
150	0.20	-	-	-	-	-	-	0.20
160	0.41	-	-	-	-	-	-	0.41
170	0.41	0.20	-	-	-	-	-	0.61
180	0.20	-	-	-	-	-	-	0.20
190	-	-	-	-	-	-	-	-
200	0.61	-	-	-	-	-	-	0.61
210	0.61	1.02	-	-	-	-	-	1.63
220	1.42	7.32	1.63	-	-	-	-	10.37
230	1.63	9.35	0.61	-	-	-	-	11.59
240	1.02	3.66	0.20	-	-	-	-	4.88
250	0.41	0.51	-	-	-	-	-	1.02
260	0.41	-	-	-	-	-	-	0.41
270	0.20	-	-	-	-	-	-	0.20
280	-	-	-	-	-	-	-	-
290	-	-	-	-	-	-	-	-
300	0.81	-	-	-	-	-	-	0.81
310	-	-	-	-	-	-	-	-
320	-	-	-	-	-	-	-	-
330	-	-	-	-	-	-	-	-
340	0.20	0.20	0.20	-	-	-	-	0.60
350	0.20	0.20	-	-	-	-	-	0.40
360	-	-	-	-	-	-	-	-
TOTAL	18.10	43.30	17.07	15.44	5.08	1.01	-	

the coast or southwesterly parallel to the coast. The data from the outer current meters (1B and 2B) show more directional scatter than data from the meters closer to shore (1A and 2A).

b. Except in late September and early October, speeds in the 40° to 70° direction were usually greater than speeds in the 230° to 260° direction.

c. The inner current meters, except for very infrequent onshore currents at the lower meters, exhibited essentially no onshore or offshore current.

d. Speeds were generally greater on the upper meters than on corresponding lower meters.

2. Current Speed Histograms were prepared from the speed portion of the speed and direction frequency tables. The histograms, a plot of the percent occurrence of various speed values, were used to calculate 20, 50 and 80 percentile values of current speed (the 20 percentile speed, for example, is the value of speed not exceeded 20 percent of the time). The percentile values of current speed for each meter are presented in Table 3-23 for the project period. The average of the percentile values for all of the meters during the project period along with the values selected for outfall design in Chapter 5 are as follows:

Average Percentile Speeds (m/sec)

Percentile	All Meters	Upper Meters (1AU, 1BU, 2AU, 2BU)	Outer Meters (1BU, 2BU, 2BL)	Values Selected for Design
U_{20}	0.042	0.048	0.054	0.05
U_{50}	0.091	0.103	0.111	0.10
U_{80}	0.159	0.177	0.186	0.18

Note that these values are somewhat less than the values of 0.20 to 0.25 m/sec reported for offshore current speeds, cited at the beginning of this section.

TABLE 3-23

SUMMARY OF CURRENT SPEEDS
(cm/sec)

Meter	Speed Percentile	1 21-31 Jul	2 1-15 Aug	3 15-31 Aug	4 1-15 Sep	5 16 Sep-7 Oct	6 12-31 Jan	7 1-15 Feb	8 16-28 Feb	9 1-15 Mar	10 16-31 Mar	11 1-15 Apr	12 16-30 Apr	13 1-15 May	14 16 May-7 June	Average
1 AU	U_{20}	4.8	4.6	4.0	1.8	2.4						4.3	3.8	2.0	3.5	3.5
	U_{50}	12.3	10.1	8.5	4.7	6.1						8.7	7.5	5.2	8.6	8.0
	U_{80}	23.7	18.2	14.0	9.2	9.8						13.6	11.2	11.2	15.1	14.0
1 AL	U_{20}	5.2	2.9	1.9	1.7	2.1						3.1	2.8	5.1	2.9	3.1
	U_{50}	8.9	7.8	5.8	4.4	5.5						7.3	6.8	7.5	8.8	7.0
	U_{80}	15.5	13.5	11.0	8.7	8.7						11.8	11.3	9.8	16.6	11.9
1 BU	U_{20}	6.2	10.1													8.2
	U_{50}	17.5	14.5													16.0
	U_{80}	26.0	19.4													22.7
2 AU	U_{20}		4.7	4.8	3.4	3.5	4.1	10.2	7.2	4.6	5.0	2.8	3.0	3.0	3.0	4.6
	U_{50}		11.5	10.0	7.9	8.7	9.7	22.2	14.5	8.8	10.5	7.5	7.5	7.6	8.7	10.4
	U_{80}		20.1	16.7	13.4	20.7	14.8	34.8	25.0	16.3	18.8	12.6	13.2	14.0	17.6	18.3
2 AL	U_{20}		0	1.9	2.1	2.6	6.3	14.5			3.1	0.6	1.0	1.7	2.0	3.3
	U_{50}		3.2	5.7	6.0	8.3	12.1	21.5			5.7	3.2	4.1	4.7	4.9	7.2
	U_{80}		12.1	12.1	10.7	15.7	21.9	27.9			16.1	8.3	9.0	9.3	12.0	14.1
2 BU	U_{20}		10.6	5.3	1.8	5.6	9.2							1.8	7.5	6.0
	U_{50}		16.3	8.6	5.3	11.6	16.2							4.7	17.2	11.4
	U_{80}		22.3	13.4	10.9	28.6	25.9							8.6	28.5	19.7
2 BL	U_{20}		5.4	3.0	1.6	4.3	5.3							2.6	5.5	4.0
	U_{50}		13.5	8.2	4.6	12.9	11.6							6.2	9.5	9.5
	U_{80}		20.0	14.0	9.7	26.3	19.0							9.3	15.8	16.3

3. Persistence of Unidirectional Current Motion. While the speed-direction frequency distributions effectively summarize the individual values of speed and direction, they provide no information about the length of time, or the length of displacement, a current persists in a particular direction. Yet it is important to know, for example, whether a northeasterly current may be expected to persist for six hours, or for six days, before significantly changing direction. It is also important to know whether elements of a sewage plume discharged to a northeasterly current may be expected to travel northeast for 1 km, 10 km, or 50 km.

Accordingly, a persistence analysis was undertaken as follows. The compass was divided into four quadrants, and each quadrant was assigned a color:

a. Red for northeast, parallel to the coast : 016° to 105°
b. Yellow, for southeast, towards the coast : 106° to 195°
c. Green, for southwest, parallel to the coast: 196° to 285°
d. Blue, for northwest, away from the coast : 286° to 015°

Next, on the computer tabulations on half-hourly time, speed, and direction, each velocity value was color-marked according to the quadrant in which its direction lay, so that one could tell at a glance the durations for which the current was moving basically northeast, or southeast, and so on.

Times at which the basic direction changed quadrant (for instance the times when a long series of blue-marked numbers gave way to red-marked numbers) were declared to be turning points.

Half-hourly velocity values were then multiplied by 1800 sec to give values of half-hourly displacement. These, in turn, were added vectorially in sequence, beginning at the first turning point and ending at the second, beginning at the second turning point and ending at the third, and so on. The result is that between each pair of adjacent turning points,

the average current displacement vector was derived. Such a vector is herein termed an excursion. For each meter and for each data period, a table was prepared, listing the date; the azimuth lay; the distance, or excursion length; and the excursion duration. These tables are available in unpublished Memorandum No. 7.

(For readers familiary with the device called a progressive vector plot, the persistence analysis may be viewed as the plotting of a continuous progressive vector plot, which is then divided up for convenience into segments at turning points where major changes of direction occur, and the segments approximated by straight lines drawn from turning point to turning point; and these straight lines summarized in a table giving direction, length, and azimuth.)

Some arbitrary criteria were set to minimize the amount of subjective judgment in calculating a continuous excursion within a directional quadrant. For example, directional deviations into other quadrants lasting not more than two hours were neglected, so that a southwesterly excursion of 48 hours duration with short northwesterly link somewhere in the middle, need not be broken into two shorter southwesterly excursions and one northwesterly excursion if the link was of one or two hours duration. However, if the northwesterly link was three or more hours long, then there would be three distinct excursions.

For each meter, for each bimonthly data period, the current excursion lenghts were plotted in a rose diagram, showing displacement lengths and directions as measured from the current meter location. A typical rose diagram is shown on Figure 3-11; the remainder are in Appendix C. Such rose diagrams indicate

approximately the directions and distances to which a wastewater plume issuing from an outfall at the current meter location is likely to be carried, if it is assumed that all water particles in the area, at the particular depth under consideration, move in unison. Clearly, this assumption is invalid near the coastline, a fact that is evident in those cases where the excursion lines are shown crossing the shoreline and proceeding inland. Nevertheless, when perceived as general indicators of time-dependent current patterns near the outfall site, the rose diagrams are valuable aids in judging the suitability of a site for dispersal of waste discharges.

The current excursions were generally parallel to the shoreline for the entire year. The outer meters indicate some excursions perpendicular to the shore, while the inner meters show very few excursions perpendicular to the shore.

Current excursions were generally longer and showed less directional scatter in the summer and fall than in the winter. The excursion lengths in the winter did not usually exceed 30 km. However, in the summer and fall, excursions were commonly greater than 30 km and some were over 100 km.

For each data period, for each meter, the excursions were ranked according to length; and 20-, 50-, and 80-percentile values of length were determined on the basis of duration. For example, 20 percent of the time in a data period is devoted to the generation of excursions whose lengths are less than or equal to the L_{20} value. Excursion directions were not considered in this analysis. The values of L_{20}, L_{50}, and L_{80} for each meter and each data period are presented in Table 3-24, which may be summarized as shown below:

TABLE 3-24

SUMMARY OF CURRENT EXCURSION LENGTH
(Km)

Meter	Length Percentile	1 21-31 Jul	2 1-15 Aug	3 16-31 Aug	4 1-15 Sep	5 16 Sep-7 Oct	6 12-31 Jan	7 1-15 Feb	8 16-28 Feb	9 1-15 Mar	10 16-31 Mar	11 1-15 Apr	12 16-30 Apr	13 1-15 May	14 16 May-7 Jun	Average
1 AU	L_{20}	4.1	1.0	5.6	1.4	3.5						3.1	1.6	1.2	4.4	2.9
	L_{50}	11.2	14.0	15.6	4.2	11.0						6.0	4.6	4.7	24.8	10.7
	L_{80}	31.3	18.0	36.0	12.8	22.4						16.8	13.3	21.6	72.7	27.2
1 AL	L_{20}	6.8	2.2	0.7	0.8	2.9						0.8	1.5	2.4	7.4	2.8
	L_{50}	29.7	10.3	7.7	5.3	11.9						7.5	9.1	6.0	12.0	9.3
	L_{80}	53.0	27.0	15.8	6.9	15.0						15.5	12.3	9.6	39.9	21.7
1 BU	L_{20}	3.7	10.5													7.3
	L_{50}	40.6	28.9													34.8
	L_{80}	97.8	35.0													65.4
2 AU	L_{20}		5.1	3.7	2.2	9.1	1.6	11.1	10.0	10.4	10.5	2.5	1.6	1.8	2.4	5.5
	L_{50}		16.5	26.5	16.7	27.7	6.2	36.2	22.8	20.7	29.9	17.3	9.2	11.2	60.6	23.2
	L_{80}		46.0	51.8	32.2	90.5	9.6	95.1	43.5	31.4	38.1	24.1	32.4	26.9	87.3	46.8
2 AL	L_{20}		0.7	1.0	1.3	1.4	2.3	8.5			2.0	1.3	1.0	1.1	7.3	2.5
	L_{50}		7.9	16.9	11.1	14.3	13.1	15.0			18.1	1.9	7.4	12.0	21.4	12.6
	L_{80}		22.4	42.6	23.8	48.2	26.0	54.1			32.2	7.2	16.0	21.5	30.1	29.5
2 BU	L_{20}		10.3	2.0	0.7	3.0	4.5							5.2	18.8	6.4
	L_{50}		27.4	13.0	6.6	28.0	13.0							11.7	103.3	29.0
	L_{80}		51.6	30.2	24.5	125.8	34.5							15.5	162.3	63.5
2 BL	L_{20}		4.7	1.2	1.3	2.9	5.0							1.5	11.2	4.0
	L_{50}		26.3	8.1	3.5	14.5	8.6							3.0	55.9	17.1
	L_{80}		57.5	24.4	13.2	109.0	19.6							5.6	104.0	47.6

Average Percentile Excursion Lengths, km

Percentile	All Meters	Upper Meters (1AU, 1BU, 2AU, 2BU)	Outer Meters (1BU, 2BU, 2BL)	Values Selected for Design
L_{20}	4.1	5.1	5.5	5
L_{50}	17.5	21.6	24.5	20
L_{80}	39.4	46.1	56.9	40

The values selected for design are applied in Chapter 5.

Drogues provide an inexpensive means of measuring currents, and are especially useful when studying the effect of wind stress on currents and current gradients at and near the water surface. The drogues consisted of two underwater sails in vertical planes intersecting at right angles, each sail measuring 600 x 2400 mm (see Figure B-6, Appendix B). Sufficient weight was added to make the drogues somewhat negatively buoyant. Thin stainless steel cables tethered the drogues to surface floats. Tether lengths of 0.5, 2, 4, 8, 16, 24, 32, and 48 m were used for the drogues. Usually, four to six drogues with varying tether lengths were depolyed simulataneously, at approximately the same location, and followed for four to six hours. The locations were noted for each drogue every 30 to 45 minutes by means of the Cubic Autotape navigation system. A complete listing of the drogue data is available in unpublished Memorandum No. 8.

The paths of all drogues deployed are shown on Figure 3-9. In general, the deeper drogues, which are less affected by wind action, travel roughly parallel to the coastline, corresponding to the predominant current directions shown from the current meter analysis. Drogues near the surface travel in paths that are not always parallel to the shore but are in other directions as well.

Analysis of drogue data was made using the vector average of a single drogue path for an entire deployment period. Measurements were made

frequently during the deployment so that individual segments of the total path could be calculated; but only the total vector path was used for analysis.

1. Speeds and Directions obtained over the course of the project period are summarized on Figure 3-12, for seven different general deployment areas. Frequency distributions for average drogue speed are shown.

   Similarly, Figure 3-13 shows direction and speed distributions for drogues deployed less than 5 km from shore ("inshore") and for drogues deployed farther than 5 km from shore ("offshore"). Figure 3-14 shows speed and direction distributions for all drogue deployments for the year (outside of Abu Kir Bay), considered together.

   Figure 3-14 shows that the 20-, 50-, and 80-percentile speeds are 5, 11, and 21 cm/sec, respectively, in fairly close agreement with values obtained with current meters. The direction distribution has three very distinct modes, at 65° (northeasterly, parallel to the coast), 235° (southwesterly, parallel to the coast), and 195° (approximately southerly, towards the coast). The modes in directions parallel to the coast are in agreement with the current meter data, which also showed these modes; the southerly mode shown by the drogue data but not by the current meter data may be attributed to onshore currents in the surface layers of the sea, well monitored by drogues but too shallow for current meters to detect.

   Figure 3-13 shows that this three-mode directional distribution is very pronounced offshore, but much less distinct inshore. "Offshore" current speeds measured 5 to 11 km from shore tend to be 30 to 40 percent greater than speeds measured less than 5 km from shore.

In addition to Figures 3-12, 3-13, and 3-14, the direction distribution obtained from "offshore" drogues on the Kait Bey and Ramleh alignments may be seen on Figure 5-3.

2. Analysis of Near-Surface Currents. While it was not practical to deploy current meters at depths shallower than 10 m, much useful and detailed information about the relative motion of near-surface waters could be and was obtained with the drogues. Examples of vertical distribution of velocity as measured by drogues are shown on Figure 3-15. The analytical approach was to adopt a value of mean current velocity for each daily group of drogue and wind data in terms of motion relative to a frame of reference oriented to and travelling with the mean current velocity.

   The questions investigated were:

   a. What is the relationship between wind velocity and surface current velocity, relative to the mean velocity? This is important for determining how fast the onshore winds will drive the surface waters towards shore.
   b. What is the range of values of vertical gradient in horizontal velocity in the near-surface waters? This is important for calculating the rate at which sewage plumes will be dispersed by the action of currents.

   The value adopted for the mean current velocity for each daily group of drogue data was usually the vector-average velocity of the drogue deployed at 16 m depth, occasionally adjusted slightly for analytical convenience. The velocity at 16 m was chosen because in most cases, it appeared to represent well the current movement in waters beneath the surface, and be below the near-surface region of large vertical gradients in horizontal velocity, as is apparent in the examples on Figure 3-15. Furthermore, there is reason to believe that, in an unstratified ocean at least, the mean current velocity may be expected to be formed at 40 percent of the depth below the

surface, which is approximately 16 m for the total water depths of 30 to 50 m found at the drogue deployment sites. (In hydrologic stream-gauging practice, it is common to use as an estimate of mean velocity the current speed measured 40 percent of the depth above the stream bed where the principal shear stresses are applied to the fluid body. By analogy, the depth of mean current velocity among wind-driven ocean currents may be reasoned to be found at 40 percent of the depth below the surface where winds exert the principal shear stresses on the fluid body.) Adopted values of mean velocity are shown in Table 3-25.

a. Surface Current and Wind. For each drogue day, the mean velocity was vectorially subtracted from the surface current velocity to obtain the relative surface velocity. Components of the relative surface velocity normal and parallel to the mean velocity direction were obtained, as were components of the wind velocity normal and parallel to the mean velocity direction. Wind velocity is plotted against relative surface current velocity, for the normal components on Figure 3-16a and for the parallel components on Figure 3-16b. The data exhibit considerable scatter. The correlation coefficients of lines fitted by the method of least squares through these points are 0.39 for the normal components and 0.07 for the parallel components.

For the normal components (Figure 3-16a), the fitted line is not very different from the curve derived from published values of wind-surface current correlation.[1] Figure 3-16a may be considered to provide a weak corroboration of the published values. For Figure 3-16b, the scatter is so great that no useful conclusions may be drawn. (In Chapter 5, it will be assumed that relative surface current speeds

[1] Wiegel, R.L., Oceanographical Engineering, Prentice-Hall, 1964.

TABLE 3-25

CURRENT VELOCITIES AND GRADIENTS AS MEASURED BY DROGUES

Date	Surface Current Direction	Surface Current Speed	Mean Current Direction	Mean Current Speed	G, Sec^{-1} [a]
28 July 1977	102.8	0.291	64.0	0.290	.0114
31 July 1977	98.4	0.076	200.0	0.054	.0047
24 August 1977	249.3	0.286	230.0	0.220	.0059
25 August 1977	161.3	0.227	240.0	0.230	.0139
28 August 1977	65.2	0.102	70.0	0.100	.0005
30 August 1977	62.0	0.223	63.0	0.130	.0002
25 September 1977	131.5	0.261	190.0	0.100	.0139
26 September 1977	183.7	0.100	200.0	0.092	.0018
29 September 1977	236.5	0.330	228.0	0.300	.0030
16 January 1978	147.7	0.034	190.0	0.055	.0014
19 January 1978	356.1	0.072	273.8	0.040	.0045
24 January 1978	183.0	0.181	198.0	0.196	.0029
30 January 1978	8.2	0.020	40.0	0.044	.0007
15 February 1978	188.7	0.240	208.0	0.164	.0050
7 March 1978	288.3	0.168	235.0	0.120	.0084
8 March 1978	273.1	0.052	230.0	0.144	.0022
15 March 1978	200.3	0.088	194.0	0.035	.0006
3 April 1978	54.2	0.167	44.0	0.206	.0018
6 April 1978	59.6	0.184	50.0	0.113	.0019
12 April 1978	227.2	0.128	168.0	0.045	.0069
17 April 1978	243.6	0.099	300.0	0.060	.0052
29 April 1978	94.9	0.321	22.0	0.028	.0192
12 May 1978	154.9	0.274	232.0	0.112	.0167
14 May 1978	224.0	0.064	84.0	0.058	.0026
17 May 1978	234.2	0.235	243.1	0.077	.0023
24 May 1978	81.8	0.125	54.0	0.227	.0036
27 May 1978	120.8	0.127	118.0	0.021	.0004

[a] G is the gradient in the velocity component normal to the mean velocity.

are 2.9 percent as great as the wind speed, a value based on the published correlation.)

Selection of mean current velocity was somewhat subjective and, it was feared, could affect the results of correlating wind speed and surface current. The sensitivity of the surface current analysis to choice of mean current velocity was tested by varying the mean current velocities about the selected mean velocity values. In no case did the surface current and wind velocity data correlate more closely by varying the selection of the mean current velocity. It was concluded that the selection of the mean current velocity as equal or nearly equal to the 16 m drogue velocity would yield as satisfactory a result for the surface analysis as could be expected.

b. The vertical gradient in horizontal velocity components normal to mean velocity may be defined as the rate of change with respect to depth of the normal horizontal velocity component. As a practical matter herein, it is simply defined as the relative surface velocity component perpendicular to the mean velocity direction, less the relative 16 m depth velocity component perpendicular to the mean velocity direction, divided by 16 m. (The normal component at 16 m depth is zero, by definition of the choice of mean velocity.) Gradient values thus obtained are listed in Table 3-25.

3. Coriolis Effects. Ekman[1] studied theoretically the problem of wind drift in homogeneous deep water, considering only frictional and Coriolis forces and assuming the eddy viscosity of the water to be constant. In addition, he considered motions in a plane of infinite extent, with winds of constant velocity. According to his solution, a surface current in the Northern Hemisphere would be directed at an angle of 45° to the right of the direction of the wind stress.

[1]Weigel, R.L., Oceanographical Engineering, Prentice-Hall, Inc., 1964.

In the present project, evidence of coriolis effects on surface currents was sought by comparing the direction of surface currents, relative to the mean current, with the wind direction. The direction of the relative surface current differed from the direction towards which the wind was blowing by a value which varied greatly, but which had a mean value of about 25° to the right of the wind destination direction.

Due to the very extensive scatter, one cannot conclude whether this 25° right deviation is due to coriolis effects or not. In other studies, it has been concluded that many other factors such as large-scale eddies, the duration of wind at a constant velocity, and the presence of the shoreline and the sea bed significantly affect current drift so that coriolis forces cannot be isolated.

Dye Studies. Dye studies can be used to measure surface currents and also to measure the degree of dispersion in the surface layer.

One dye study was conducted for this project northwest of Fort Kait Bey. Two litres of Rhodamine WT dye were dumped in the ocean at 10:27 hours on 31 August 1977 and followed for approximately 4 hours. The dye patch travelled with the westerly wind at a mean speed of about 0.28 m/sec as shown on Figure 3-17.

The dispersion in the direction of the wind is much greater than the dispersion in the transverse direction (perpendicular to the wind). The transverse dispersion of the dye patch is typical of transverse dispersion in ocean currents with no wind. Longitudinal dispersion (with the wind) was much greater than the transverse dispersion, demonstrating the extent to which wind-driven shear forces in the surface layer may enhance dispersion.

No other such dye studies were conducted during the project, as it became evident that the drogue studies were providing more useful insights into the dispersive capacity of the top 10 to 16 m of the sea.

Waves

Waves were not systematically measured in this study. Yet, from wave data obtained by others, and from wind data, one may determine a design wave of significant height and period to permit preliminary estimates of the extent of sediment transport and wave forces on an exposed pipeline that one might expect. Analysis using the concept of "significant" wave height and period will be sufficient for a preliminary level of analysis. However, in the design phase, it would be well to have a waves analysis based on the concept of wave spectrum, which is a more powerful method.[1]

It may be said that the biggest waves striking the Alexandria coast occur during the winter storms, which commonly have a duration of two to five days. To obtain the estimate of significant wave height, the frequency distributions of onshore wind speeds (270° through 30°, inclusive) for February-April (Table 3-1) and November-January (Table 3-4) were combined, as shown in the first two columns of Table 3-26. In the next column, the frequency is multiplied by 4368, the number of hours in six months, to indicate the aggregate duration for each wind speed in any one storm The values are more judgmental than rigorous, but are loosely related to those in the previous column by the consideration that the greatest wind speeds may be attained in only one storm of the season, while the lesser speeds may be attained in as many as ten storms in a winter season. Speeds less than 13 knots are not considered storm speeds. The greatest duration indicated for a storm wind is 60 hours (5 days).

Next, estimates of significant wave height and period were made for each wind speed and duration, for deepwater conditions, using the Bretschneider curves published in the Shore Protection Manual.[2] As speeds increase, the significant wave heights appear to converge towards an upper limit of 4.5 m, with periods approaching 8.5 sec.

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[1] Barnett, T.P., "Wave Prediction," Chapter in Pipelines in the Ocean, ASCE.

[2] Shore Protection Manual, Vol. 1, U.S. Army Coastal Engineering Research Center, 1973.

TABLE 3-26

WAVE HEIGHTS DURING WINTER STORMS

Wind Speed, kt	Frequency[a] of Onshore Winds,%	Total Hours in 6 Months	Likely Duration in One Storm, hr	Wave Height, m	Period, sec
Calm or not onshore	42.8	1870	-	-	-
2	2.1	92	-	-	-
5	8.1	354	-	-	-
9	15.5	677	-	-	-
13	16.1	703	60	1.2	4.7
18	8.3	363	48	2.2	6.2
24	4.4	192	24	3.1	7.4
30	2.0	87	15	3.7	7.8
37	0.5	22	10	4.4	8.4
44	0.1	4	4	3.7	7.5
52	0.1	4	4	4.4	8.3

[a] From Tables 3-1 and 3-4 combined, for winds from 270° through 30° inclusive.

These values are consistent with observations of 8 to 9 sec periods during winter storms made at the CDM office in Sidi Bishr; and with the wave rose diagram in the Sumed Sidi Kreir Port Manual indicating that only about 1 percent of the waves exceed 4 m in height. It is slightly less than the A.H. Glenn and Associates[1] prediction that significant wave heights will exceed 15 ft (4.6 m) 3.8 percent of the time in February in 60 ft (18 m) of water. Consequently, the significant wave height adopted herein will be 5 m and the significant wave period will be 8.5 sec.

On Figure 3-18, the maximum horizontal orbital velocity at the sea bed, u_b, and the wave height, 2a are plotted against water depth, h, according to the linear wave theory:

$$u_b = \frac{a\ w}{\sinh kh}$$

$A_b = u_b/w$ = horizontal excursion amplitude

$w = 2\pi/\text{wave period}$

$k = 2\pi/\text{wave length}$

$w^2 = kg \tanh kh$

$a/\sqrt{k}$ = constant = 10.587 for the significant wave conditions adopted

Also indicated on Figure 3-18, on the curve for speed, are threshold calcareous sand grain sizes. The interpretation is as follows: at the point indicated for a given grain size, say 2 mm, the maximum bottom speed and the wave period are such that a calcareous sand grain (s.g. = 2.72) 2 mm in diameter will just be on the threshold of sediment motion, according to the Shields-type analysis developed by Madsen and Grant.[2]

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[1] A.H. Glenn and Associates, "Meteorological-Oceanographic Conditions Affecting Design and Operation of Facilities in the Abu Qir Gas Field," undated.

[2] Madsen, O.S., and Grant, W.D., "Sediment Transport in the Coastal Environment," Report No. 209, Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics, MIT, January 1976.

Calcareous sand was considered because it appears to be predominant offshore (see Section 3.5). While the threshold-grain-size analysis cannot be considered precise, it may be inferred that in waters deeper than 45 m, there will be little movement of sand grains larger than 1 mm even in severe winter storms; while in waters less than 20 m deep, storm waves will be capable of moving even gravel-size pebbles. Sand ripples, presumably due to wave action, have been observed by divers 5 km off Sidi Bishr, in 31 m depth; median sand grain diameter was of the order of 1 mm.

In Chapter 5, this wave analysis will be extended to determine the magnitude of wave forces on an exposed pipeline.

Salinity Deficit Studies

During the course of gathering salinity, temperature, and dissolved oxygen (STDO) data for the alignments shown on Figure 3-3, it was frequently observed that a layer of water less saline than the ambient near-coastal waters was present. The profile presented on Figure 3-4 shows isohalines delineating lenses of less saline water along the shore and near the 9 km point on 11 September 1977. These lenses ocurred mostly along the shore.

After investigating the phenomenon further, it was decided that this salinity deficit could be used: (1) as a means of estimating the dilution that might be available for wastewaters discharged into the coastal environment; and (2) as a means of calculating an average velocity of currents parallel to the coast. This velocity might also be used to supplement current meter information (speed) on days for which current meters were not operating but salinity measurements had been taken.

The average current velocity was estimated by calculating the required velocity through a given cross-sectional area along an alignment to produce the measured salinity values. Two important assumptions in this analysis are: (1) the salinity deficit was caused by the less saline Mex Canal discharge; and (2) that the coast-wise current is maintained in a steady state condition.

Having calculated the average velocity through an alignment, as shown in Table 3-27, it was compared to the average velocity recorded at the closest current meters for the same period. For this purpose, the Kait Bey alignment salinity measurements and the current meter data along that alignment were used. Correlation between the current meter data and calculated average velocities was very poor for the six days that were studied. No other alignments were analyzed for this type of correlation because of the poor results.

Several reasons for these poor results are possible. First, the calculated discharge of the Mex Canal may not be correct; but any reasonable adjustment of this value would not bring the computed average velocities into agreement with the current meter values. Second, assumptions of the salinity deficit analysis are that the flow is roughly perpendicular to the alignment and also that the freshwater flow component comes solely from the Mex Canal. Both of these assumptions were probably violated at times. Current directions often cut through the alignment at angles other than 90° and sometimes the Mex Canal discharge actually flows away from the alignment section and theoretically would not produce a salinity deficit at the alignment section (although one was observed).

It is also possible to determine the flow that would be needed to produce the measured salinity deficit by utilizing the recorded current meter velocity and calculating the flow. These values, listed in Table 3-28, show that the Mex discharge in itself is not large enough to produce the salinity deficit. In two cases, this flow would have to be nearly an order of magnitude higher than the estimated Mex Canal flows when the current direction indicates that the flow should have come from the Mex area.

It is more likely that the salinity deficit is produced by a pool of less saline water that moves back and forth along the coast with the changing current direction. While the Mex Canal discharge contributes substantially to this deficit, the Tabia discharge, overland runoff, wastewater outfalls, and to some degree the Nile River discharge at Rosetta, all contribute.

TABLE 3-27

AVERAGE VELOCITIES AND DILUTIONS BASED ON SALINITY DEFICIT

Location/ Alignment	Date	C_∞ °/oo	Average Concentration $C_{z,y}$	Average Velocity cm/sec	Current Meter Velocity cm/sec	Average Dilution	Minimum Dilution
Kait Bey	27 Jul 77	39.2	38.8	2.5	21	105	12
Kait Bey	16 Aug 77	39.2	38.6	1.2	9.9	58	8
Kait Bey	17 Sep 77	39.2	38.8	2.6	5.2	105	14
Kait Bey	24 Sep 77	39.2	39.0	2.9	5.5	149	9
Kait Bey	9 Oct 77	39.2	38.9	8.5	8.9	170	12
Kait Bey	15 Nov 77	39.1	38.7	10.0	-	93	18
Agamy	6 Sep 77	39.2	38.9	3.2	-	121	12
Agamy	8 Oct 77	39.2	39.0	50	-	197	110
Agamy	14 Nov 77	39.2	39.0	5.7	-	215	90
Ramleh	1 Aug 77	39.3	38.9	2.6	-	96	23
Ramleh	7 Sep 77	39.2	38.9	5.1	-	121	45
Ramleh	10 Oct 77	39.0	38.8	70	-	290	133
Ramleh	16 Nov 77	39.2	38.8	2.7	-	104	35
Abu Kir	15 Aug 77	39.0	38.5	2.0	-	74	50
Abu Kir	11 Oct 77	39.2	39.0	7.6	-	316	181
					Mean	148	50

TABLE 3-28

FLOWS NEEDED TO PRODUCE OBSERVED KAIT BEY SALINITY DEFICIT

Date	Flow, m^3/day
27 Jul 77	60,000,000
16 Aug 77	59,000,000
17 Sep 77	14,000,000
24 Sep 77	13,000,000
9 Oct 77	7,300,000

TABLE 3-29

FRESHWATER DISCHARGES TO MEDITERRANEAN SEA NEAR ALEXANDRIA

Source	Flow, m^3/day
Kait Bey Outfall	187,000- 250,000
Outfalls from Eastern Harbor to Montazah	39,000- 57,000
Mex Canal	7,500,000
Tabia Pump Station	1,500,000-2,000,000
Nile River	67,000,000[a]

[a] Approximate average daily flow for peak months of 1971, 1972, 1973.

The oceanographic work conducted by the joint Russian-Egyptian expedition on the "Icthyolog" showed that under certain conditions, e.g., during the February 1971 discharge, the freshwater influence of the Nile River could be measured at least as far away as Alexandria. Table 3-29 lists approximate discharge from the point sources of freshwater discharge to the sea in and around Alexandria.

The implication of the above findings is that a wastewater outfall should reach beyond the area of freshwater buildup to prevent submergence of the plume in a shallow poorly mixed region. In general, the salinity profiles show that this distance is about 5 km, and that the present plans for 10 km long outfalls would place them well beyond the problem area.

Another conclusion drawn from the above analysis is that curtailing fresh water input along the beaches by eliminating the existing sewage overflows and outfalls is not likely to greatly affect the salinity deficit along the coast, since other larger freshwater discharges will continue.

From the salinity deficit data, minimum dilutions were calculated based on the assumption that the sole source of less saline water was from the Mex Canal. These minimum dilution values are tabulated in Table 3-27 and can be used to estimate the degree of far-field dilution that would be available for wastewater discharged from an outfall. As it turns out, the Mex Canal, as discussed above, is not the only source of fresh water available and this affects the dilution calculations. By including other sources, the dilution factor would be increased, thus providing better dilution than that shown by the figures in Table 3-27. Thus, this type of analysis gives some physical support to the theoretical analysis of far-field dispersion developed in Chapter 5.

Abu Kir Bay

Because Abu Kir Bay lies at the edge of the study area, and because there have been other recent studies of the hydrography[1] and pollutional status[2,3] of the bay, the time devoted to the bay in the present project has been limited. Nevertheless, even our limited observations permit us to draw some useful conclusions about the wind and current regimes there. Abu Kir Bay is ecologically important. Sharkawy and Sharaf el Din[1] note that for many years before it was polluted, the bay was one of the main sources of fish fry for the inland lakes. One of these, Lake Idku, lies just south of the bay and is connected to it by an inlet at Maadiya. Many species of Eastern Mediterranean fish, including eels, labrax, sargus, mullets, and prawns are known to migrate between brackish coastal lakes and the sea. Their migrational cycle to relatively unpolluted Lake Idku may well be interrupted by polluted conditions in Abu Kir Bay, particularly near Maadiya.

The pollution is principally from two paper mills at Tabia at the southwestern end of the bay. An urea plant at El Tarh, a few kilometers east of Tabia, promises to increase the pollutional stress on the bay, as will a generating station and other industries planned for the area.

The plume of the freshwater discharge from Tabia, estimated by Mitwally et al.[3] at 1.5 to 2 million m^3/day, can be easily seen on most days with the naked eye. As Mitwally et al. point out, the plume usually flows eastward along the shore, as is confirmed by the presence of organic sediments along the shore as far as Maadiya and even Idku, 20 km east of Tabia.

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[1] Sharkawy, S.H. and Sharaf el Din, S.H., Hydrographic Structure and Circulation Pattern of Abu Kir Bay near Alexandria, Egypt, Bull. Inst. Ocean and Fish, Vol. 4, 1974.

[2] Ezzat, E. and El Ghrabawy, M., Effect of Water Pollution on the Population of Solea Vulgaris in Abu Kir Bay, Alexandria (Egypt), IIes Journees Etud. Pollutions, 1974.

[3] Mitwally, H. et al., Pollutional Status of Abu Kir Bay, Department of Environmental Health, Alexandria University, May 1977.

During CDM's field studies in Abu Kir Bay, the plume from Tabia, identified by a surface oil slick, grey or yellow water color, and floating clumps of sludge, was often observed to flow eastward along the coast in a band a few hundred metres wide. On several days, however, the plume fanned out and flowed generally northward, reaching Abu Kir village. Since the latter condition was usually observed on days with a south wind, it was decided to seek a correlation between plume direction and wind direction.

A table was prepared, with an entry for every day on which CDM field studies were conducted in Abu Kir Bay. For each day, observations about the Tabia plume were recorded and a judgment made as to whether the plume was flowing eastward in a narrow band along the coast or was fanning out northward. Also for each day, recorded wind speeds and directions were noted.

A scatter plot of the wind data was then prepared (Figure 3-19), indicating the approximate distribution of speed and direction for the data in the sample. Data points were given one symbol for days of an easterly plume from Tabia, and another symbol for days of northerly plume.

With few exceptions, the wind direction on days of a northerly plume was from the sector 150°-270°, while on days of an easterly plume the wind was from the rest of the compass directions (270° through north and east to 150°). From the WEPCO seasonal wind data, Tables 3-1 to 3-4, an analysis of frequency distributions was prepared. It shows that in the summer (May through October) winds may be expected from the 270°-150° sector more than 90 percent of the time, while in winter (November through April), winds may be expected from this sector about 70 percent of the time.

From the correlation of wind direction with plume direction, one may also infer that between 70 and 90 percent of the time, the Tabia discharge tends eastward along the coast towards Maadiya, rather than fanning out northward across the bay. This supports the observation by Mitwally et al. that the plume usually flows eastward along the shore.

While this analysis has been based on only a very limited number of observations, the procedure could be easily continued, at little expense, until a more substantial correlation between wind direction and current direction is obtained. The conclusions imply considerable urgency about curtailing the Tabia pollution load for the sake of fish migrations to and from Lake Idku, and create concern about the advisability of planning other discharges, or cooling water intake and discharge, for the Tabia-Maadiya coastal strip.

3.2 Bacteriological Studies

Introduction

One of the most important concerns in ocean outfall design is the concentrations of bacteria and viruses in the sewage effluent, and the rate at which they may be expected to disappear from the discharge plume with the passage of time.

Aside from physical dilution, which is considered separately, the progressive reduction in concentration of bacteria in a dispersing wastewater plume, herein termed "disappearance," is believed[1] to be due to a combination of die-off and sedimentation processes. It is also believed that disappearance rates depend on local seawater conditions, local climate, and the characteristics of the particular sewage to be discharged. Therefore, it was deemed advisable to measure the time rate of bacterial disappearance in Alexandrian sewage discharged to Mediterranean seawater.

Tests were made for concentrations of total coliforms, fecal coliforms, total enterococci, and fecal enterococci. The rate of disappearance of fecal coliforms is particularly important, as these have been adopted in this study (Appendix E and Chapter 4) as the indicator organism for which design criteria are set.

[1] Harremoes, P., "*In Situ* Methods for Determination of Microbial Disappearance in Sea Water," Proceedings of Symposium on Discharge of Sewage from Sea Outfalls, Pergamon Press, 1975.

Bacterial disappearance is often measured in terms of an exponential decay rate, T_{90}, which is the number of hours needed for the concentration to decrease by 90 percent, or one order of magnitude. World wide, T_{90} values in daylight generally range from one hour to eight; values measured elsewhere in the Eastern Mediterranean have been found to be about one hour or less.[1] Recent research[2,3] has indicated that T_{90} at night may be much greater than during daytime, with values ranging from 30 to 60 hours.

The bacteriological studies undertaken in this project are discussed below in three separate parts:

1. Short-term daytime studies in the plume from the existing Kait Bey outfall, to determine daytime disappearance rates.
2. Longer-duration studies with immersed bags, to determine nighttime as well as daytime diasppearance rates.
3. Measurements of bacterial concentrations in undiluted effluent and in effluent immediately after discharge.

Short-Term Daytime Studies in the Kait Bey Plume

These tests, carried out on 5 September, 28 September, and 26 November 1977, involved the examination of seawater samples taken directly from the sewage plume of the existing Kait Bey outfall. They had the advantage of most directly studying the natural conditions of plume dispersal, but were of rather short duration (at most 2.5 hours).

The procedures for the 5 September test were as follows: one litre of Rhodamine WT dye was dumped at the principal point of discharge of the existing Kait Bey outfall, as marked by the largest visible sewage boil

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[1] Shuval, Thompson, Fattal, Cymbalista, and Wiener, "Natural Virus Inactivation Processes in Sea Water," Journal Sanitary Engineering Division, American Society of Civil Engineers, 1971.

[2] Gameson, A.L.H., and Gould, D.J., "Effects of Solar Radiation on the Mortality of Some Terrestrial Bacteria," Proceedings DSSO, Pergamon Press, 1975.

[3] Bellair, J.T., et al., "Significance of Diurnal Variations in Fecal Coliform Die-Off Rates in the Design of Ocean Outfalls," JWPCF 49 (9), Sept. 1977.

on the sea surface that could be safely reached by the survey boat. Due to numerous breaks in the pipe, there are, in effect, several points of discharge. The farthest from shore is at 490 m. The dye served to mark a particular sample of sewage. Next, samples of sewage-seawater mixture were taken from the dye patch at frequent intervals for as long as the dye could be detected. The operating assumption was that any sample taken from the dye patch at any time would contain sewage that has been discharged at the moment of dye dump. The "age" of the sewage-seawater mixture was thus determined. The position of the boat was fixed by sextant sightings to known landmarks at the time each sample was taken.

Each of the samples was later analyzed for salinity, dye concentration, total coliforms, fecal coliforms, and fecal streptococci. Salinity analysis was done at the Intitute of Oceanography and Fisheries using a Beckman R 7-D salinometer. Dye concentration was measured ashore using a Turner M10 Fluorometer. Bacterial counts were done at the High Institute of Public Health and are reported as Most Probable Number (MPN) per 100 mL; presumptive and confirmed multiple fermentation tube tests were used to establish the concentrations of total coliforms, fecal coliforms, and fecal streptococci. The procedures are described in Appendix F. Between the time of collection and arrival at the laboratory (4 hours or less) samples for bacterial analysis were shaded and kept on ice. In Table 3-30, the concentrations of bacteria measured at times after the initial dye dump are shown. These values are not corrected for the effect of dilution after discharge from the outfall. In the boil where the first samples were taken (time = 0 min), the sewage has received at most a 10:1 dilution with seawater.

With increasing time, the concentrations decrease, partly due to increasing dilution with seawater, and partly due to die-off and sedimentation processes. For each sample after the first, an estimate of the physical dilution factor is shown in the final column of Table 3-30.

For total and fecal coliforms and for fecal streptococii, each concentration listed in Table 3-30 was multiplied by its corresponding estimated

TABLE 3-30

BACTERIAL DATA-5 SEPT 77

Time After Dye Appears in Boil (Minutes)(b)	Distance From Boil (Meters)	Sample Depth (Meters)	Salinity ‰	Bacteriological Sampling(a): Total Coliforms (Presumptive) MPN/100 mL	Fecal Coliforms (Confirmed) MPN/100 mL	Enterococci (Presumptive) MPN/100 mL	Fecal Streptococci (Confirmed) MPN/100 mL	Estimated Physical Dilution Factor
First Dye Dump								
0	0	Surf.	-	4.6×10^{8}	4.6×10^{8}	4.6×10^{8}	4.6×10^{8}	1.0
8	95	3 m	33.3	2.1×10^{7}	2.1×10^{7}	2.1×10^{8}	1.5×10^{8}	1.0
15	130	Surf.	33.1	2.1×10^{7}	1.5×10^{7}	1.1×10^{7}	4.6×10^{6}	4.1
20	310	"	31.7	7.5×10^{5}	4.6×10^{5}	2.1×10^{5}	2.1×10^{5}	4.3
23	330	"	31.4	4.6×10^{5}	4.6×10^{5}	1.5×10^{5}	1.5×10^{5}	4.4
32	355	"	31.8	$> 2.4 \times 10^{5}$	1.1×10^{4}	2.4×10^{5}	2.4×10^{5}	4.7
35	390	"	33.3	$> 2.4 \times 10^{2}$	4.6×10^{2}	2.4×10^{2}	2.4×10^{2}	4.8
55(c)	785	"	27.1	0.43×10^{5}	0.43×10^{5}	0.93×10^{4}	0.43×10^{4}	5.4
76	825	"	31.2	1.1×10^{5}	1.1×10^{5}	4.6×10^{4}	4.6×10^{4}	5.9
Second Dye Dump								
3	0	Surf.	32.8	4.6×10^{6}	1.1×10^{6}	1.1×10^{7}	1.1×10^{7}	1.0
9	90	"	31.8	$> 2.4 \times 10^{6}$	2.4×10^{6}	2.4×10^{6}	2.4×10^{6}	2.2
31	235	"	31.1	$> 2.4 \times 10^{6}$	2.4×10^{6}	2.4×10^{6}	2.4×10^{6}	3.6
40	170	"	31.0	1.1×10^{6}	1.1×10^{6}	2.4×10^{6}	2.4×10^{6}	4.1
53	415	"	30.2	1.1×10^{5}	4.6×10^{4}	2.4×10^{5}	2.4×10^{5}	4.6
61	410	"	30.2	2.4×10^{5}	1.1×10^{5}	2.4×10^{5}	2.4×10^{5}	4.8

(a) Concentration as measured, without adjustment for physical dilution.

(b) Dye appeared in Boil at 9:10 a.m.

(c) Background Concentration.

physical dilution factor, and plotted on Figures 3-20 through 3-22 to show the rate of disappearance due solely to die-off and sedimentation. In each figure, the data can be bounded by a line of slope equal to one logarithmic cycle per 60 minutes, which thereby indicates a 90 percent decrease in value, (T_{90}) in one hour.

For the tests conducted on 28 September and 26 November, the procedure was slightly different. First, samples for bacterial analysis were taken directly from the pump station at the time of the dye dump to establish the initial concentrations. To begin, 2 litres of Rhodamine WT dye were dumped into the pumping station wet well. When the main boil of the outfall turned red, a surface drogue was placed in the boil and sampling was started. For the next 2-1/2 hours, samples for bacterial, dye, and salinity analysis were taken at depths of 1 m and 3 m below the surface in the vicinity of the drifting drogue. With each sample, the boat position was fixed by sextant angles to known landmarks.

The concentrations of the indicator organisms, total coliforms, fecal coliforms, and fecal streptococci, are shown in Tables 3-31 and 3-32 as a function of time. Again, these concentrations represent the combined effects of dilution, die-off, and sedimentation and must be multiplied by dilution factors to isolate the effects of die-off and sedimentation.

To estimate the dilution factors, the change in dye concentration of the dye patch was used, after adjustment to reflect the effect of its longitudinal dispersion, which would have effectively not been present with a continuous dye release. During the tests, the flow from the Kait Bey outfall was estimated to be 1.4 m^3/sec with approximately 20 percent of the flow being discharged at the last boil.

The results of all three of these tests, despite some differences in technique, indicated daytime T_{90} values of one hour or less. This is

TABLE 3-31

BACTERIAL DATA-28 SEPT 77

Time After Dye Appears in Boil (Minutes)[b]	Distance From Boil (Meters)	Sample Depth (Meters)	Dye Conc. (PPB)	Conductivity T=25.4°C	Bacteriological Sampling[a]: Total Coliforms (Presumptive) MPN/100 mL	Fecal Coliforms (Confirmed) MPN/100 mL	Entrococci (Presumptive) MPN/100 mL	Fecal Streptococci (Confirmed) MPN/100 mL	Estimated Physical Dilution Factor
					2.4×10^{10}	1.1×10^{10}	1.1×10^{10}	4.6×10^{10}	0.1
					2.4×10^{11}	4.6×10^{11}	2.4×10^{11}	2.4×10^{11}	0.1
- 16	Pump Station	-	6000	-	2.4×10^{11}	1.1×10^{11}	2.4×10^{11}	2.4×10^{11}	0.1
0	0	Surf.	72.0	55.0	2.4×10^{7}	2.4×10^{7}	1.5×10^{7}	7.5×10^{6}	1
4	45	3 m	0.40	55.3	4.6×10^{5}	1.5×10^{5}	4.6×10^{5}	4.6×10^{5}	0.6
11	110	Surf.	12.5	55.1	2.4×10^{7}	2.4×10^{7}	1.1×10^{7}	1.1×10^{7}	1.0
17	150	3 m	3.70	55.5	2.4×10^{7}	1.5×10^{7}	1.5×10^{6}	7.5×10^{5}	1.3
28	220	Surf.	16.8	55.1	2.4×10^{7}	2.1×10^{6}	2.4×10^{7}	2.4×10^{6}	0.7
30	230	3 m	0.45	56.0	1.5×10^{4}	1.5×10^{4}	1.1×10^{4}	1.1×10^{4}	1.7
59	435	Surf.	3.30	55.0	1.1×10^{7}	1.1×10^{7}	2.4×10^{7}	2.4×10^{7}	2.4
88	660	"	1.70	55.0	7.5×10^{5}	1.5×10^{5}	1.5×10^{5}	1.5×10^{5}	3.0
91	685	"	1.70	55.3	2.4×10^{6}	2.4×10^{6}	2.4×10^{6}	2.4×10^{6}	3.0
105	825	"	1.60	55.3	1.1×10^{5}	4.6×10^{5}	4.6×10^{4}	4.6×10^{4}	3.2
122	1000	"	1.20	54.8	1.1×10^{5}	1.1×10^{5}	4.6×10^{4}	4.6×10^{4}	3.5
125	1030	"	0.90	55.4	7.5×10^{4}	7.5×10^{4}	2.4×10^{4}	2.4×10^{4}	3.5
141	1210	"	0.65	55.1	4.6×10^{4}	4.6×10^{4}	1.1×10^{4}	1.1×10^{4}	3.8
144	-	"	0.93	55.9	1.1×10^{4}	1.5×10^{3}	4.6×10^{3}	4.6×10^{3}	3.8
165	-	"	0.35	54.9	1.5×10^{3}	1.5×10^{2}	1.1×10^{3}	1.1×10^{3}[c]	-

[a] Concentrations as measured without adjustment for physical dilution.

[b] Dye appeared in Boil at 9:11 a.m.

[c] Background Concentration.

TABLE 3-32

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Time After Dye Appears in Boil (Minutes)(b)	Distance From Boil (Meters)	Sample Depth (Meters)	Dye Conc. (PPB)	Conductivity T=25.4°c	Bacteriological Sampling[a] Total Coliforms (Presumptive) MPN/100 mL	Fecal Coliforms (Confirmed) MPN/100 mL	Entrococci (Presumptive) MPN/100 mL	Fecal Streptococci (Confirmed) MPN/100 mL	Estimated Physical Dilution Factor
- 18	Pump Station	-	4762	-	$2.4x10^{10}$	$2.4x10^{10}$	$2.4x10^{10}$	$2.4x10^{10}$	0.1
0	0	Surf.	10.4	53.9	$2.4x10^{9}$	$2.4x10^{9}$	$1.5x10^{10}$	$1.5x10^{10}$	1.0
5	270	3 m	0.34	56.5	$2.4x10^{5}$	$2.4x10^{4}$	$1.1x10^{6}$	$4.6x10^{5}$	1.7
7	440	Surf.	1.24	55.1	$1.1x10^{8}$	$1.5x10^{8}$	$4.6x10^{8}$	$2.4x10^{8}$	1.1
10	400	3 m	0.11	56.2	$2.4x10^{4}$	$2.4x10^{4}$	$4.6x10^{4}$	$4.6x10^{4}$	1.8
15	600	Surf.	0.54	55.6	$1.1x10^{7}$	$1.1x10^{7}$	$2.4x10^{7}$	$2.4x10^{7}$	1.2
19	680	1 m	1.60	55.8	$2.4x10^{7}$	$1.1x10^{7}$	$1.1x10^{6}$	$4.6x10^{6}$	1.3
43	750	1 m	0.38	56.0	$1.1x10^{6}$	$1.1x10^{5}$	$1.1x10^{6}$	$2.1x10^{5}$	1.6
47	950	3 m	0.17	56.1	$1.1x10^{4}$	$2.1x10^{3}$	$1.1x10^{4}$	$4.6x10^{3}$	2.4
53	850	1 m	0.39	56.0	$2.4x10^{6}$	$4.6x10^{6}$	$4.6x10^{6}$	$2.4x10^{6}$	1.6
60	900	1 m	0.31	56.3	$2.4x10^{5}$	$2.4x10^{5}$	$1.5x10^{5}$	$1.5x10^{5}$	1.7
65	900	3 m	0.13	56.4	$2.4x10^{3}$	$1.1x10^{3}$	$2.4x10^{3}$	$1.1x10^{3}$	2.6
71	1000	1 m	0.24	56.2	$4.6x10^{5}$	$1.1x10^{5}$	$2.4x10^{5}$	$2.4x10^{5}$	1.8
75	1100	3 m	0.11	56.0	$1.1x10^{5}$	$1.1x10^{5}$	$4.6x10^{4}$	$4.6x10^{4}$	2.7
82	1200	1 m	0.32	56.6	$1.1x10^{5}$	$2.4x10^{5}$	$1.1x10^{6}$	$1.1x10^{6}$	1.8
85	1350	3 m	0.12	56.8	$2.4x10^{4}$	$2.4x10^{4}$	$2.4x10^{4}$	$2.4x10^{4}$	2.8
95	1550	1 m	0.26	56.4	$2.4x10^{6}$	$1.1x10^{6}$	$4.6x10^{5}$	$4.6x10^{5}$	1.9
99	1600	3 m	0.12	56.6	$1.1x10^{4}$	$2.4x10^{4}$	$1.5x10^{4}$	$7.5x10^{3}$	2.9
110	1800	1 m	0.24	56.4	$4.6x10^{6}$	$1.1x10^{6}$	$2.4x10^{6}$	$2.4x10^{6}$	1.9
114	1900	3 m	0.10	56.3	$1.1x10^{4}$	$2.4x10^{4}$	$2.4x10^{3}$	$2.4x10^{3}$	3.1
122	2000	1 m	0.24	56.4	$2.4x10^{5}$	$2.4x10^{5}$	$2.4x10^{5}$	$2.4x10^{5}$	2.0
129	2200	1 m	0.24	56.1	$4.6x10^{5}$	$2.4x10^{5}$	$2.4x10^{5}$	$1.1x10^{5}$	2.0

(a) Concentration as measured, without adjustment for physical dilution.

(b) Dye appeared in Boil at 12:20

comparable to data gathered by Shuval et al.[1] showing T_{90} values of one hour in the Mediterranean and Red Seas. A conservative value of 1.5 hours is herein adopted as a daytime T_{90} for design purposes.

Twenty-Four-Hour Bag Studies in the Harbor

On 26 and 27 June 1978, three additional tests were carried out to determine the variation of T_{90} values over a 24-hour period. The results of these experiments are summarized in Tables 3-33 through 3-35. The tests were started at different times of the day to study the effects on sewage that had been exposed to seawater under varying daylight and night-time conditions. The studies were performed in Alexandria's Eastern Harbor, in clean polyethylene plastic bags, 0.13 mm thick. The bags were held open at the mouth and suspended from a floating frame which kept the mouth 300 mm above the stillwater level to prevent water from splashing in or out, and which kept the mouth open in a 330 mm by 230 mm rectangle. The bags extended approximately 800 mm beneath the water surface. For each rig, two bags were used, one inside the other, to ensure adequate strength. The bags were moored in the harbor to avoid wave disturbance and for swift delivery of the samples to the laboratory.

For each series, 50 L of seawater was collected at a point 2 km from shore, bought to the harbor and placed in one of the bags. Then 0.17 L of wastewater was added to the seawater to attain a sewage:seawater dilution ratio of 1:300. This represents an initial plus partial secondary dilution that the sewage would receive when discharged from the proposed outfalls. The wastewater used in the studies was collected from the Kait Bey pumping station and filtered through glass wool before being placed in the plastic bags.

After adding the wastewater to the seawater in the bags, the contents were well mixed and an initial sample was withdrawn. Thereafter, sampling

[1] Shuval, Thompson, Fattal, Cymbalista, and Wiener, "Natural Virus Inactivation Processes in Sea Water," Journal Sanitary Engineering Division, American Society of Civil Engineers, 1971.

TABLE 3-33

BACTERIAL DATA, SERIES I, 26-27 JUNE 1978

Sample Description	Clock Time [a]	Temp °C	Total Coliforms (Presumptive) MPN/100 ml	Fecal Coliforms (Confirmed) MPN/100 ml	Enterococci (Presumptive) MPN/100 ml	Fecal Streptococci (Confirmed) MPN/100 ml
Sewage	13:30	-	3.5×10^{12}	7.0×10^{11}	2.4×10^{13}	3.5×10^{12}
Seawater	14:00	27.4	7.9×10^{2}	8.0×10^{1}	4.9×10^{2}	1.1×10^{2}
Sewage and Seawater Mixture	14:00	27.4	1.1×10^{5}	1.1×10^{5}	1.7×10^{6}	1.1×10^{6}
"	16:00	27.5	7.9×10^{3}	4.9×10^{3}	1.7×10^{4}	1.7×10^{4}
"	18:00	27.5	1.7×10^{3}	1.3×10^{3}	7.9×10^{3}	7.9×10^{3}
"	20:00	27.5	1.7×10^{3}	1.1×10^{3}	7.0×10^{2}	7.0×10^{2}
"	22:00	26.9	1.3×10^{3}	1.3×10^{3}	7.0×10^{2}	7.0×10^{2}
"	24:00	26.3	1.1×10^{3}	4.9×10^{2}	2.2×10^{2}	1.7×10^{2}
"	2:00	26.2	2.2×10^{2}	1.7×10^{2}	1.7×10^{2}	1.7×10^{2}
"	4:00	26.0	1.7×10^{2}	1.7×10^{2}	1.1×10^{2}	1.1×10^{2}
"	6:00	26.0	8.0×10^{1}	8.0×10^{1}	8.0×10^{1}	5.0×10^{1}
"	8:00	26.3	5.0×10^{1}	2.0×10^{1}	8.0×10^{1}	4.0×10^{1}
"	10:00	26.9	3.5×10^{1}	2.5×10^{1}	2.5×10^{1}	2.5×10^{1}

Note: (a) Sewage placed in seawater at 14:00.

TABLE 3-34

BACTERIAL DATA, SERIES II, 26-27 JUNE 1978

Sample Description	Clock Time [a]	Temp °C	Total Coliforms (Presumptive) MPN/100 ml	Fecal Coliforms (Confirmed) MPN/100 ml	Enterococci (Presumptive) MPN/100 ml	Fecal Streptococci (Confirmed) MPN/100 ml
Sewage	22:30	-	2.4×10^{12}	2.8×10^{11}	2.4×10^{12}	1.6×10^{11}
Seawater	23:00	-	2.4×10^{5}	1.6×10^{5}	2.4×10^{5}	2.25×10^{4}
Sewage and Seawater Mixture	23:00	-	5.4×10^{5}	4.9×10^{5}	5.4×10^{5}	1.7×10^{5}
"	24:00	26.3	3.5×10^{5}	2.7×10^{5}	5.4×10^{5}	2.2×10^{5}
"	2:00	26.2	1.1×10^{5}	2.2×10^{4}	3.5×10^{5}	2.4×10^{5}
"	4:00	26.0	9.2×10^{4}	2.2×10^{4}	4.9×10^{4}	4.9×10^{4}
"	6:00	26.0	4.9×10^{4}	7.9×10^{3}	3.4×10^{4}	3.4×10^{4}
"	8:00	26.3	7.9×10^{1}	2.2×10^{1}	2.4×10^{4}	2.4×10^{4}
"	10:00	26.9	2.2×10^{1}	1.3×10^{1}	1.7×10^{2}	1.7×10^{2}

Note: (a) Sewage placed in seawater at 23:00.

TABLE 3-35

BACTERIAL DATA, SERIES III. 27 JUNE 1978

Sample Description	Clock Time [a]	Temp °C	Total Coliforms (Presumptive) MPN/100 ml	Fecal Coliforms (Confirmed) MPN/100 ml	Enterococci (Presumptive MPN/100 ml	Fecal Streptococci (Confirmed) MPN/100 ml
Sewage	3:30	-	7.9×10^8	7.9×10^8	1.8×10^{10}	1.7×10^9
Sewage and Sea-water Mixture	4:00	26.0	7.9×10^4	4.9×10^4	1.4×10^5	4.9×10^4
"	6:00	26.0	7.9×10^4	4.9×10^4	4.9×10^4	4.9×10^4
"	8:00	26.3	1.1×10^3	7.9×10^2	2.8×10^3	1.4×10^3
"	10:00	26.9	2.2×10^2	1.7×10^2	2.3×10^2	2.3×10^2
"	12:00	27.5	3.3×10^2	8.0×10^1	1.3×10^2	8.0×10^1

Note: (a) Sewage placed in seawater at 4:00.

followed the schedule shown in Tables 3-33 through 3-35. At the time of sampling, the contents of the bags were mixed well. A 100-ml sample was taken in a sterilized bottle which was then ferried to the laboratory station. There, initial dilutions were prepared for the multiple fermentation tube tests. The tests were carried out by personnel from the High Institute of Public Health, University of Alexandria. The procedure is as described in Appendix F, but with five tubes used, rather than three, to determine each MPN concentration.

Compared to the procedures used in the first set of tests, use of the plastic bags in this set removed the uncertainty of where to find the sewage sample and what the sewage:seawater dilution ratio is. In the first set of tests in the discharge plume, there was always some uncertainty about where to find the sewage sample being followed, despite the use of a drogue or of dye. Furthermore, there was the greater uncertainty of what the physical dilution ratio was at any given time. Use of the bags in the 26-27 June tests removed these uncertainties, at the expense of altering conditions of turbulence and diffusion found in the open-sea plume. By keeping the bags of seawater in the harbor rather than, say, in the laboratory, one did maintain conditions of solar radiation, temperature, and some turbulent agitation typical of open-sea conditions.

To better simulate receiving water at the proposed discharge points offshore, dilution water was collected not from the harbor with its high bacterial concentrations and otherwise poor water quality, but from a point 2 km offshore. However, water temperatures in the upper 1 m were nearly the same in the harbor and 2 km offshore. Furthermore, it was judged that the turbidity of the harbor water, while greater than offshore, was such in the upper 1 m that the solar radiation obliquely incident on the bags would not be much less in the harbor than offshore.

Interpretation. First, one may make the simple observations that fecal coliform counts in a 1:300 sewage:seawater mixture fell below 100/100 mL after 16 hours in Series I; after 9 hours in Series II; and after 8 hours in Series III. For dilutions of the order of 300, then the required

decay period will be of the order of 10 to 20 hours to bring fecal coliform concentrations down to the criterion level of 100/100 mL not exceeded 50 percent of the time, as presented in Chapter 4.

A more sophisticated study of the data proceeds as follows:

1. As with the set of daytime tests, one may plot the bacterial concentrations against time on semi-logarithmic paper, and determine a T_{90} value from the slope of the resulting curve.
2. However, it is not expected that one T_{90} value will apply to all hours of the test; one expects, rather, a daytime T_{90} of about 1.5 hours, a nighttime T_{90} of about 40 hours, and intermediate values at twilight. Such a diurnal distribution of T_{90} values is given in Column A, Table 5-2, Chapter 5.
3. Each T_{90} value may be represented by a line of particular slope on a plot of logarithm of bacteria concentration versus time. On Figure 3-23, lines of appropriate slope dictated by T_{90} values presented in Table 5-2, Column A, have been plotted for each hour of the day, and joined end-to-end to indicate a cumulative decay function.
4. On the decay-function curve, the ordinate value is arbitrarily set at unity at time 12:00 hours (noon). (For the moment, absolute values of concentrations are not important, only ratios of concentrations at different times.) The curve may now be used to answer such questions as: if concentration is 10^6/100 mL at 14:00 one day, what will be the concentration at 06:00 the next morning according to the curve? At 14:00, the curve's ordinate value is 4.6×10^{-2}; at 06:00 the next morning, the value is 7.8×10^{-5}; the ratio of concentrations is 1.7×10^{-3}; this times the initial concentration of 10^6/100 mL gives 1700/100 mL.
5. How well is the postulated decay function shown on Figure 3-23 supported by the test data? For comparison, the fecal coliform data given in Tables 3-33, 3-34, and 3-35 are plotted on Figure 3-23, with all values for a test multiplied by a common factor so as to put the first point for each test onto the

postulated curve. The data support the decay function to the extent that data points after the first point in a test remain near the postulated decay function curve.

6. Over the course of the tests, Series I and Series III show fairly good ultimate agreement with the decay function, which is to say that the last points lie not far at all from the function curve. Series II shows a more rapid decay than is predicted by the curve.

These tests were too few in number to substantially confirm or deny the validity of the postulated decay function, but they do suggest that the decay function has at least approximate validity. Certainly, they confirm that 10 to 20 hours are needed for decay through 3 to 4 log cycles of concentration, as postulated in Columns E and F of Table 5-2.

Discharge Concentrations in the Effluent

Table 3-36 contains bacterial concentrations in samples taken directly from the sewers, most often at Kait Bey Pump Station, but also at Saray Pump Station (Sidi Bishr), East Treatment Plant, and Industries Pump Station. For each of the four types of test, the concentrations range over several orders of magnitude. Log mean values are shown; the value for fecal coliforms is 3.4×10^9/100 mL.

Table 3-37 contains bacterial concentrations in sewage-seawater mixtures immediately after mixing, multiplied by the known or estimated dilution ratio. Any systematic differences between these values and those in Table 3-36 may be attributed not to physical dilution and not to decay with the passage of time, but to whatever physical, chemical, or biological effects the immediate mixing with seawater may have on the sewage. Log mean values are shown; the value for fecal coliforms is 2.2×10^8/100 mL.

For design purposes, a value of 1×10^9/100 mL is chosen as the nominal concentration of fecal coliform bacteria in sewage being discharged. This value is close to the geometric average of the average values shown in Tables 3-36 and 3-37.

TABLE 3-36

BACTERIA CONCENTRATION IN ALEXANDRIA SEWERS[a]

Sampling Location	Date	Total Coliforms, Presumptive	Fecal Coliforms, Confirmed	Total Enterococci, Presumptive	Fecal Enterococci, Confirmed
Kait Bey Pump Station	28 Sep 77	2.4×10^{10}	1.1×10^{10}	1.1×10^{10}	4.6×10^{10}
		2.4×10^{11}	4.6×10^{10}	2.4×10^{11}	2.4×10^{11}
		2.4×10^{11}	1.1×10^{11}	2.4×10^{11}	2.4×10^{11}
	26 Nov 77	2.4×10^{10}	2.4×10^{10}	2.4×10^{10}	2.4×10^{10}
	17 Jun 78	9.4×10^{8}	1.1×10^{8}	2.2×10^{11}	2.2×10^{11}
		1.4×10^{9}	3.3×10^{8}	3.5×10^{11}	2.4×10^{11}
	26 Jun 78[b]	3.5×10^{12}	7.0×10^{11}	2.4×10^{13}	3.5×10^{12}
		2.4×10^{12}	2.8×10^{11}	2.4×10^{13}	1.6×10^{11}
Influent, East Treatment Plant	17 Jun 78	1.7×10^{8}	1.3×10^{8}	3.3×10^{9}	2.6×10^{9}
		5.4×10^{8}	2.2×10^{8}	3.5×10^{9}	2.6×10^{9}
Outfall, Industries Pump Station	17 Jun 78	1.7×10^{9}	1.3×10^{9}	7.0×10^{10}	1.7×10^{10}
		5.4×10^{9}	5.4×10^{9}	1.4×10^{11}	7.0×10^{10}
Saray Pump Station, Sidi Bishr	17 Jun 78	3.5×10^{8}	1.1×10^{8}	2.8×10^{9}	2.2×10^{9}
		5.4×10^{8}	1.1×10^{8}	1.8×10^{9}	1.4×10^{9}
Log Mean Values[c]		9.6×10^{9}	3.4×10^{9}	7.9×10^{10}	4.2×10^{10}

[a] Analysis was by the Multiple Tube Fermentation Procedure. Three tubes were used in 1977 tests; five tubes were used in the 1978 tests. Results are reported as MPN per 100 mL.

[b] Samples for 26 June 1978 were filtered through glass wool.

[c] "Greater than" (">") symbols were neglected in computing log mean values.

TABLE 3-37

BACTERIAL CONCENTRATIONS IN SEWAGE FRESHLY MIXED WITH SEAWATER[a]

Date, Series	Estimated Dilution Factor	Total Coliforms, Presumptive	Fecal Coliforms, Confirmed	Total Enterococci, Presumptive	Fecal Enterococci, Confirmed
5 September 1977					
Series I	10	4.6×10^9	4.6×10^9	4.6×10^7	4.6×10^9
Series II	10	4.6×10^7	1.1×10^7	1.1×10^8	1.1×10^8
28 September 1977	10	2.4×10^8	2.4×10^8	1.5×10^8	7.5×10^7
26 November 1977	10	2.4×10^{10}	2.4×10^{10}	1.5×10^{11}	1.5×10^{11}
26/27 June 1978[b]					
Series I	300	3.3×10^7	3.3×10^7	5.1×10^8	3.3×10^8
Series II	300	1.6×10^8	1.5×10^8	1.6×10^8	5.1×10^7
Series III	300	2.4×10^7	1.5×10^7	4.2×10^7	1.5×10^7
Log Mean Values		2.9×10^8	2.2×10^8	3.3×10^8	3.9×10^8

[a] Values are taken from Tables 3-30 through 3-35 and have been multiplied by the estimated dilution factor.

[b] On 26 June 1978, sewage was filtered through glass wool before being mixed with the seawater.

3.3 Sampling for Water and Sediment Quality

Several series of water samples were taken for water quality analysis. Sediment samples were taken for heavy metals analysis. Sampling locations are shown on Figure 3-3.

For water samples, the sampling procedure was to take water from one or more depths at each location with a Kemmerer sampler, and store the samples in shaded, iced plastic jars or jerrycans until they could be delivered later in the same day to the High Institute of Public Health Laboratory, which performed the analyses reported in Tables 3-38, 3-40, 3-41, 3-42 and 3-43. Sediment samples obtained on 13 October 1977 were taken with a steel grab sampler coated with epoxy paint to prevent contamination of the sample by the steel. On 13 January 1978, this sampler was inoperative, and samples were taken with a zinc-coated iron grab sampler. The heavy metals analyses of these sediment samples is reported in Tables 3-39 and 3-44. The heavy metals analyses were performed in CDM's Boston laboratory.

Particle size analyses of these samples are presented in the next section, on Geophysical Studies.

The results presented in this section are discussed briefly by broad geographical area.

Near Anfushi; Western Harbor; Mex Bight

Analyses of water samples obtained on 13 October 1977 are presented in Table 3-38. In addition, water samples from these areas taken on 13 January 1978, were tested at the Faculty of Agriculture, University of Alexandria, for the pesticides aldrin, lindane, dieldrin, endrin, DDE and DDT; no concentrations of these compounds were found in any sample. The laboratory reports on pesticides analysis is available in Unpublished Memorandum No. 2.

TABLE 3-38

ANALYSES OF SEAWATER SAMPLES FROM WATERS NEAR ANFUSHI, WESTERN HARBOR, AND MEX BIGHT

	Location/Date[a]	Depth (m)	pH	Turbidity[b]	Cl (g/l)	BOD_5 (mg/l)	NO_2 (mg/l)	NH_3 (mg/l)	Albuminoid-N (mg/l)	PO_4-P (mg/l)
Within 1-2 km of major outfall	Sta. 1, 13 Oct.77	Surface	8.2	5	21.7	0.7	0.02	0.09		0.08
		10.0	8.2	Nil	22.1	0.9	Nil	0.09	0.20	0.04
		20.0	8.3	5	22.0	1.2	0.08	0.15		0.04
	Sta. 2 "	Surface	8.2	5	21.8	1.3	0.02	0.08		0.08
		8.5	8.2	Nil	22.2	0.7	0.02	0.09	0.15	0.02
		17.0	8.3	5	22.0	1.2	0.08	0.09		0.02
	Sta. 3 "	Surface	8.2	Nil	19.5	0.8	0.08	0.09		Nil
		8.0	8.3	Nil	22.1	1.1	0.02	0.08	0.30	0.04
		15.5	8.3	Nil	22.4	1.2	0.03	0.05		Nil
Western Harbor	Sta. 4 "	Surface	8.2	Nil	21.2	0.9	0.11	0.18		0.08
		5.0	8.2	Nil	22.0	0.9	0.02	0.10	0.35	Nil
		10.5	8.2	Nil	21.8	1.4	Nil	0.16		0.04
	Sta. 5 "	Surface	8.3	25	20.3	7.0	0.11	0.08		0.20
		6.0	8.2	5	21.6	2.4	0.05	0.15	0.50	0.04
		12.0	8.2	Nil	22.1	2.7	0.02	0.10		0.04
Mex Bight	Sta. 6 "	Surface	8.2	10	19.7	1.7	Nil	0.10		0.08
		6.0	8.2	Nil	22.1	1.0	Nil	0.05	0.20	Nil
		12.0	8.2	5	22.1	1.2	Nil	0.12		Nil

Notes: (a) See Fig. 3-3.

(b) Standard turbidity units.

Heavy metals analyses of sediments from this area are shown in Table 3-39. Sample 5 on 13 October, a muddy sand from the bottom of the Western Harbor, proved to have high concentrations of chromium, copper, iron, mercury, manganese, nickel, lead and zinc. Sample 1 on 13 October was high in lead and Sample 2 on 13 October was high in mercury; both samples were sands obtained at stations northwest of the entrance to the Eastern Harbor within 2 km of the Kait Bey outfall and major sewer overflows at Eastern Harbor and Silsila. Sample 4 on 13 January 1978 was taken very close to the Misr Chemical Co. discharge at Mex, which is reported to have a high mercury content. This sample proved to have a mercury content of 2.1 mg/kg, greater than other samples in the Mex Bight, but less than indicated for Sample 2 (off Anfushi) and Sample 5 (Western Harbor) on 13 October. The sediment samples were generally sandy, except for Sample 4 on 13 October, which was a lump of rock.

Kait Bey and Ramleh Alignments, 4 to 13 km from Shore

Analyses are presented in Table 3-40 for water samples taken 27 April and in Table 3-41 for water samples taken on 2 and 3 May 1978. Six stations were visited on 27 April; the same six stations were revisited on 2 and 3 May (see Figure 3-3). Also included in Table 3-41 are the analyses of a sample taken from surface waters 2 km off Anfushi on 28 June 1978.

On 6 January, water samples were taken at plankton sampling station No. 3 off Kait Bey for pesticides analysis. As before, no pesticides were detected.

Abu Kir Bay

Water samples were taken on 16 May 1978 from near the surface and near the bottom at the three plankton sampling stations in Abu Kir Bay. Results of analyses are reported on Figure 3-42. Station 1 was in the effluent plume from the Tabia pump station; the surface sample shows elevated turbidity, BOD and $KMnO_4$ levels. The chloride concentration there is about 15 percent less than elsewhere in the Bay, implying that the Tabia discharge has been diluted to a ratio of 5 or 6 to 1 with seawater at the point of sampling.

TABLE 3-39

TOTAL METALS CONTENT[a] OF SEA SEDIMENT SAMPLES, ANFUSHI, MEX BIGHT, WESTERN HARBOR

	Station No.[b] and Date	Cadmium as Cd	Chromium as Cr	Copper as Cu	Iron as Fe	Mercury as Hg	Manganese as Mn	Nickel as Ni	Lead as Pb	Zinc as Zn
Within 1-2 km of Outfall	1 13 October 1977	4.0	7.5	6.0	1250	0.10	81	1.0	13	8.0
	2 "	3.5	7.0	13.0	880	4.1	89	2.0	6	11.0
	3 "	2.5	8.0	40.0	1450	1.2	110	6.0	7	48.0
	4 "	6.0	5.5	16.0	890	0.35	140	29.0	3	53.0
	5[c] "	3.5	83.0	61.0	7050	3.2	200	16.0	240	170.0
	6[d] "	3.5	8.0	7.0	1050	0.40	110	4.0	3	18.0
Mex Bight	1 13 January 1978	3.5	8.0	24.0	1850	0.45	120	3.5	<1	81.0
	1A "	3.0	7.4	10.0	1700	0.10	67	2.5	<1	21.0
	2 "	3.5	5.0	7.0	620	< 0.05	51	1.5	7	4.0
	3 "	3.0	8.5	8.0	1550	0.65	160	6.0	11	16.0
	4[e] "	2.5	7.0	11.0	700	2.1	76	1.5	3	12.0
	5 "	3.5	7.0	5.0	580	1.4	62	4.5	4	15.0
	6 "	3.5	7.5	5.5	650	0.20	61	4.0	<1	16.0

Note: (a) mg/kg dry basis
(b) See Fig. 3-3.
(c) Western Harbor
(d) Mex Bight
(e) Misr Chemical Co.

TABLE 3-40

ANALYSES OF SEAWATER SAMPLES FROM KAIT BEY AND RAMLEH ALIGNMENTS
27 APRIL 1978

	Location[a]	Depth (m)	NO_2[b] (mg/l)	NH_3[b] (mg/l)	Albuminoid-N[b] (mg/l)	PO_4 P (mg/l)
5 to 10 km from shore	Sta. 1	5	.0052	0.06	0.06	0.14
	Sta. 2	5	.0036	0.06	0.06	0.17
		Bottom - 55	.0062	0.10	0.16	0.20
	Sta. 3	5	.0030	0.06	0.24	0.26
	Sta. 4	5	.0046	0.11	0.21	0.23
	Sta. 5	5	.0033	0.05	0.21	0.17
		Bottom - 55	.0030	0.10	0.15	0.26
	Sta. 6	5	.0036	0.10	0.10	0.10

Notes: (a) See Fig. 3-3.

(b) All nitrogen forms expressed as N.

TABLE 3-41

ANALYSES OF SEAWATER SAMPLES FROM KAIT BEY AND RAMLEH ALIGNMENTS
2 AND 3 MAY 1978, AND 28 JUNE 1978

	Location[a]	Depth (m)	pH	Turbidity[b]	Cl (mg/l)	BOD_5 (mg/l)	$KMnO_4$ (mg/l as 0)	NO_2[c] (mg/l)	NH_3[c] (mg/l)	Albuminoid-N[c] (mg/l)	PO_4P (mg/l)
5 to 10 km from shore	Sta. 1	5	7.9	1	21,750	<1	<1	.0030	0.06	0.06	0.14
	Sta. 2	5	7.9	2	21,750	<1	<1	.0024	0.06	0.06	0.12
		Bottom - 55	7.9	1	21,800	<1	<1	.0030	0.06	0.06	0.14
	Sta. 3	5	7.9	2	21,750	<1	<1	.0024	0.06	0.06	0.20
	Sta. 4	5	7.9	3	21,700	<1	<1	.0015	0.06	0.06	0.20
	Sta. 5	5	7.9	3	21,750	<1	<1	.0033	0.27	0.05	0.20
		Bottom - 55	8.0	4	21,750	<1	<1	.0030	0.04	0.04	0.20
	Sta. 6	5	7.9	3	21,750	<1	<1	.0024	0.16	0.16	0.20
	28 June 1978[d]		7.9	10	19,500	1.0	1.6	.0286	0.12	0.12	0.35

Notes: (a) See Fig. 3-3. All samples but last on 2 and 3 May.

(b) Standard turbidity units.

(c) All nitrogen forms expressed as N.

(d) Surface sample taken 2 km NW of Eastern Harbor entrance.

TABLE 3-42

ANALYSES OF SEAWATER SAMPLES FROM ABU KIR BAY - 16 MAY 1978

Location[a]	Depth (m)	pH	Turbidity[b]	Cl (mg/l)	BOD_5 (mg/l)	$KMnO_4$ (mg/l as O)	NO_2[c] (mg/l)	NH_3[c] (mg/l)	Albuminoid-N[c] (mg/l)	PO_4P (mg/l)
Sta. 1	Surface	7.7	28	17,900	4	27	.0154	0.40	0.50	0.07
	Bottom - 5	7.9	11	20,700	<1	<1	.0052	0.03	0.08	0.10
Sta. 2	Surface	8.0	6	21,200	<1	<1	.0046	0.04	0.07	0.07
	Bottom - 10	8.0	6	21,400	<1	<1	.0052	0.04	0.07	0.15
Sta. 3	Surface	8.1	6	20,500	<1	<1	.0055	0.04	0.06	0.10
	Bottom - 7	8.1	5	20,500	<1	<1	.0058	0.05	0.06	0.12

Notes: (a) See Fig. 3-3.

(b) Standard turbidity units.

(c) All nitrogen forms expressed as N.

Lake Maryut

On 22 October 1977, samples of water and bottom sediments from Lake Maryut were obtained at the stations shown on Figure 3-3. Water samples were taken from one depth only. Results of water quality analyses are presented in Table 3-43, accompanied by observations made at the time of sampling. Analyses of metals content of the sediments are presented in Table 3-43, accompanied by observations made at the time of sampling. Analyses of metals content of the sediments are presented in Table 3-44. Sediment particle size analyses are presented in Section 3.5, Geophysical Studies.

In preparation of the Environmental Impact Statement[1] for the Alexandria Wastewater Master Plan Study, a collection of fish was obtained from the Lake Maryut commercial fishery on 5 December 1977. This included samples of *Tilapia nilotica* and *T. galilaea* and one specimen of the catfish *Clarias* sp. from the eastern, heavily polluted part of the lake (near the Gabbary Drain) and the same two species of *Tilapia* and a single mullet (*Mugil* sp.) from the western, relatively unpolluted part of the lake. The specimens were preserved in 90 percent ethyl alcohol and subsequently analyzed for heavy metals and organic trace contaminants. Analyses of heavy metals were made for both muscle and liver tissue, but there was sufficient material for only muscle tissue analyses for the organic compounds.

Samples for heavy metals analyses were dried to constant weight at 150°C, ashed at 550°C, and digested with nitric acid. Analyses were done by flame atomic absorption with dual channel background correction. Very low (trace) quantities were determined using a graphite tube atomizer with deuteruim arc background correction and method of additions. Mercury was determined using cold vapor atomic absorption.

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[1] *Draft Initial Environmental Impact Statement*, Alexandria Wastewater Master Plan Study, Camp Dresser & McKee Inc., Environmental Planning Division, April 1978.

TABLE 3-43

ANALYSES OF LAKE MARYUT WATER SAMPLES - 22 OCTOBER 1977

Sta. No.	Location[a]	pH	Electric Conductivity x 100	Turbidity	Cl (mg/l)	BOD_5 (mg/l)	COD (mg/l)	Oil (mg/l)	NO_2 (mg/l)	PO_4P (mg/l)	Remarks
1	Near Industries Pump Station Discharge, 150 m from Shore	7.0	30	980	1040	120	450	8.0	Nil	1.6	Water brown and opaque with black floating sludge. Bottom is deep ooze.
2	Near Gheit of Enab Discharge, 100 m from Shore	7.1	25	630	740	92	250	4.2	0.08	11.0	Flock of white egrets. Bubbles rising from bottom. Many swallows darting among reeds.
3	Near Center of Main Basin	8.3	29	400	950	35	185	34.0	0.15	1.8	Water very green, but not bubbling. 2 m deepth; grey mud, less oozy. Worm tubes.
4	Near Gabbary Discharge	7.4	36	80	1190	34	135	8.2	0.15	0.7	Pole easily driven 60 cm into mud.
5	Near Southern Corner of Main Basin	7.9	29.5	330	940	47	200	7.0	0.15	2.3	Heavy growth of grasses at sampling site. Water flows into main basin from Umum drain here.
6	El Umum Drain at Cairo Highway	7.8	46	90	1510	16	135	7.0	0.08	Nil	-
7	Noubaria Canal at Cairo Highway	8.0	45	45	1550	36	125	5.8	Nil	Nil	Fishermen taking 10 cm long Tilapia from canal at Umum drain siphon under canal.
8	Fish Farm Basin	8.0	59	70	2020	29	125	Nil	Nil	Nil	Large floating rafts of water hyacinths.
9	Main Basin at Kalaa Drain Discharge	7.2	25	115	800	63	200	9.4	0.15	3.0	Large floating rafts of water hyacinths.

Note: (a) See Fig. 3-3.

TABLE 3-44

TOTAL METALS CONTENT OF LAKE MARYUT SEDIMENTS[a] - 22 OCTOBER 1977

Sta. No.	Location[b]	Cadmium as Cd	Chromium as Cr	Copper as Cu	Iron as Fe	Mercury as Hg	Manganese as Mn	Nickel as Ni	Lead as Pb	Zinc as Zn
1	Near Industries Pump Station Discharge, 150 m from Shore	4.5	54	220	26 000	1.3	560	74	110	1 850
2	Near Gheit el Enab Discharge, 100 m from Shore	3.5	79	160	24 000	0.75	760	63	66	1 500
3	Near Center of Main Basin	4.0	110	270	19 000	1.1	460	90	160	2 450
4	Near Gabbary Discharge	2.5	32	110	46 500	0.90	630	50	150	200
5	Near Southern Corner of Main Basin	2.5	38	58	15 000	0.35	690	46	26	450
6	Main Basin at Kalaa Drain Discharge	2.5	14	78	3 650	0.30	140	33	4	200

Notes: (a) All units are mg/kg dry basis.

(b) See Fig. 3-3.

Samples for organic trace contaminants were extracted and analyzed by gas-liquid chromatography using American Association of Analytical Chemists (AOAC) methodology.

The results, which represent single analyses of only one specimen in each category, are shown in Table 3-45. No detectable concentrations of pesticides (eight compounds) were found. Very low concentrations (ca. 1 ppm) of dibutyl phthalate, a plasticizer used in the solvent industry, were found; but these were not notably higher in the fish from the heavily polluted area than in those from the unpolluted end of the lake.

3.4 Biological Studies

Scope

Biological studies conducted between August 1977 and July 1978 included plankton tows, sampling for benthic abundance and biomass, fish market surveys, and a short study of fouling organisms. The plankton sampling, complementing earlier studies by El-Maghraby and Halim[1] and Dowidar and El-Magharby[2], will enable present plankton abundance to be compared with past and future abundance for an historical trend. The study of fouling organisms complemented the plankton study. The sampling of benthos indicated the relative richness of each area, as indicated by organisms more stationary and longer-lived than plankton, and thus presented something of a "time-average" of conditions in each area. The fish market survey indicated the size and characteristics of the commercial marine fishery in the Alexandria area.

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[1] El-Maghraby, A.M., and Halim, Y., "A Quantitative and Qualitative Study of the Plankton of Alexandria Waters," Hydrobiologia 25 (1-2), pp 221-238, 1965.

[2] Dowidar, N.M., and El-Maghraby, A.M., "The Neritic Zooplankton of the South-eastern Mediterranean at Alexandria," Parts I and II, Bull. Inst. Oceangr. Fish. A.R.E., 1, pp 225-303, 1970.

TABLE 3-45

CONCENTRATIONS OF TRACE CONTAMINANTS IN FISH FROM LAKE MARYUT [a]

	Cd	Co	Cr	Cu	Fe	Hg	Ni	Pb	Zn	Pesticides[b]	Plastics[c]
L. Maryut (East End)											
Tilapia nilotica											
Muscle	0.07	0.02	1.75	9.55	38.80	0.01	1.40	0.29	48.60	<0.01	1.10
Liver	0.36	0.02	12.40	23.80	314.00	<0.01	1.20	2.10	107.00	-	-
Tilapia galilaea											
Muscle	0.25	0.07	1.24	9.50	29.80	0.01	0.45	0.12	52.10	<0.01	1.61
Liver	0.64	0.50	9.02	26.60	356.00	0.02	1.00	1.15	180.00	-	-
Clarias sp.											
Muscle	0.04	0.07	1.83	4.44	21.70	0.02	0.21	0.05	25.00	<0.01	1.42
Liver	4.57	2.10	25.90	47.40	7328.00	0.02	5.20	87.9	216.00	-	-
											-
L. Maryut (West End)											
Tilapia nilotica											
Muscle	0.04	0.03	1.50	6.57	39.40	0.05	0.14	0.05	34.70	<0.01	1.02
Liver	0.21	3.30	14.60	27.3	10070.00	0.33	11.00	1.76	157.00	-	-
Tilapia galilaea											
Muscle	0.14	0.01	1.42	9.42	16.50	0.03	0.09	0.35	40.40	<0.01	0.78
Liver	0.46	0.80	23.70	33.50	982.00	0.04	<0.01	5.71	268.00	-	-
Mugil sp.											
Muscle	0.08	0.05	3.49	6.45	58.60	0.04	<0.01	0.21	34.10	<0.01	-
Liver	0.07	0.10	3.69	4.93	419.00	0.14	0.37	0.42	169.00	-	-

Notes:
(a) Metals Concentrations are expressed in mg/L dry weight;organics concentrations are expressed in mg/L wet wt.
(b) Pesticides include DDT, dieldren, toxophone, malathion, parathion, guthion, diazinon, and methyl parathion.
(c) Dibutyl phthalate.

Phytoplankton and Zooplankton

Sampling Procedure. Three sampling stations off Anfushi and three stations in Abu Kir Bay were visited monthly, and whenever possible, bimonthly. These sampling station locations are shown in Figure 3-3.

The Anfushi stations were 1-2 km from shore, 5 km and 10 km from shore. The near-shore station was generally in the wastewater plume from the Kait Bey outfall and the Mex Canal; the surface water there being often green and somewhat turbid. Current meter implants there have been observed to support heavy growths of algae and sessile fauna, at least in the upper ten metres. At the station 10 km from shore, the water was often very clear and blue; current meter implants there were generally free of fouling growth. At the 5 km station, the water was usually clear, but occasionally somewhat turbid.

The stations in Abu Kir Bay were: a few hundred metres from shore near El Tarh, in an area often occupied by the discharge plume from the Tabia pump station; at a point about 5 km southeast of Nelson Island; and at a point between Nelson Island and Abu Kir village.

During the period of August through September, phytoplankton samples were taken using a plankton net having a diameter of 0.25 m, 1 metre long and with a mesh size of 20 per linear cm. A review of the procedure and the data collected during that time showed that representative results were not being obtained with a phytoplankton net. Accordingly, since October, the following procedure was used. At each station, 800 to 1000 ml samples were obtained with a Kemmerer water sampler from just above the bottom and just below the surface, and fixed with formalin. In the laboratory, each sample was poured into a graduated cylinder, and the solids allowed to settle. When the organisms had settled into the lowest 50 or 100 ml of the cylinder, the water above was discarded; the remaining volume then mixed well, and samples taken for enumeration in a 1 ml microscope counting cell. When organism concentration was poor, an additional 1 ml sample was drawn and the two results were averaged to give the cell count for each species of plankton.

Having obtained the cell count or concentration of cells per 1 ml of sample the concentration of phytoplankton cells (cells/liter) was determined by the following formula:

cells/1 ml x volume in ml of settled sample ÷ total sample volume (liters)

Zooplankton samples were taken with a net 0.52 m in diameter at the mouth, 2 m long, and with a mesh size of 20 per linear cm. Ten-minute horizontal trawls, with the net just beneath the surface, were taken at each station, with a boat speed of about one m/sec. Where the water depth was 10 m or more, vertical trawls were also taken. Two methods were used. One method was to weight the bridle of the net and lower the net to within a few metres of the bottom. The net was then raised by hand and brought on deck. The results were noted as counts/liter for a vertical haul. The second method, which was used on most samples taken after October, was the oblique zooplankton haul. The weighted net was lowered to within 10 m of the bottom and then towed slowly for two minutes. The towline was shortened by 10 metres and the net was towed again for two minutes. The process of shortening and towing was continued for ten minutes with the final tow occuring at the surface. For nearly all zooplankton tows, a flow meter was installed in the mouth of the flow net to determine the volume of water that entered the net during a tow. In some early trawls, when a flow meter was not yet available, the boat speed was carefully measured during towing, and later correlated with flow meter readings.

After collection in the plankton net, organisms were washed from the inside of the net down into the collection jar at the apex of the net. The contents were then transferred to a storage jar and fixed with formalin solution. Samples were taken from the storage jar for zooplankton counting/cell identification, without further concentration. An additional 1 ml sample was drawn for organism enumeration when the organism concentration was low. Having obtained the concentration of cells per 1 ml of sample, the concentration of zooplankton cells (cells/liter) was determined by the following formula:

cells/1 ml x volume of sample in ml ÷ total volume of seawater (liters) passing through net

where the flow meter readings were used to calculate the volume of seawater which passed through the sampling net.

All plankton identification and cell counting was done at the University of Alexandria, Faculty of Science. Cell counting was accomplished by the strip count method.

The results of the year-long plankton sampling program are shown in the tables in Appendix A.1. These results are summarized in the graphical form in Figures 3-24 to 3-35 and tabulated in Tables 3-46 and 3-47.

Phytoplankton. A listing of phytoplankton abundance in Alexandria waters is summarized in Table 3-46. Phytoplankton were subjectively classified as abundant or most abundant by the University of Alexandria. As seen in the table, the relative abundance of these genera is not uniform throughout the area.

Figures 3-24 through 3-29 show the bimonthly variation in total cell count for the Kait Bey stations at the bottom and surface. At Station 1, four phytoplankton blooms are evident, one each in November, January, March and June. The bloom of November was the largest of all and may be due to the increase of sewage discharges during this period. A sudden decrease in surface salinity (to 35.8 0/00) during November was also evident. The surface phytoplankton were more numerous than bottom phytoplankton.

At Station 2, one bloom occurred at the surface, a minor bloom occurred in February and another bloom was in June. At this station, the growth of phytoplankton on the bottom did not follow the same pattern as on the surface. Also the overall numbers of phytoplankton were less on the bottom than at the surface.

At Station 3, two blooms occurred: the first in February, and the other in April. The phytoplankton production at this station was less on the bottom than on the surface. However, the difference was not so great as it was at Stations 1 and 2. It is also interesting to note that there was only a very small decrease in the surface salinity over the bottom water salinity. Surface water temperature was higher than at depth.

From a comparison of the phytoplankton production at the three stations, it can be seen that Station 1 was the most productive, while Station 3 was the least productive. During the winter, surface and bottom water

TABLE 3-46

ABUNDANT GENERA AT EACH PHYTOPLANKTON STATION

I. Diatoms	Off Kait Bey 1	2	3	In Abu Kir Bay 1	2	3
Asterionella		X				
Aulacodiscus		X	X			
Bacteriastrum			X			
Bellarochia	X	X	X			
Biddulphia	(X)			X		X
Chaetoceros	(X)	(X)	(X)	X	X	X
Climacosphenia						
Corethron	X					
Coscinodiscus	(X)	(X)	(X)	X	X	X
Dacthyliosolen				X		
Dinophysis			X			
Ditylum		X				
Grammatophora	X	X				
Guinardia		X				
Gyrosigma	X	X	X			
Hemiaulus	X					
Leptocylindrus		X	X			
Licmophora	X					
Lithodesmium		(X)				
Melosira	(X)		(X)	X	X	X
Navicula	X		X			
Nitzschia						
Pleurosigma			X			
Rhabdonema	X		X			

I. Diatoms (continued)	Off Kait Bey 1	2	3	In Abu Kir Bay 1	2	3
Rhizosolenia	X	(X)	(X)		X	
Skeletonema						
Striatella	X					
Surirella	X					
Thalassionema	X	X				
Thalassiosira	X					
Thalassiothrix		X				
II. Tintinnids						
Codonella		X	X			
Codonellopsis						
Eutintinnus		X				
Favella	X	X	X			
Tintinnopsis	X	X	X			
Undella			X			
III. Dinoflagellates						
Ceratium	(X)	X	(X)	X	X	X
Petalotrica	X					
Proplectella	X					
Prorocentrum		X		X	X	X
Triceratium			X			
IV. Radiolaria	X					
Dictyocysta			X			
Peridinium		X	X			

X Abundant
(X) Most Abundant

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samples were nearly the same, showing that mixing may have been high in this area in December and January. At Station 2, the bottom seems to be more productive than the surface layer in early summer.

From Table 3-46 it can be seen that there is homogeneity of generic distribution of phytoplankton in the stations in Abu Kir Bay. Stations 1 and 3 have exactly the same types of organisms present.

Figures 3-30 through 3-35 show the total cell counts for the Abu Kir Bay stations. At Station 1, two blooms of phytoplankton occurred, the first one was small and occurred in January, while the second bloom, which was larger, occurred in May. At Station 2, peaks occurred in November, January and April, while at Station 3, blooms occured in December and May. It should also be noted that an increase in phytoplankton usually accompanied a decrease in salinity values.

In Abu Kir Bay, the phytoplankton production was nearly the same for both surface and bottom samples at the three stations studied. This suggests good mixing in the Bay although slight differences between surface and bottom salinity and temperature were observed.

Zooplankton. A summary of zooplankton abundance in Alexandria waters is presented in Table 3-47. These were subjectively classified as abundant or most abundant by the University of Alexandria.

Figures 3-24 through 3-29 show the bimonthly total cell count for the Kait Bey stations. From the figures, it can be seen that there is a general rise in production by the end of November and other rises can be seen in February and April. Consistent with the growth of the phytoplankton and the location of coastal sewage discharges, the highest cell counts can be seen at Station 1 while Station 3 has the least.

In general it was found that quantitative estimates of zooplankton in vertical hauls was usually less than in horizontal tows. Evidently, the zooplankton were located more densely in the upper layers during the daytime.

TABLE 3-47

REPRESENTATIVE ZOOPLANKTON AT EACH SAMPLING STATION IN KAIT BEY[a]

	Off Kait Bey			In Abu Kir Bay		
	1	2	3	1	2	3
Coelenterates			X	(X)	(X)	X
Rotifers						
Echinoderms-Larvae						
Annelids						
Polychaete Larvae				X	X	
Phoronid Larvae						
Molluscs						
Gastropods-Larvae				X	X	X
Pteropods						
Heteropods						
Crustaceans						
Copepods-Species:						
Acartia	(X)	X		(X)	(X)	X
Candacia						X
Calanus	(X)	(X)	(X)	X	X	X
Centropages	X			X	X	X
Clausocalanus						X
Euaetideus						X
Euchaeta						
Haloptilus						
Isias clavipes	X	X	X	X	X	X
Paracalanus						X
Temora				X	X	X
Pleuromamma						
Aetideus						
Copilia						
Corycaeus		X				X
Corycella						X
Euterpina				X	X	
Sapphirina						
Lubbokia						
Oithona nana				X	X	

X Abundant
(X) Most Abundant

[a]The system of classification presented here is informal and is used to give a general categorization of the available data.

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TABLE 3-47. (continued)

	Off Kait Bey			In Abu Kir Bay		
	1	2	3	1	2	3
Crustaceans (continued)						
Cladocerans				X	X	X
Ostracods-*Conchoecia* sp.						
Cirripeds-Nauplii				X	X	X
Amphipods				X	X	
Decapods-Larvae	X		X	X	X	X
Chaetognaths						
Sagitta sp.	X	X	X	X	X	X
Chordates						
Ascidians-Larvae						
Other Tunicates						
Fish Eggs	X	X		X	X	X

From the available data for Abu Kir Bay, shown in Table 3-47, it can be seen that Station 3 contains a greater variety of zooplankton than Stations 1 and 2. Figures 3-30 through 3-35 show the total cell counts for the Abu Kir Bay stations.

The graphs of monthly abundance of zooplankton show that Station 2 is the richest of three stations. A sudden increase in zooplankton takes place at Station 2 by the middle of January. A corresponding slight increase was also recorded in the other two stations. If we compare this with surface phytoplankton counts, we can see that a corresponding phytoplankton increase (although slight), was recorded by the middle of January at Stations 1 and 2.

Another rise in zooplankton abundance was noted in March and April at Stations 2 and 3. At Station 2, a clear drop in zooplankton abundance occurs often by the first of April. Another flourishing of zooplankton occurs by the middle of April.

In Abu Kir Bay, zooplankton organisms are dispersed in the water column, so that the amount of zooplankton organisms in a vertical haul, is higher than those obtained from a horizontal tow. This is true for the three stations. This would also suggest mixing of water or homogeneity of water in the bay.

Benthic Biota

This study was conducted during the months of January and February 1978 in a few visits to the field. Its aim was to identify the types of benthic fauna and flora near sewage or industrial outfalls, as well as far from all outfalls. This investigation covered three areas: Abu Kir Bay, Eastern Harbor and Mex Bight.

Except where noted, benthic sampling was by a dredge lowered to the bottom and slowly dragged along the bottom for approximately eight minutes. The dredge consisted of a deep rope net of coarse mesh (about 2 cm), whose mouth was formed by a steel frame weighing about 40 kg. The frame was hexagonal, 63 cm long by 35 cm wide at the ends and 55 cm wide in the

middle. After being towed along the bottom, the dredge was brought aboard the ship, where biological specimens and rocks were washed free of clay and silt and placed in storage bags for later identification in the laboratory. Where noted, samples were taken with a self-closing grab sampler. The results of all sampling are presented in Appendix A.2. Sampling station locations are shown in Figure 3-3.

Fouling Organisms

Two brief studies of the quality and depth distribution of fouling organisms were conducted at the current meter buoy moored 2 km off Anfushi. On 20 March 1978, five samples of fouling organisms were scraped at different depths from the surface buoy and its chain, which had been in place since 19 December 1977.

In addition to the samples that were taken on 20 March 1978, 11 square panels, made of polyvinylchloride, each 12.5 x 12.5 cm, were suspended vertically from the chain of the anchor of the buoy located 2 km from Anfushi. These panels were suspended on 20 March 1978 at depth intervals of one m, between 0.5 m and 10.5 m. Four of these panels were detached and lost due to storms during this period.

The results of these two studies are presented in Appendix A.4, under Analyses of Fouling Organisms.

Fish

Introduction. A study of commercial fish catch landed from the Mediterranean waters around Alexandria was done with the aim of assessing the amount and types of fish landed. For this purpose, three areas were chosen to cover the region of Alexandria. They were the Eastern Harbor, Abu Kir Bay and Maadiya (the lake-sea connection of Lake Edku). Weekly visits were made to the fish market at the time of landing the commercial catch. However, this data was supplemented by daily statistics for the Abu Kir and Eastern Harbor markets compiled by the government. Each fish family or species (for dominant fish species) present was noted. The most dominant species were given a number of abundance as follows:

1.	more than 200 boxes	11.	35-30 boxes
2.	more than 150 boxes	12.	30-25 boxes
3.	between 150-100 boxes	13.	25-20 boxes
4.	100-80 boxes	14.	20-15 boxes
5.	80-70 boxes	15.	15-10 boxes
6.	70-60 boxes	16.	10-5 boxes
7.	60-50 boxes	17.	4 boxes
8.	50-45 boxes	18.	3 boxes
9.	45-40 boxes	19.	2 boxes
10.	40-35 boxes	20.	1 box

Each box had a capacity of from 20 to 25 kg.
Fish appearing in the catch in lesser quantities were given numbers more than 20 according to their abundance in the catch. In this analysis, Crustacea were included with fish in the estimation of abundance. Abundance of cartilagenous fish, however, was done separately. The cartilagenous fish catch was very small compared to the bony fish. The number 1 was given to the fish species for which more than 10 boxes were present; 2 for 10-8 boxes, 3 for 8-5 boxes; 4 for 5-3 boxes; and 5 for less than 3 boxes.

A summary for fish species abundance in the commercial catch for each month was then calculated by adding the numbers of abundance and dividing by the number of days in which they were present. A new mean number was thus obtained. Fish species found in each month were then arranged in order of mean abundance values. The mass of each species of fish landed was also noted during the visits. This data is presented in the tables of Appendix A.3.

Fish Fauna off Alexandria. Fish fauna in the Alexandria fish market were found to belong to about 37 fish families. The commercial catch depends on fish belonging to nearly half of these families. Compared to bony fish, cartilagenous fish represent a small amount of the catch, especially in the Eastern Harbor fish market. Crustacea was mostly represented by crabs, *Pennidae* and *Palinurus* spp. From Cephalopods, *Sepia* is the only genera present in the sampled commercial catch. Fisheries in Alexandria are not rich in shellfish. The dominant species are *Pholas*, *Dactylus*, *Donax* sp.,

Murex, *Lithphaga lithophaga* and *Venus* spp.

As a summary of the fish market surveys, the species distribution of fish landings for Eastern Harbor, Abu Kir and Maadiya is shown in Figure 3-48, while the fish species of minor importance are listed in Figure 3-49. Comments on the abundance of particular fish species present in the commercial catch are contained in Appendix A.3.

TABLE 3-48

SPECIES DISTRIBUTION OF FISH LANDINGS[a]

Species	Areas Investigated		
	Eastern Harbor	Abu Kir	Maadiya
Sardines	34.29	44.5	7.95
Mullus	10.5	3.85	4.88
Pagrus	7.7	1.12	-
Epinephelus	3.1	4.1	-
Sciaenidae	2.4	0.75	2.68
Solea	4.3	1.11	5.38
Synodontidae	0.88	1.78	0.32
Marone	0.14	0.09	1.89
Temnodon	2.18	0.63	0.04
Sparus autatus	0.88	2.36	4.80
Mugil	0.07	0.07	0.23
Diplodus	1.83	2.2	0.03
Trachurus	0.57	-	-
Lichia	0.01	-	-
Scomber	0.03	-	-
Merluccius	-	-	1.54
Sphyraena	-	-	2.33
Trigla	-	-	1.06
Trichiurus	-	-	0.45
Pagellus	-	-	0.29
Scombersox	-	-	0.95
Boops boops	-	-	0.25
Scorpaena	-	-	0.06
Gobius	-	-	0.29
Teuthis	-	-	0.68
Trachinus	-	-	0.19
Oblada melanura	-	-	0.04
Turtle	0.15	-	-
Crabs	0.06	0.87	5.9
Pennidae	3.5	5.74	30.8
Sepia	4.57	3.09	7.19
Cartilaginous fish	0.55	-	3.08
Other fish	22.29	27.74	16.70
Total	100.00	100.00	100.00

Note: (a) Percentages by weight.

TABLE 3-49

FISH SPECIES APPEARING IN THE COMMERCIAL CATCH IN MINOR QUANTITIES

Family	Species Present	Season of Abundance	Markets Where Present
Cephalacanthidae	Dactylopterus pirapeda	Oct-Nov	Eastern Harbor, Abu Kir, Maadiya, in April only
Triglidae	Trigla lyra Trigla lucerna	Nov-Dec Feb-April	More dominant in Abu Kir
Echeneidae	Echeneis naucrates	Nov	Absent from Abu Kir. Present in Eastern Harbor. A few individuals in Maadiya in Oct-Nov.
Exocoetidae	Exocoetus volitans	Feb-April	Eastern Harbor. Not observed in Abu Kir or Maadiya.
Gobiidae	Gobius spp.	March-April	Present with equal amounts in the three markets.
Holocentridae	Holocentrus ruber	Nov-Feb	Present as few individuals in the three markets. In Nov, seen in Abu Kir only.
Labridae	Xrichtys novacula	Throughout the whole year	Present in very small quantities. Not seen in Abu Kir.
	Julis vulgaris		Very small quantities.
	Labrus viridis		Very small quantities. Not seen in Abu Kir or Maadiya.
Bramidae	Lepidotus catalonicus	Jan-March	Eastern Harbor only.
Gadidae	Merluccius merluccius	Winter and spring	Present in all markets.
Muraenidae	Muraena helena	The whole year	Absent from Maadiya. Only a few individuals in other marlets/
Platycephalidae	Platycephalus indicus	Sept-March	A few individuals.
Siganidae	Teuthis sigana	Winter and early spring	Eastern Harbor; a few in Abu Kir and Maadiya.
Trachinidae	Trachinus draco	March, April, May	All markets.
Trichiuridae	Trichiurus lepturus	Nov,Dec,June	All markets.
	Lepidopus candatus		Seen in Eastern Harbor only.

TABLE 3-49
(Continued)

Family	Species Present	Season of Abundance	Markets Where Present
Sphyraenidae	Sphyraena sphyraena	April-May	Small quantities seen in the three markets.
Uranoscopidae	Uranoscopus scaber	April-May	Small quantities seen in all three markets.
Lophiidae	Lophius piscatorius	June	Absent from Maadiya.
Zeidae	Zeus faber	The whole year	A few individuals in all markets.
Blenniidae	Blennius spp.	Oct-Nov	Seen in Eastern Harbor market. Absent from Maadiya, Abu Kir.
Scorpaenidae	Scorpaena spp.	Nov-Dec	Small quantities in all markets.
Scomberosocidae	Scomberesox	The whole year	Absent from Abu Kir. A few individuals in other markets.
Belonidae	Belone belone	Oct	In all markets in minor quantities.
Stromateidae	Stromateus flatola	The whole year	A few individuals in Eastern Harbor market. Absent from Abu Kir and Maadiya.
-	Lutianus spp.	Dec, Jan	Seen in Eastern Harbor market. This is a Red Sea immigrant.
Scaridae	Scarus cretensis	The whole year	In all months, a few individuals seen in Eastern Harbor and Abu Kir markets. Not seen in Maadiya.

3.5 Geophysical Studies

Purpose and Procedure

In the wastewater Master Plan, it has been determined that wastewaters destined for disposal through ocean outfalls should be collected and pretreated at Kait Bey and Ras el Soda. Elsewhere in these marine studies it is determined that the outfalls should terminate approximately 10 km from the shore.

Given these conditions, the purpose of the geophysical studies has been to determine for each outfall the route to sea that affords the most favorable seabed conditions for construction; and to indicate what those conditions are. The aim is to choose alignments with the assurance that no alternative alignment would be vastly less expensive; and to be able to make a reasonable estimate of construction cost for the alignments chosen.

Field studies were undertaken in October, November, and December, 1977. Studies were confined to areas off Anfushi and Sidi Bishr where, according to those who were concurrently preparing the Wastewater Master Plan, outfalls would be proposed. (At that time, it was anticipated that the Kait Bey outfall might be proposed to run offshore from a point close to the present Kait Bey pumping station and outfall. This concept has not changed. For Sidi Bishr, however, it was anticipated that the outfall might cross the shoreline several hundred metres northeast of Ramleh Fort; since then, the proposed collection point and pump station site was moved about two km east, so that one would wish to consider an outfall alignment that crossed the shoreline at a point just east of the Miami Beach promontory. Such an alignment was not surveyed in total in our survey.)

The geophysical studies consisted of bathymetric, subbottom, and side-scan sonar remote surveys; several gravity cores and hand samples of offshore bottom sediments; and notes and photographs taken by divers on the bottom at selected points.

The remote-surveying equipment used was:

1. For bathymetry, a Raytheon Model DE-719 Fathometer Depth Sounder, which continuously recorded the water depth beneath the ship.
2. For subbottom profiling either a "boomer" system or a "sparker" system. Records from both systems were obtained; the boomer records provided better resolution of bottom strata, while the sparker provided better sonic penetration of the bottom sediments.
3. For side-scan sonar, a Klein Side Scan Sonar Model 402A towfish, providing a continuously recorded sonic planview image of the bottom beneath the ship and for 100 or so metres to either side.
4. For horizontal control, a Cubic DM-40 "Autotape" system providing electronically determined distance measurement from the ship to two shore stations, updated every second.

On any given run, the fathometer and the Autotape were operated simultaneously with either the boomer, sparker, or side-scan. Every 100 to 200 m of ship travel, an event mark was made simultaneously on the fathometer and other continuous records, and the Autotape readings recorded. The marked events were numbered serially from No. 1, at the beginning of the survey on October 22, to No. 1317 on December 1.

For direct sampling, a Benthos Model 2171 gravity corer was used to obtain samples of fine grained or cohesive materials. The corer, equipped with 100 kg of lead weight, and utilizing 73 mm diameter plastic liners, was allowed to free-fall from the surface. It was then recovered by hauling in with a nylon rope using the cathead on the vessel winch. The core in its liner was extracted, capped, sealed, marked and delivered to the soils laboratory. The effective inside diameter of the corer was 66 mm, and the effective outside diameter was 89 m. The total mass was about 143 kg.

Hand samples were obtained by divers. A weight attached to a down line was dropped at the predetermined position, using the "Autotape" for precise positioning. The divers then descended this line to the bottom, broke off rock samples with hammers, placed them in sample bags, and returned to the surface.

The underwater photography and diver inspection was undertaken in order to verify that topographic forms and rock types could be identified on the

remote-survey bottom and subbottom profiles. A number of representative features were selected from the profiles and their "Autotape" coordinates determined.

The features were then physically inspected by divers and their descriptions of the form and material noted. In all cases, they agreed quite well with the descriptions interpreted from the graphic recorder records.

Based on these tests, it was determined that excellent definition of the material, shape and conformation of the bottom could be obtained using remote-survey methods, i.e., bottom and subbottom profiling and sidescanning.

Underwater photos were made of a number of typical terrain features with a Nikonos II underwater camera using Kodacolor II, ASA 400 film. No flash was necessary even at 50 meter depths. Visibility varied from over 50 meters on the offshore locations to 10 meters about 1 or 2 km from shore. Turbidity varied with wind conditions usually being best following several days of onshore winds. All diving was done with standard SCUBA equipment.

Field Data

The remote-survey paths and the sampling and observation locations are shown on Figure 3-36. Six survey paths were run near the Anfushi Peninsula, and five were run off Sidi Bishr.

Physiography. The bathymetric and subbottom cross-section profiles obtained are sketched in Figure 3-37 for the Sidi Bishr region, and in Figure 3-38 for the Kait Bey region. In these figures, the profile of the sea floor is indicated by a solid line. The profile of the surface of hard, relatively lithified material which is a strong seismic reflector, and which would resist mechanical excavation, is indicated by a broken line. (The horizontal distance axis on Figures 3-37 and 3-38 is measured not from the shoreline in each case, but from the inshore end of the actual line run, which is always several hundred meters out from the shore.) The location of coring, sampling, and observation stations are shown on Figures 3-36, 3-37, and 3-38. Notes taken at these stations are presented in Table 3-50.

TABLE 3-50

CORING, SAMPLING, OBSERVATION NOTES

CORES

G-2A	Core location on Profile 3. Recovered few pieces of coral gravel and scattering of coral sand 2 mm size.
G-2B	Core location 10 meters east of Profile 3. Recovered few pieces of coral gravel and scattering of coral sand 2 mm size.
G-3	Core location 30 meters west of Profile 3. No penetration. Handful of coarse sand, gravel, and limestone.
G-4	Core location 20 meters east of Profile 3. Apparent penetration = 176 cm. Recovered 49 cm very fine, grey-white, silty sand/ sandy silt.
G-5	Core location 30 meters east of Profile 3. Apparent penetration = 90 cm. Recovered 36 cm very fine, grey-white, silty sand/ sandy silt.
G-6	Core location 20 meters west of Profile 3. Apparent penetration = 10-20 cm. Coarse, brown sand. Recovered only trace.
G-7	Core location on Profile 3. Apparent penetration = 10-20 cm. Recovered trace light brown, coarse sand, shell fragments.
G-8	Core location 1160 meters west of Profile 7. Apparent penetration 15 cm. Recovered 6 cm rough, coarse, brown sand, some gravel.
G-9	Core locqtion 1020 meters west of Profile 7. Apparent penetration = 10 cm. Recovered handful medium-fine grain salt and pepper sand.
G-10	Core location 480 meters west of Profile 7. Minimal penetration. Recovered fragments of foggy limestone conglomerate. including one piece approximately 5 cm. Trace of brown sand.
G-11	Core location 500 meters west of Profile 7. Minimal penetration . Recovered trace coarse sand to fine gravel, brown, calcareous with shell fragments.
G-12	Core location 130 meters west of Profile 7. Penetration = 7.5 cm. Recovered solid piece of weathered limestone; piece is approximately 6.5 cm diameter x 5 cm long. Few broken pieces about 2 cm square.
G-13	Core location 90 meters west of Profile 6. Minimal penetration. Trace of coarse, brown sandstone as fine gravel with shell fragments.

TABLE 3-50
(Continued)

Cores

G-16	Core location 2150 meters west of Profile 7. Penetration 150 to 180 cm. Recovered 50 cm grey, silty clay, sticky. cohesive.
G-17	12 km from shore (shown on Fig. 3-36 but not Fig. 3-38). Apparent penetration 174 cm. Recovered 94 cm of very fine, grey-white clay.
G-18	8 km from shore (shown on Fig. 3-36 but not Fig. 3-38). Apparent penetration 139 cm. Recovered 75 cm of very fine, grey-white clay-silt.

HAND SAMPLING AND DIVER OBSERVATIONS
(Shown on Fig. 3-36 but not on Figs. 3-37 or 3-38)

R-1	41 m depth. Medium-grain grey sand between fields of 2 m high oval boulders. Sand ripples about 20 cm high by 1 m wavelength.
R-3	31 m depth. Bumpy, rocky slope.
R-4	25 m. Medium grey/tan sand in front of flat, rocky slope of possibly 15 to 20 .
R-5	14 m. Rocky ridge with sand fissures about 1 m deep. Slopes downward from here in both directions. Old telephone or electric cable on bottom.
K-1	49 m depth, at location of current meter station 2B. Fine, light grey sand, like flour. Reef 100 to 125 cm high, linear ridge except for outcrops 10 to 20 m in diameter at observation location.
K-2	46 m depth. Medium-fine grey/tan sand.
K-3	40 m. Reef, flat, very low relief.
K-4	40 m. Light brown sand. Large field of 364 m high "island" reef outcroppings about 10 m north of observation location. Reef has large (10 to 30 m) sections cut by sand-bottom channels.
K-5	38 m. Ligh grey sand. Reef with sheer wall about 2.5 to 3 m high, unbroken by fissures or channels.

All the bathymetric data obtained were used to create a bathymetric chart for each of the two regions. Information about the distribution of rocky ridges and crevasses, flat rocky areas, and sandy areas, as gathered from subbottom profile records, side-scan sonar records, and diver observations, was plotted onto overlays of the bathymetric charts. These charts of bathymetry and bottom conditions are available in Unpublished Memorandum No. 10.

Representative photographs, originally in color, are reproduced in black-and-white on Figure 3-39. Taken five km off Sidi Bishr in 31 m of water, the photographs form a panorama showing a typical rock formation and a ripple formation in the sand. The ripple crests run approximately north and south; the trough to crest height is about 200 mm, and the crest-to-crest distances are about one metre.

The principal observations to be made are:

1. The dominant physiographic pattern is a series of narrow, rocky ridges running parallel to the shore, with plains or slopes of granular material between them. The ridges rise as much as ten metres above the neighboring grade elevations, and sometimes have fissures or crevasses along the scarps. Because they trend parallel to the present shoreline, the ridges may be related to ancient erosional shorelines.
2. In the areas of granular material between these ridges, over distances of up to several kilometers, the bottom often rises in a seaward direction (i.e., water depth <u>decreases</u> with increasing distance from shore) by as much as several meters in elevation. This is particularly true off the Anfushi Peninsula.
3. The rock ridges become broader and more complex closer to shore.
4. Many of the features can be traced from one end of the survey area to the other.
5. With increasing distance from shore, and increasing water depth, the granular material tends to become finer in grain size. (This was also noted by El Sayed [1].)

[1] El Sayed, M.K., <u>Littoral and Shallow Water Deposits Along the Mediterranean Coast of Egypt off Alexandria</u>, M. Sc. Thesis, Faculty of Science, Alexandria University, Egypt, 1974.

6. There are hard, nearly flat areas apparently composed of coquina and denser limestone. They are cut by small sand-filled fissures often about 20 to 40 cm deep and 30 to 60 cm wide. Some of these areas are "lumpy," with protrusions above grade of one half to one metre.
7. Apart from the rock ridges, there are several areas with "boulder"-like rock features, generally five to ten m across and two to three m high. As in the example shown in Figure 3-39, these "boulders" might appear at first to be discrete rocks resting on the surrounding granular material; however, it is likely that they are part of the underlying bedrock, with the "neck" at the surrounding grade elevation caused by erosion by the sand.
8. The rock nearly everywhere contains interconnected pores of the order of one to ten mm in size.
9. At 5 km from shore, in 31 m of water off Sidi Bishr, large sand ripples, likely created by wave motion, were observed.

Soil Properties. Laboratory tests on the soil samples were conducted by the Consultative Bureau for Civil Constructions (CBCC), 73 El-Sultan Hussein Street, Alexandria. Their report to CDM is available as Unpublished Memorandum No. 4. The results reported therein are summarized in Tables 3-51 through 3-55.

Of the samples listed in Table 3-51, all proved to be highly calcareous; on treatment with dilute (1:1) hydrochloric acid, there was always a brisk evolution of CO_2. In Table 3-52, the rock specimens tested contained holes covering 20 to 25 precent of their surface area. Particle size analyses on the cohesionless soils were carried out using British Standard seives. Strength characteristics were determined by using a motorized shear box apparatus.

The cohesive soil samples reported in Tables 3-53, 3-54, and 3-55 were delivered to the soils laboratory in the plastic tubes used in the gravity coring operation. They were subjected to tests as "undisturbed" samples, although, as the CBCC report points out, the samples can hardly be described as being perfectly undisturbed. There were many opportunities for jarring

TABLE 3-51

PHYSICAL AND CHEMICAL PROPERTIES OF SOIL SAMPLES

Sample No.	Percentage Moisture Content	Percentage Volatile Matter	Percentage Free Smell	pH	Percentage Silica	Percentage Trivalent Metal Oxides	Percentage Divalent Metals as $CaCO_3$	Percentage Sulphate Ion Content	Percentage Chloride Ion Content
ROCK									
K5-A	23.4	19.0	Nil	7.6	2.4	9.0	84.7	0.6	0.8
SAND									
G9	11.0	28.1	Nil	7.4	8.9	1.9	85.1	0.7	1.0
G11	3.2	34.2	Nil	7.3	1.5	6.8	88.3	0.6	0.6
K4	8.1	14.8	Nil	7.6	1.0	1.3	95.8	0.5	0.3
COHESIVE									
G4	39.0	13.3	5	7.3	4.6	4.8	87.6	0.8	1.5
G17	41.9	15.5	10	7.3	5.7	5.3	83.6	0.9	1.7

TABLE 3-52

DESCRIPTION AND SOIL PROPERTIES OF ROCK AND SAND SAMPLES

Sample No.	Description	Dimensions (mm)	Area of Section (cm^2)	Failure Load (kg)	Failure Stress (kg/cm^2)	Working Stress (kg/cm^2)
ROCK						
K5-A	Calcareous sandstone enriched in corals	95x75x35	71.25	400	5.6	1.87
K3	Calcareous sandstone enriched in corals	50x55x35	27.50	250	9.1	3.03

SAND		Angle of Internal Friction, Ø		Size Analysis	
		Loose	Dense	d_{10}, mm	d_{60}, mm
R1	Grey fine to medium calcareous sand	33° 25'	43° 40'	0.11	0.25
K1	Grey calcareous graded sand	34° 10'	42° 40'	0.08	0.28
K2	Grey fine to medium calcareous sand with crushed shells	32° 50'	40° 30'	0.18	0.39
K4	Mottled yellowish and grey sands, small pebbles, calcareous flakes, and minute crushed shells	40° 00'	47° 50'	0.40	1.70
K5	Grey fine to medium calcareous sand	34° 10'	42° 40'	0.10	0.20
K2-A	Yellowish medium to coarse calcareous sand containing crushed shells and calcareous fragments	40° 30'	47° 10'	0.50	1.10
G8	Grey medium to coarse calcareous sand containing pebbles	41° 35'	48° 15'	0.43	1.80

TABLE 3-53

DESCRIPTION AND PARTICLE SIZES OF COHESIVE SOIL SAMPLES

Sample No.	Description	Size Analysis	
		d_{10}, mm	d_{60}, mm
G4	Grey, soft sandy clayey silt containing small black stones	0.09	0.48
G5	Grey, calcareous sandy clayey silt containing small black stones	0.09	0.34
G16	Grey, clayey silt	0.10	0.23
G17	Grey, soft silty clay containing calcareous material	0.09	0.33
G18	Grey, silty fine sand containing calcareous material	0.10	0.16

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TABLE 3-54

PROPERTIES OF COHESIVE SOIL SAMPLES

Sample No.	Natural Water Content "W" %	Specific Gravity "G_s"	Bulk Density " " (t/m^3)	Voids Ratio "e"	Unconfined Compression Strength (kg/cm^2)	Shear Strength Parameters: Cohesion C, (kg/cm^2)	Shear Strength Parameters: Angle Ø°	
G-4	70.09	2.74	1.596	1.920	0.12	0.03	38°	50'
G-5	45.65	2.83	1.798	1.292	-	0.04	34°	40'
G16	69.85	2.63	1.575	1.837	0.08	0.02	36°	10'
G-17	91.38	2.78	1.503	2.540	0.08	0.025	35°	30'
G-18	60.43	2.69	1.643	1.626	-	0.02	38°	40'

TABLE 3-55

CONSOLIDATION CHARACTERISTICS OF CLAYEY SOILS

Sample No.	Consolidation Test Voids Ration at: Zero Pressure	4 kg/cm^2 Pressure	Pressure Range (kg/cm^2)	Coefficient of Consolidation, $C_v \times 10^{-3}$ (cm^2/sec)	Coefficient of Compressibility, $m_v \times 10^{-2}$	Coefficient of Permeability, $K_v \times 10^{-7}$ (cm^2/sec)
G4	1.92	1.49	0.25-0.50	60.34	6.80	41.03
			0.50-1.00	57.78	5.16	29.82
G16	1.83	1.35	0.25-0.50	57.69	7.75	44.71
			0.50-1.00	74.83	5.64	42.24
G17	2.54	1.83	0.25-0.50	55.89	9.34	52.20
			0.50-1.00	52.81	6.58	34.47

and compaction of the samples, although not thorough stirring, before delivery to the laboratory. The strength characteristics of the clayey samples were determined by using the Autographic Unconfined Test Apparatus (Table 3-54, Column 6) and the Motorized Shear Box Apparatus.

Another series of bottom sediment samples was taken on October 13, 1977, at locations shown on Figure 3-3; particle size analyses of these samples, by Dr. M.L. Sabaroty of the Faculty of Science, University of Alexandria, are summarized in Table 3-56. Dr. Sabaroty's report is available in Unpublished Memorandum No. 3.

Construction Considerations

From the field data, one may infer the following about construction conditions:

1. Blasting will probably be required in the rocky areas, both in the ridge areas and in the areas of hard, flat rock surface.
2. The regions of rock ridges will require a considerable amount of excavation of rock, and the pipe will have to undergo many large changes in grade (as much as 20° or 25°) at the pipe joints.
3. Where the pipe is to be laid on a hard, flat rock surface, a certain amount of smoothing and bedding will be required, even if deep trenching is not.
4. In regions of sandy or gravelly bottom, a smooth bed for the pipe can be easily prepared. Where the sands are sufficiently coarse, there will be sufficient bearing capacity to support the pipe with little settlement of the soil.
5. The potential for erosion of sand supporting or covering the pipeline should be very carefully analyzed during the outfall design phase. The large sand ripples observed at a depth of 31 m, the "necks" on rock formations at the elevation of the surrounding grade, and the fact that the grade in sandy areas often slopes towards shore rather than away from shore, all indicate significant sediment transport dynamics which should be well understood if the pipeline is to be properly protected.

TABLE 3-56

PARTICLE SIZE ANALYSES OF OTHER SEDIMENT SAMPLES

Location	Mean Size mm	Mean Size Ø Units	Standard Deviation Geometric	Standard Deviation Ø Units	Skewness	Kurtosis
13 Oct 77[a]						
1	1.12	0.33	1.803	0.85	- 0.129	1.1885
2	0.55	1.366	1.686	0.754	- 0.01	0.4098
3	1.12	0.33	1.919	0.94	- 0.10	1.0929
4	Rock only; no sediment					
5	0.328	5.43	4.053	2.019	+ 0.3935	0.8100
6	0.87	0.7	1.866	0.9	- 0.076	1.2295
22 Oct 77[a]						
1	0.029	5.63	3.036	1.602	+ 0.1196	0.69
2	0.020	6.13	4.773	2.255	+ 0.104	0.75
3	0.019	6.24	3.779	1.918	+ 0.0454	0.65
4	0.033	5.43	4.025	2.009	+ 0.50	0.75
5	0.019	6.20	3.808	1.929	+ 0.009	0.81
6, 7, 8	No sediment samples taken					
9	0.029	5.63	3.640	1.864	0.0833	0.77

Notes: (a) Sampling station locations are shown on Fig. 3-3.

(b) Ø units define size ranges, thus: $2^{-Ø} < d < 2^{1-Ø}$.

Mean size in mm is $d = 2^{0.5-Ø}$.

(c) Geometric standard deviation is $2^{-Ø}$ (units standard deviation).

6. Fine-grained silts and clays are found six km and more offshore, and possibly in some areas closer to shore. The tests conducted on these soils in this study were born of a concern about whether there will be sufficient bearing capacity for the pipeline. Tentative conclusions, based on the relatively few data obtained, indicate that bearing capacity will be adequate provided that a certain amount of settlement of the pipeline is acceptable. The amount of settlement increases with loading rate; for the loading rates anticipated, settlement of 20 to 30 cm should be expected. The greatest differential settlement will be imposed on pipeline sections that pass from a rock ridge to a region of silt and clay.

Choice of Outfall Alignments

Figures 3-37 and 3-38, and the plan of bottom conditions included in Unpublished Memorandum No. 10, were studied in a search for suitable outfall alignments off Anfushi, for the Kait Bey outfall, and off Sidi Bishr, for the Sidi Bishr outfall discharging sewage from the proposed Ras el Soda Preliminary Treatment Plant and Pump Station.

In each of the two regions, any outfall alignment chosen will unavoidably pass over considerable distances of rocky and sometimes precipitous terrain, as well as distances of granular terrain. In each region, the preferred surveyed alignment was chosen on the basis of having the greatest proportion of distance over granular terrain to distance over rocky terrain. In the Sidi Bishr region, this was Profile 8 (see Figure 3-36). In the Kait Bey region, this was Profile 1. However, the second choice there, Profile 2, was ultimately chosen for a tentative outfall alignment because Profile 1 is very close to the offshore anchorage frequented by ships waiting to enter the Western Harbor.

While this procedure for selecting alignments is not the most exhaustive or detailed possible, it is believed that alternative alignments providing vastly more favorable construction conditions probably do not exist. As noted above, it may well be desirable to investigate an alignment at Sidi Bishr that is located east of the Miami promontory; conditions on the outer portions of such an alignment will be similar to those shown on Profiles 9 and 10.

While certain knowledge of conditions on the five km nearest shore must await further surveys, it is very probable that the terrain is roughly similar to the nearshore five km of Profiles 6 through 10.

Alignment lengths for the proposed outfalls are determined in Chapter 5 of this report.

Recommendations for Further Surveys

At the design stage, detailed route surveys of the chosen alignments will be necessary. These surveys should provide:

1. Details regarding grade, slope changes and foundation properties which will affect pipe design.
2. The detailed knowledge of the amount, type and rippability, or "excavatability" of the rock to be removed; or the amount of fill and type of material required for bedding the pipe.

These detailed surveys should be performed with an electronic navigation system having better than two-metre accuracy (and, accordingly, on days with very calm seas, to avoid variability in horizontal location and vertical position due to vessel roll and heave). The echo-sounder and the boomer or minisparker used should be run at very low speed. Each alignment should be run at least twice to provide sufficient redundancy. Salinity, temperature and density profiles should be obtained to provide echo-sounder calibrations (for acoustic wave velocity) at the start, middle and end of each run. The echo-sounder chart should be run at high speed to provide the greatest detail possible. The subbottom profiles should be obtained with a boomer or minisparker "tuned" to provide the best resolution of detail in the upper three metres of the sea bed. This subbottom record is necessary to discover any rock pinnacles beneath the sand bottom which might exert "point" support of the pipe.

To obtain additional information of the engineering properties of the subbottom, a small hydraulic drill capable of taking at least 3-m long cores should be used. A combination unit capable of interchanging from rotary to vibratory drilling would be best. The rotary cores should be taken in the "rock" areas to determine the type and hardness of the material to be excavated. The vibrating drill can sample the gravels and sand areas for

excavating and foundation properties. Additional information on excavatability of the harder materials can be obtained using refraction seismic equipment. Many studies have yielded empirical data which closely correlates the speed of sound in the rock with an attendant difficulty in excavation.

The unusual clarity of the water provides excellent conditions for bottom photography. Photos are particularly valuable for helping the contractor determine the best methods of excavation and emplacement through the rock areas existing from shore out to about six kilometers. These photos can be taken using a magazine loaded marine camera with a capacity of several hundred pictures. A diver can be towed at slow speed while he guides the camera. The camera can be advanced and fired from a control box on the surface or on command of the diver, photographing all changes or significant anomalies in bottom topography. As the pictures contain an identification frame, they can be correlated with the "Autotape" position at the surface to later identify each photo location.

3.6 Existing Kait Bey Outfall

According to the 1946 design plans, the existing outfall at Kait Bey is 725 m long, terminating in 16 m of water. The pipe is of steel, 1.25 m in diameter. From the pump station, across the beach, into the surf, and out to the principal reef about 155 m from shore, the pipe is encased in concrete, in a rectangular "box" section. For the next 345 m through and beyond the reef zone, the pipe is covered with ballast bags. For the last 250 m, the pipe lies unballasted.

The outfall was proposed by Lloyd-Davies in 1908, designed in 1946, and built in the late 1950's.

At the present time, it is evident that there are leaks in the system that permit sewage to escape from the pipe much nearer to shore than

725 metres. Inspection of the outfall boil areas from a launch in February, 1977, revealed that there were not one or two leaks but many, implying a well-advanced state of deterioration of the whole pipeline, rendering repairs impractical. The number and location of the breaks were determined in a dye study conducted by CDM in October, 1977.

In July, 1977, the Egyptian company, EGYCO, in coordination with the French company, GO International, undertook a diving inspection of the outfall. After submarine inspection, with reportage of the pipe's condition every 5 m, EGYCO/GO concluded that the whole pipeline is in very bad condition and that repair was impractical. In particular, they observed that over the final 163 m, where the steel pipe simply lies on the sea bed, the pipe is nearly completely destroyed.

In the CDM dye study, two litres of Rhodamine WT dye were dumped into the outfall discharge chamber at Kait Bey pump station. The discharge rate was gauged at 1.37 m^3/sec, using a rating curve developed earlier in a CDM survey of Alexandrian sewer discharges.

The boil area was observed from the top of the Kait Bey Fort and the time and location of each new appearance of the dye was noted. Locations were fixed by sextant readings from the fort of the angle between each dye patch and Ras el Tin lighthouse, together with knowledge of the pipeline alignment.

The first major dye patch appeared 235 m from shore, and the last appeared 490 m from shore. Seven distinct dye patches appeared. Five of the patches can be correlated with breaks reported by EGYCO/GO; two dye patches were noted in areas where EGYCO/GO did not report leaks. The

dye study observations are summarized in Table 3-57.

The CDM dye study corroborates the findings by EGYCO/GO; the present outfall is in advanced state of deterioration and virtually nonexistent more than 500 m from shore.

The rapid deterioration of the pipe over 20 years can be attributed to insufficient protection from wave action, and insufficient corrosion protection. Note that the section of the pipeline encased in poured concrete, and nearest to shore, is nearly intact. The section in the surf zone, protected merely by cement bags yet subject to wave forces, has many breaks.

TABLE 3-57

KAIT BEY OUTFALL DYE STUDY [a]

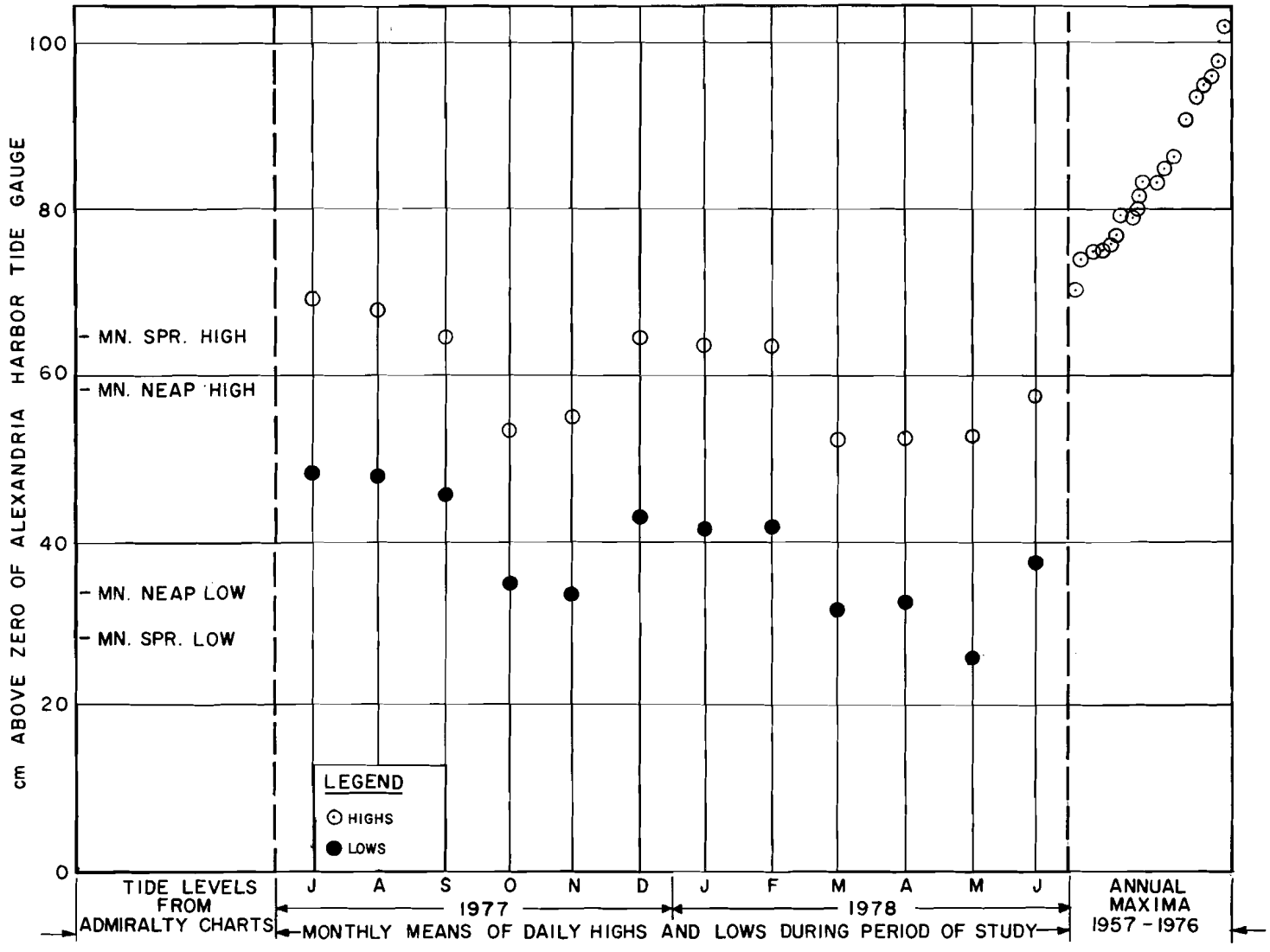
Dye Patch Number	Time after Dye Dump, sec.[b]	Distance from Station, m
1	240	236
2	340	300
3	445	318
4	540	392
5	660	436
6	870	462
7	1020	490

[a] These observations were recorded during a dye study at the existing Kait Bey Outfall 25 Oct 77, pumps No. 1 and 5 operating. Rated discharge of each pump is 50 m^3/min. Depth of flow in discharge chamber averaged 0.70 m, implying discharge of 82 m^3/min from rating curve developed in May 77 by CDM.

[b] Two litres of rhodamine WT dye used in dump into discharge chamber.

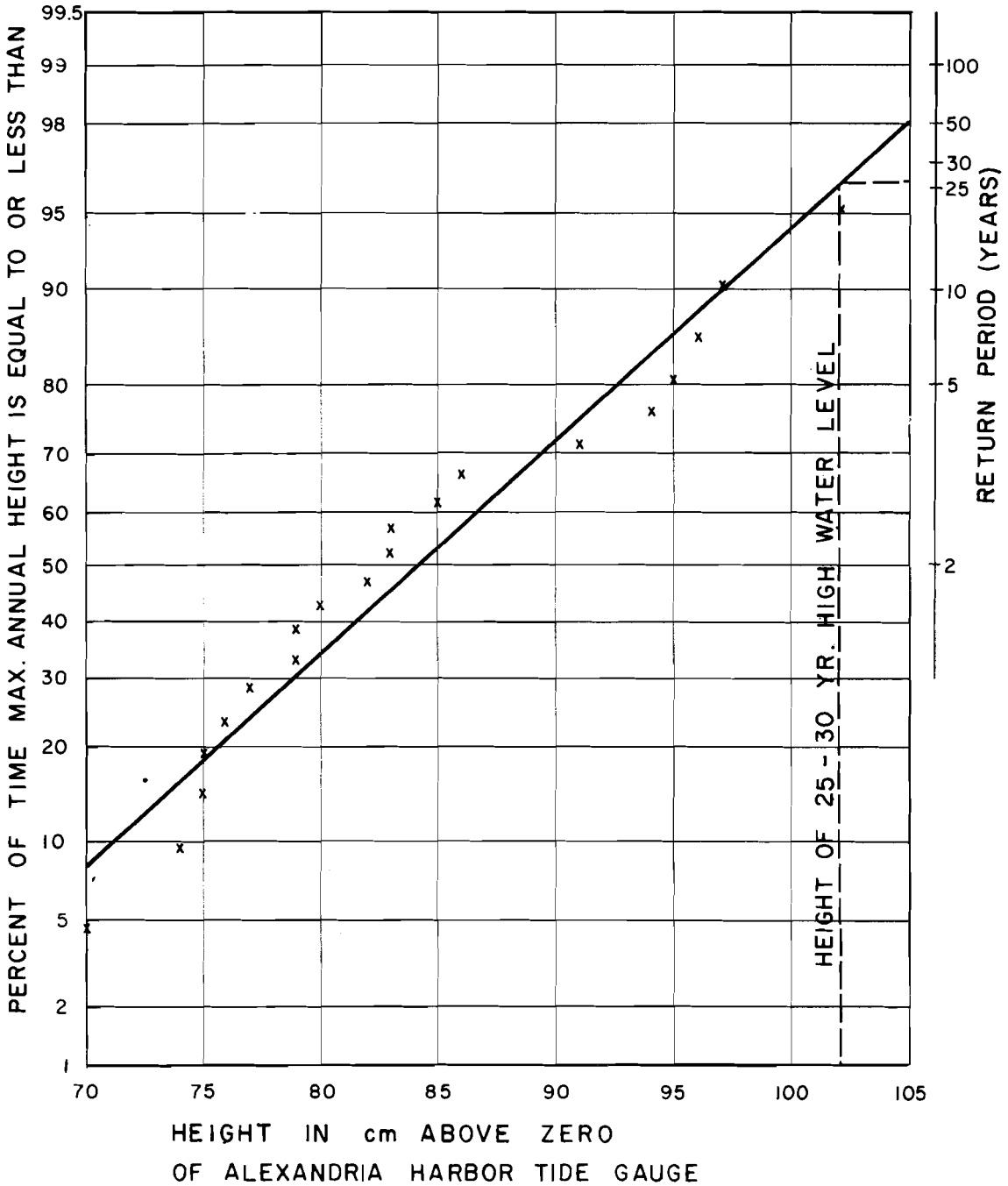
The section more than 500 m from shore is by no means deep enough to avoid wave forces, yet lies on the sea bottom unprotected. Furthermore, it was made of steel with insufficient cathodic protection provided, judging from the degree of corrosion reported.

Future outfall design should, of course, ensure against these failures by selecting stronger, more corrosion resistant materials, by employing protective coatings and cathodic protection, by burying the pipeline through the surf zone and offshore to a suitable depth, and by proper bedding and revetment beyond that depth.



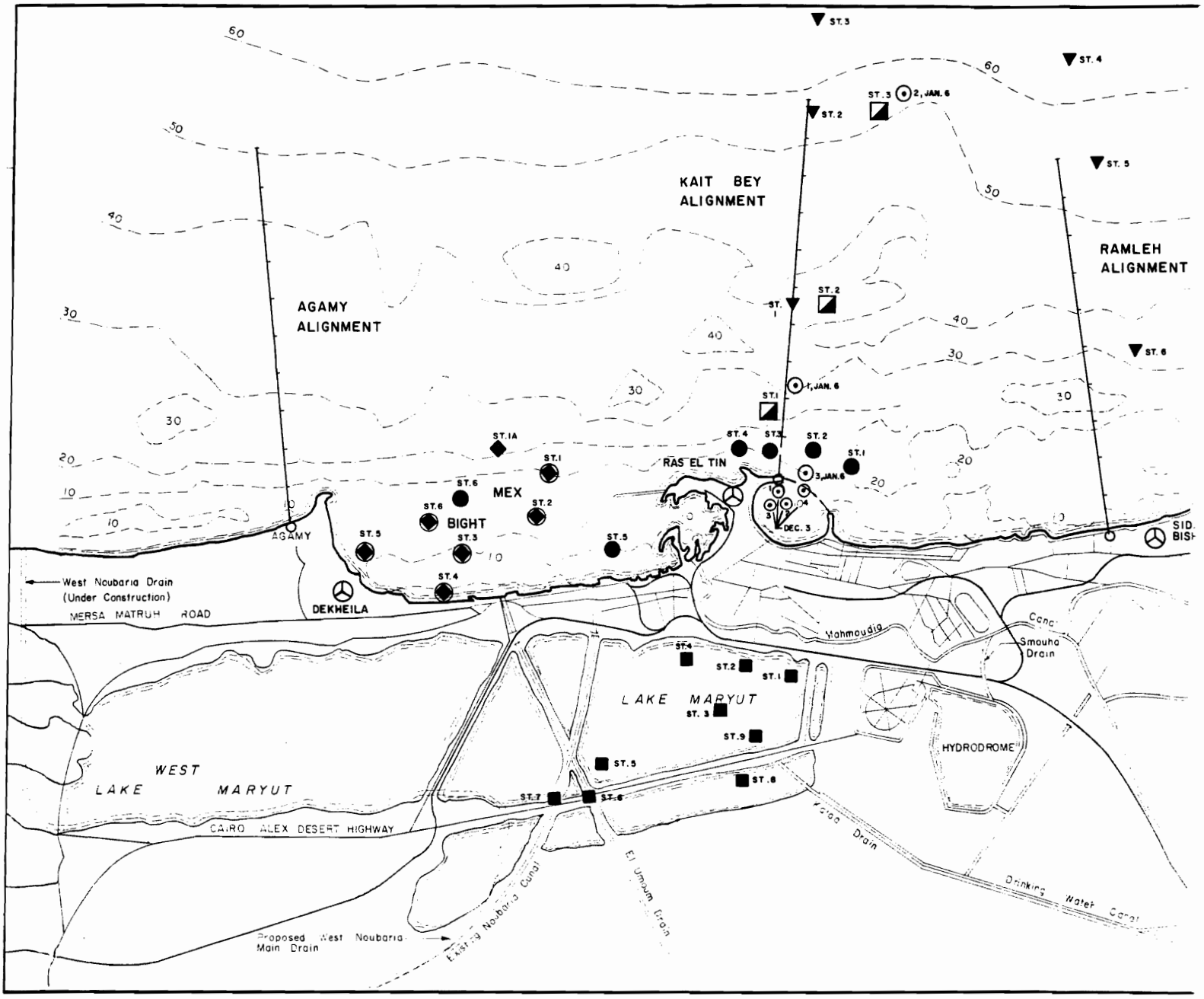
WATER LEVEL AT ALEXANDRIA

FIGURE 3-1



MAXIMUM ANNUAL WATER LEVELS
AT ALEXANDRIA HARBOR TIDE GAUGE

FIGURE 3 - 2


KAIT BEY ALIGNMENT
AGAMY ALIGNMENT
RAMLEH ALIGNMENT
RAS EL TIN
MEX
BIGHT
AGAMY
DEKHEILA
West Noubaria Drain (Under Construction)
MERSA MATRUH ROAD
LAKE MARYUT
WEST LAKE MARYUT
HYDRODROME
CAIRO ALEX DESERT HIGHWAY
Mahmoudia
Smouha Drain
Kadd Drain
Drinking Water Canal
El Umum Drain
Existing Noubaria Canal
Proposed West Noubaria Main Drain
ST. 1A
ST. 1
ST. 2
ST. 3
ST. 4
ST. 5
ST. 6
ST. 7
ST. 8
ST. 9
2, JAN. 6
1, JAN. 6
3, JAN. 6
DEC. 3
60
50
40
30
20
10
0

136

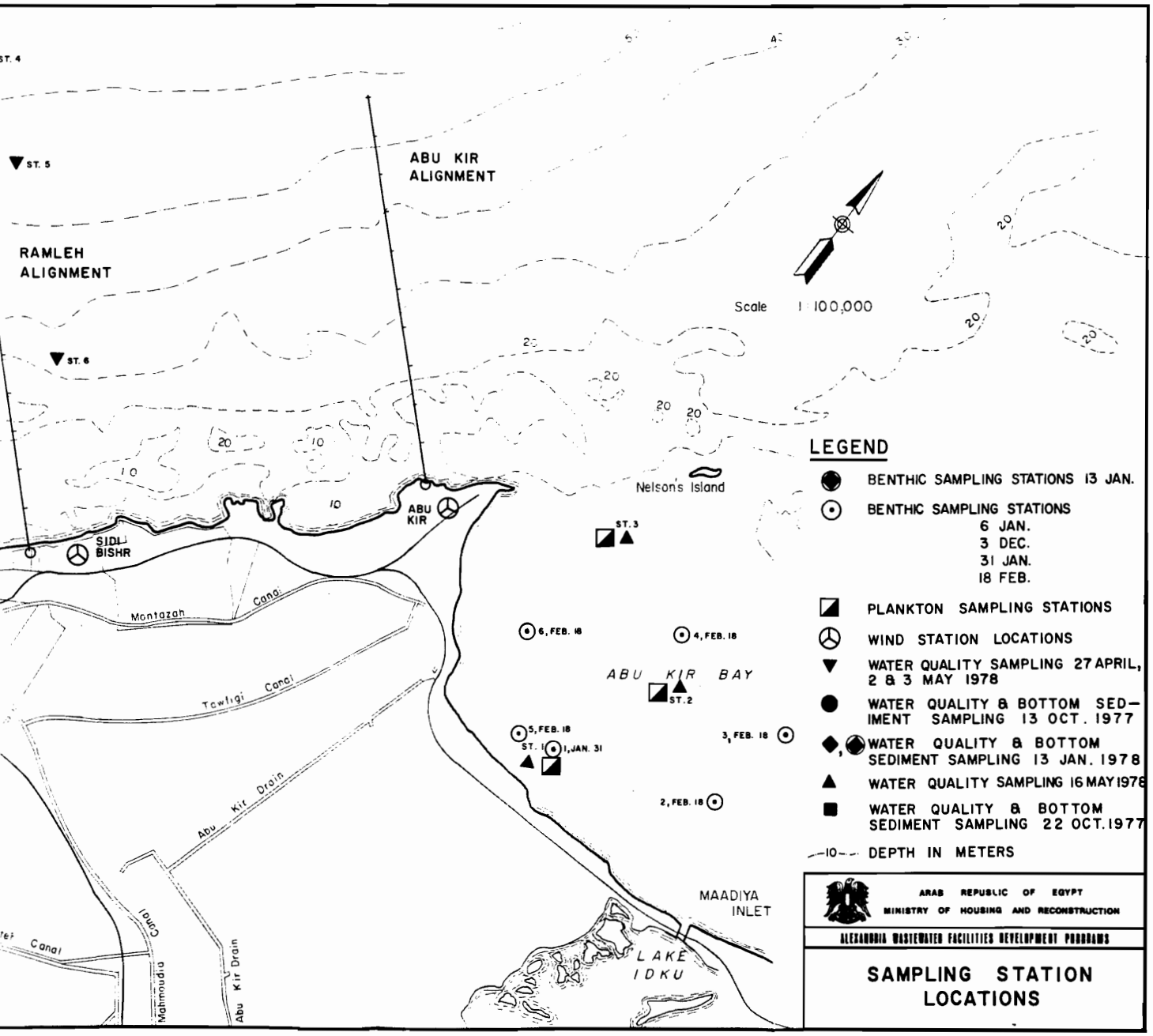
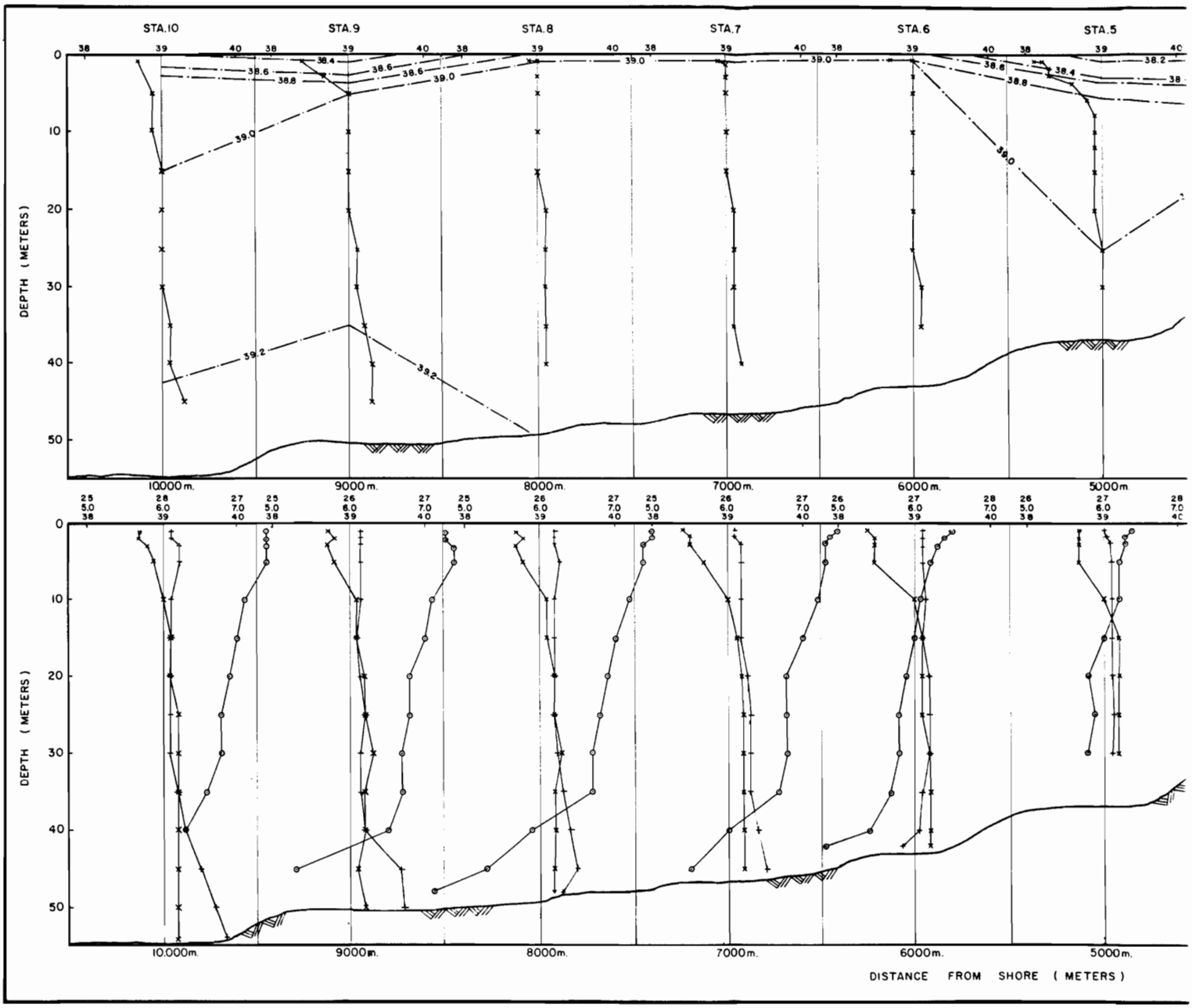


FIGURE 3 — 3

1364


STA.10
STA.9
STA.8
STA.7
STA.6
STA.5
DEPTH (METERS)
10000 m.
9000 m.
8000 m.
7000 m.
6000 m.
5000 m.
10,000 m.
DISTANCE FROM SHORE (METERS)

137

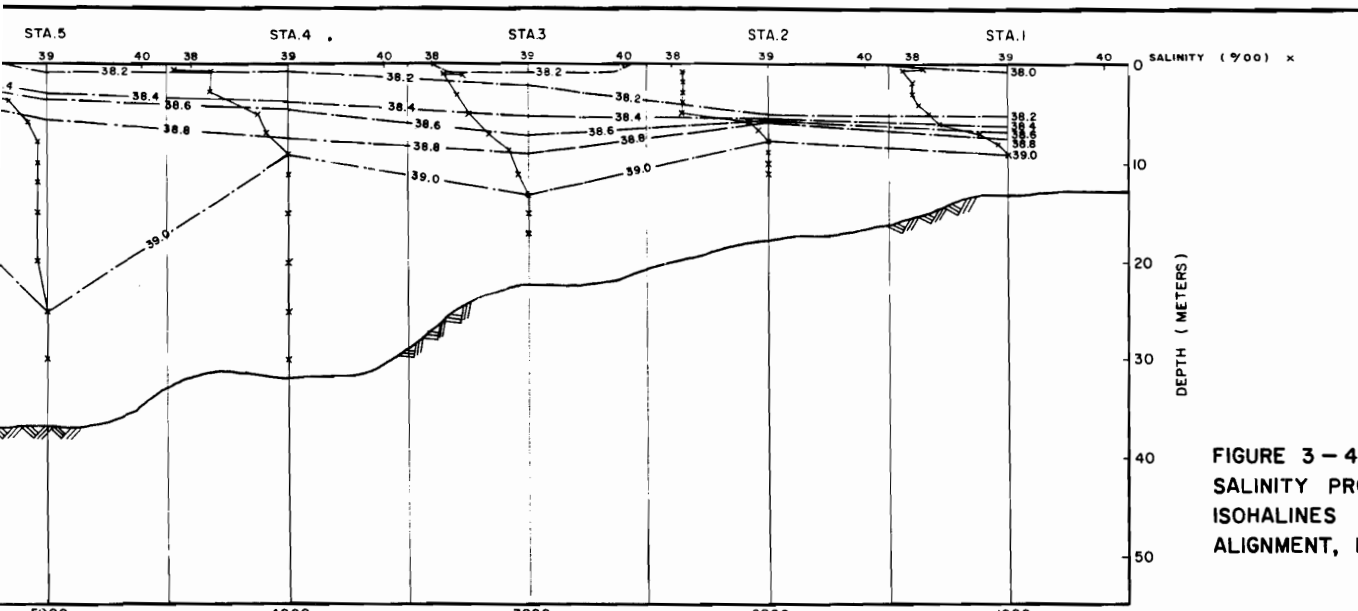


FIGURE 3 – 4
SALINITY PROFILES AND ISOHALINES FOR RAMLEH ALIGNMENT, 17 SEPT. 1977.

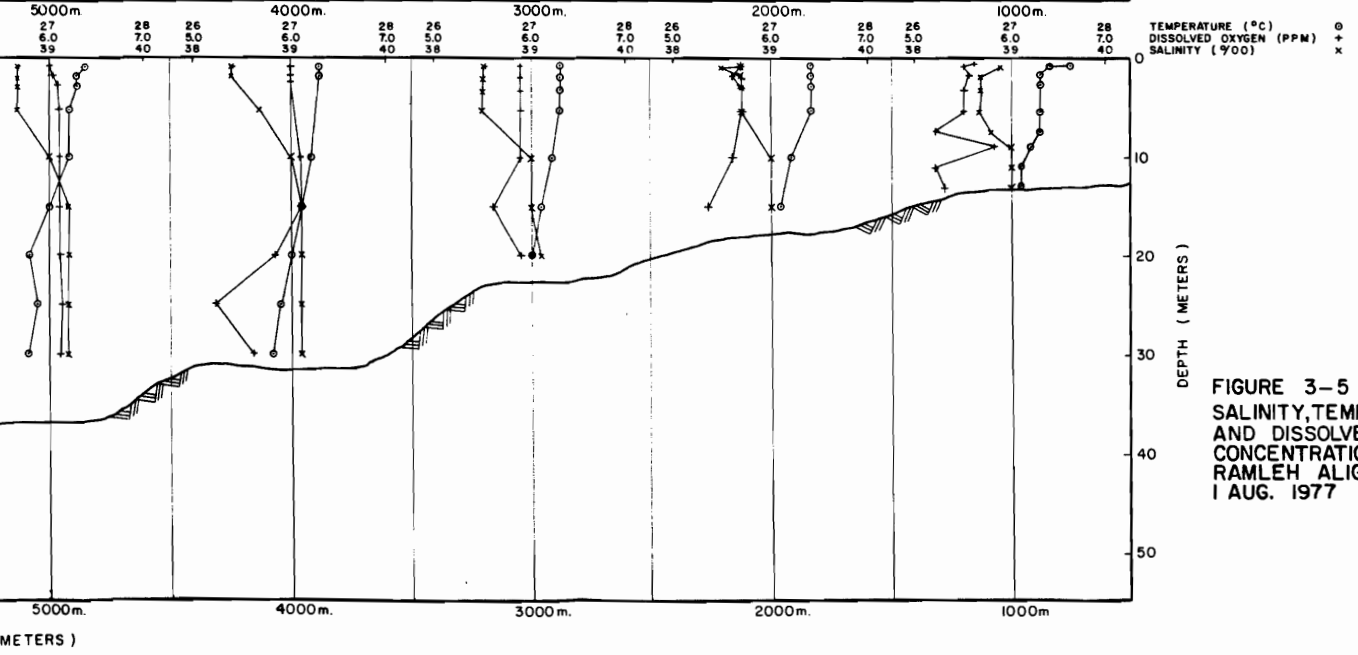
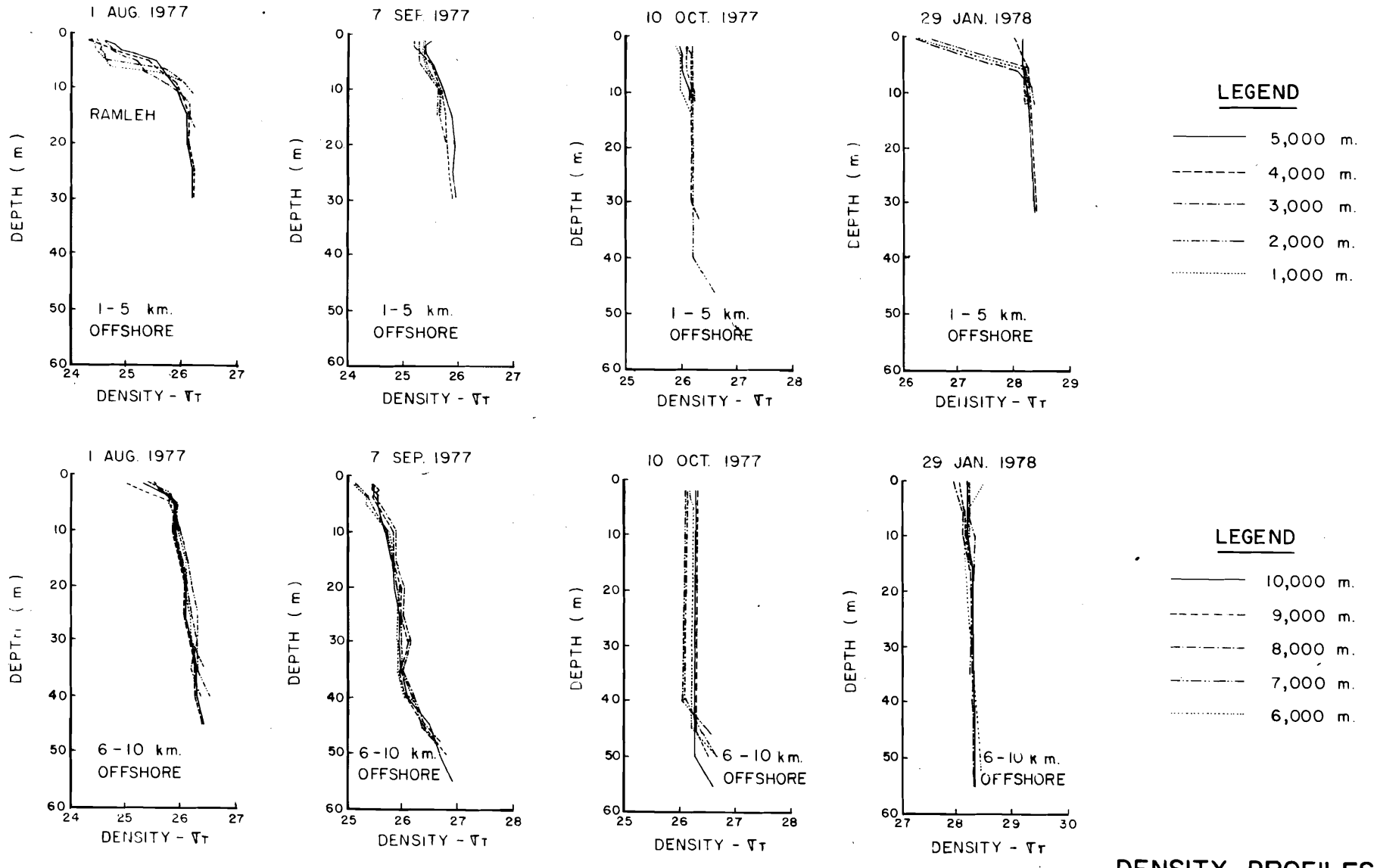


FIGURE 3–5
SALINITY, TEMPERATURE AND DISSOLVED OXYGEN CONCENTRATIONS FOR RAMLEH ALIGNMENT 1 AUG. 1977

FIGURE 3 – 4 , FIGURE 3 – 5

137A



DENSITY PROFILES
RAMLEH ALIGNMENT

FIGURE 3 - 6

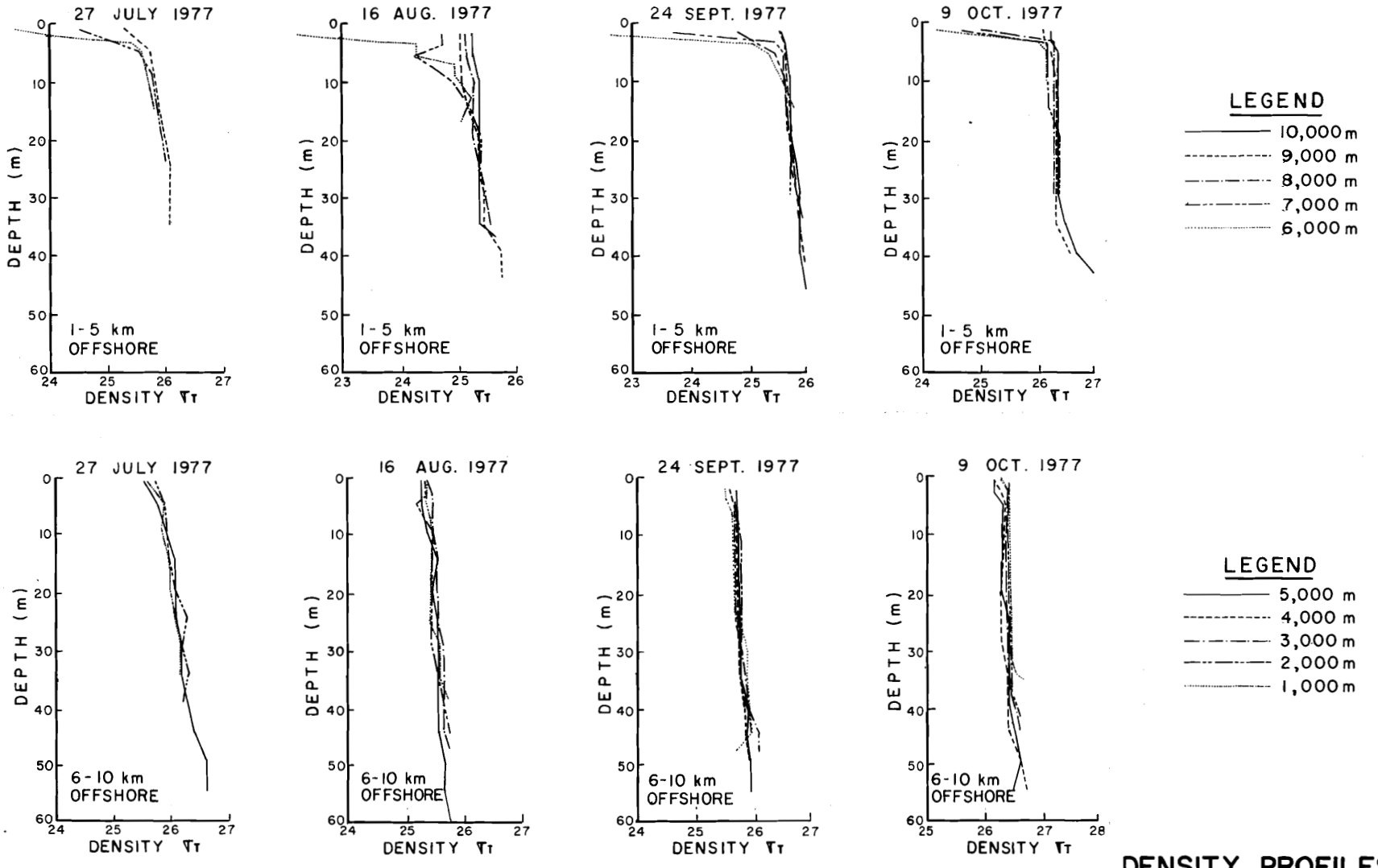


FIGURE 3-7

DENSITY PROFILES
KAIT BEY ALIGNMENT

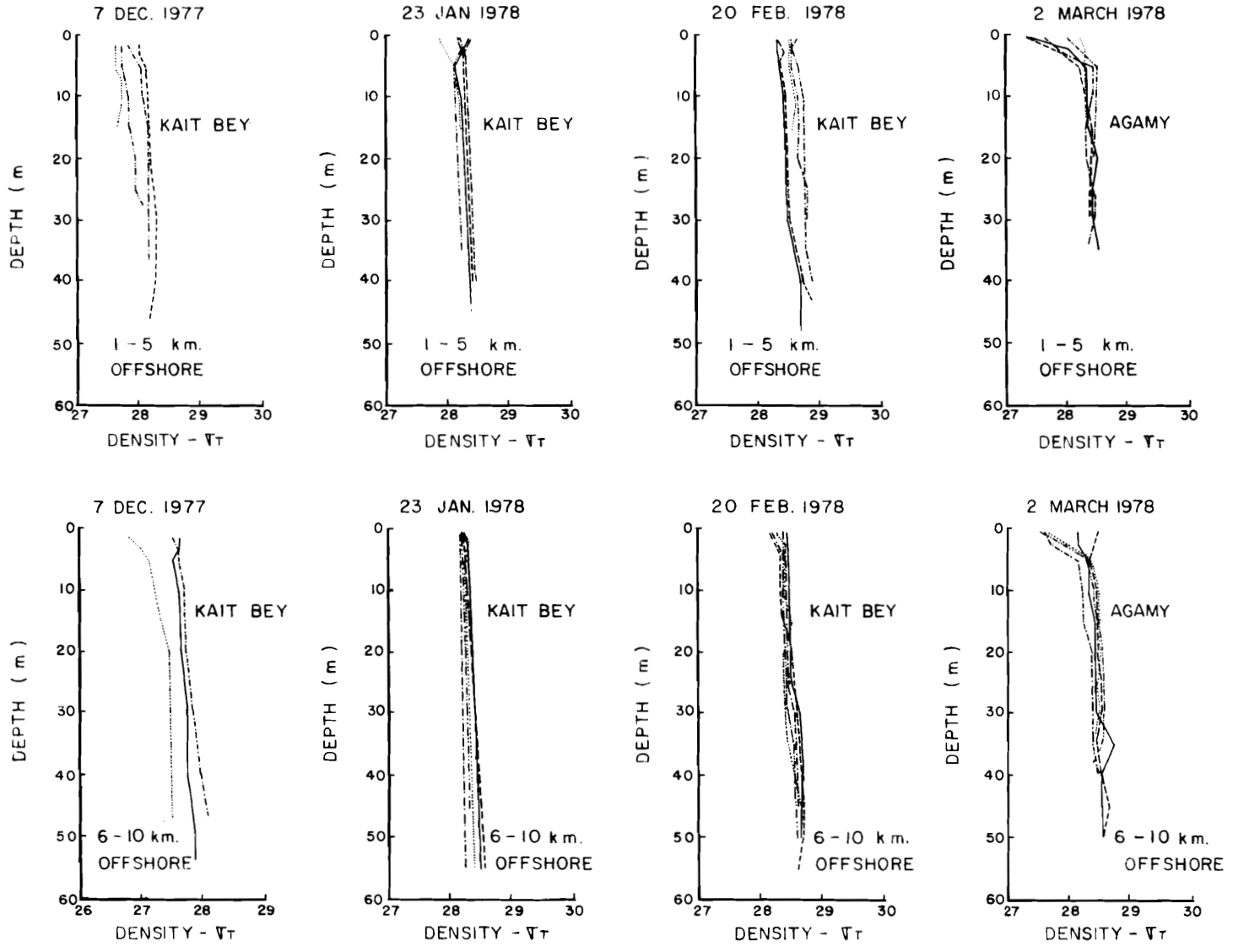
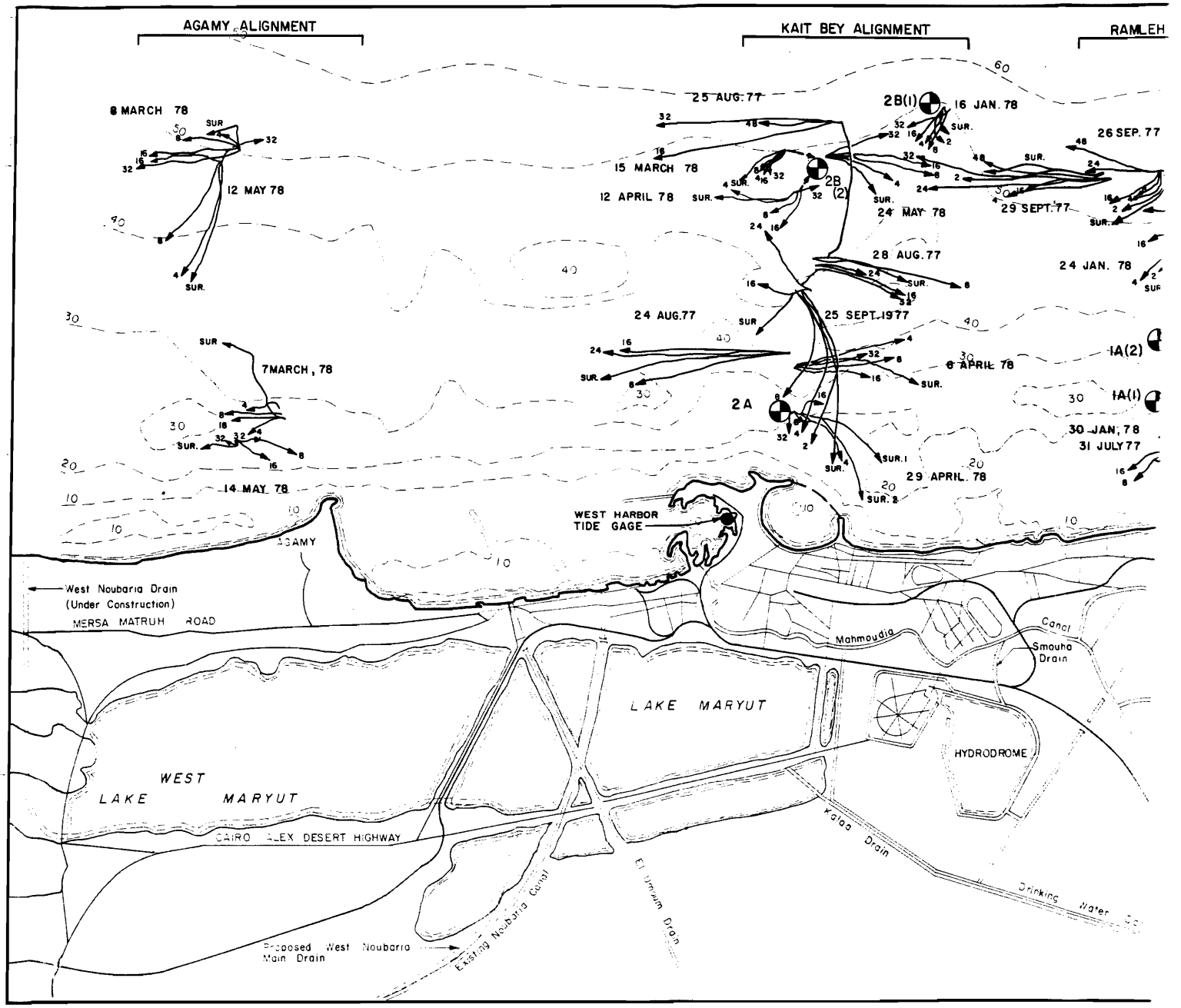


FIGURE 3-8

DENSITY PROFILES
KAIT BEY & AGAMY
ALIGNMENT


AGAMY ALIGNMENT
KAIT BEY ALIGNMENT
RAMLEH
8 MARCH 78
12 MAY 78
7 MARCH, 78
14 MAY 78
25 AUG. 77
15 MARCH 78
12 APRIL 78
2B(1)
16 JAN. 78
2B (2)
24 MAY 78
26 SEP. 77
29 SEPT. 77
28 AUG. 77
24 JAN. 78
24 AUG. 77
25 SEPT. 1977
8 APRIL 78
1A(2)
1A(1)
2A
30 JAN. 78
31 JULY 77
29 APRIL. 78
WEST HARBOR TIDE GAGE
AGAMY
West Noubaria Drain (Under Construction)
MERSA MATRUH ROAD
Mahmoudia
Canal
Smouha Drain
LAKE MARYUT
WEST LAKE MARYUT
HYDRODROME
CAIRO ALEX DESERT HIGHWAY
Kalaa Drain
Drinking Water
El Omoum Drain
Existing Noubaria Canal
Proposed West Noubaria Main Drain

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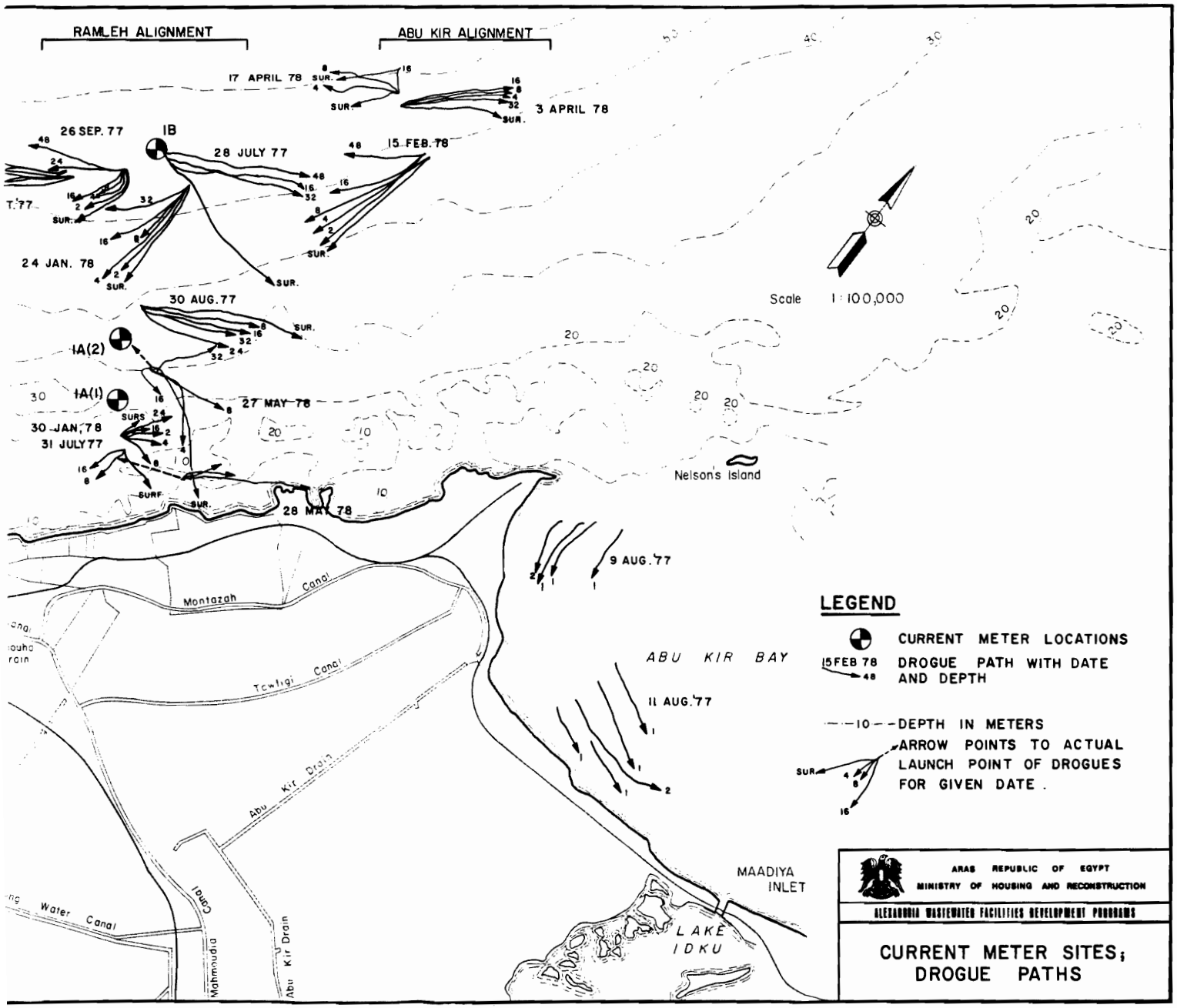

FIGURE 3—9

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CHAPTER 4

DISCHARGE STRATEGY AND QUANTITATIVE CRITERIA

4.1 Strategy

Development Program

These oceanographic studies are a part of the Alexandria Wastewater Facilities Development Program. The Master Plan contains the recommendations that:

1. Wastewater from the central and eastern parts of the Alexandria Governorate be discharged to the Mediterranean sea through long outfalls at Sidi Bishr and Kait Bey Fort.
2. That wastes from industries bordering Abu Kir Bay be detained in an evaporation pond near Lake Idku.
3. That wastes from Mex and Dekheila and from Ameria be treated in stabilization ponds before discharge to the West Noubaria Drain and thence to the sea.

These recommendations are discussed below in qualitative terms.

Sidi Bishr and Kait Bey Outfalls

Interpretation of the oceanographic field data obtained in this program leads to the conclusion that discharge of large quantities of sewage from properly designed outfalls will not impair the aesthetics nor endanger public health at Alexandria beaches, and will not have a net adverse impact on marine life. In fact, the nutrient-deficient sea may benefit from the increasing wastewater flows expected through the year 2000 which will be dispersed and not trapped along the shoreline. The oxygen content throughout the water column in the study area is high, so that wastewater discharges can be adequately oxidized without severe oxygen depletion.

Proper design of the outfall system would include:

1. Discharge sufficiently far from shore to be beyond the low-salinity lens occasionally observed along the coast.
2. Discharge sufficiently far from shore to be in a region of relatively strong and persistent currents.
3. Discharge in waters sufficiently deep, through a diffuser sufficiently long, to ensure a high degree of initial dilution.

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4. Discharge sufficiently far from shore to ensure adequate overall dilution and microbial decay by the time any part of the effluent plume reaches shore, so as to meet public health criteria for bathing beaches.
5. Preliminary treatment of the wastewater to remove rags, string, grit, and other large solids; and to remove much of the oil found in Alexandria sewage.
6. Adequate structural protection for each outfall to prevent damage by direct wave action or by beach erosion.
7. Adequate port size to avoid clogging of the ports by solids not removed in the pretreatment process.

The outfalls will be part of a sewerage system that is intended to free the beaches of shoreline and nearshore sewage discharges. With such a system, one may expect safer bathing conditions and generally cleaner water along the beaches. There may be some reduction in the amount of oil deposited on the beaches if the mazout and crankcase oil presently dumped into the sewers are either effectively excluded from the sewers and/or removed in the pretreatment process.

One should realize, however, that the system cannot be expected to entirely relieve the beaches of the unattractive yellow or even brown color the nearshore waters sometimes attain when the low-salinity lens is trapped near the shore for several days. This is because, even with the outfalls, large-scale discharges from the Mex Canal will continue carrying waters from the Umoum Drain and Lake Maryut. Furthermore, the system will not be able to relieve the beaches of most of the oil that washes ashore from ships.

In the Alexandria Wastewater Facilities Master Plan, the outfalls were chosen in preference to several other disposal alternatives, including disposal to Lake Maryut following secondary treatment. It has been pointed out in the Master Plan Report, that at the rate of eutrophication now occurring in Lake Maryut, there will, in a few decades, no longer be a lake but only a marsh, with a channel through the marsh from the treatment plant to the Mex Canal. Discharge to Lake Maryut will become, in effect, discharge to the

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Mex Bight, mitigated somewhat by the nutrient removal provided by flow through the marsh. Discharge of large quantities of secondary effluent at the Mex shoreline will be a form of ocean disposal considerably inferior to discharge far offshore through outfalls, particuarly if in the future the Mex Bight is partially enclosed by new breakwaters which may be constructed as part of a harbor expansion program.

Abu Kir Bay

As noted in Section 3.1, Abu Kir Bay is presently subjected to heavy pollution from paper mill and other wastes discharged at the Tabia Pump Station. It is shown in Section 3.1 that most of the time the discharge plume flows east along the coast past Maadiya and Idku towards Rosetta.

There are numerous indications that this discharge is significantly harming local marine life, as well as tending to obstruct the Maadiya inlet. With measured current speeds of the order of 0.1 m/sec, and a total volume (southeast of a line from Nelson Island to Ras Umm El Nabayil) of only 3 million m^3, this shallow, quiet bay has only a limited capacity for assimilating wastes. Wastes discharged at the shoreline stay near the shoreline much of the time. Outfalls could, of course, be built to carry the wastes offshore, but with water depths of only 5 to 10 m, it will be difficult to obtain good initial dilution of the wastes, even with long multiport diffusers.

Any discharges from future industries will aggravate the situation. There is also the prospect that an electric power plant which draws cooling water from the bay may encounter maintenance problems due to the pollution.

These comments about Abu Kir Bay are based on limited observations only, but corroborative observations may be easily made by local oceanographers. For the present, it is proposed in the Alexandria Wastewater Facilities Program Master Plan that industrial wastes now being discharged to the Bay be sent instead to an evaporation pond near El Tarh. It is important that overflow or drainage from such a pond not be admitted to Lake Idku. It may be proposed further that a management plan for Abu Kir Bay be created in the near future.

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The management plan would necessarily involve both Alexandria and Beheira governates, and several ministries such as Housing and Reconstruction, Fisheries, Agriculture, Industry, and Electricity, to name a few. The plan would serve to regulate the industrial development along the Abu Kir Bay shoreline so that the bay may enjoy balanced optimim use as a fishery, a source of cooling water, and a receiving water for waste discharges, yet with no one use ruining the bay for other uses.

Mex, Dekheila, Ameria

These areas are somewhat distant from the areas served by the Kait Bey and Sidi Bishr outfalls; and their projected loads for the next few decades are sufficiently small that separate outfall systems are not justified. Therefore, stabilization ponds are recommended.

The flows are small and well-managed stabilization ponds can provide an adequate degree of treatment. The pond effluents will be diluted with the other water in the West Noubaria Drain. Still, because the discharge will be ultimately to the shoreline near a bathing area, the water quality should be monitored regularly.

Northwest Coastal Zone

A recent planning report[1] submitted to the Ministry of Housing and Reconstruction,outlined a proposal for development of the coastal strip west of Alexandria, from Sidi Kreir to El Alamein. The population projected for the 20th year of the program is 500 000, with a projected sewage discharge of 160 ML/day, or about 2 m^3/sec. The plan calls for secondary treatment with disposal inland as irrigation water; or, as an alternative, disposal to the sea.

[1]Prof. Dr. A. A. Attia and Associates, NW Coastal Zone Physical Planning and Development Program, Report 1, Planning and Urban Development, Cairo, 1 March 1978.

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This northwest coastal zone is of course not within the study area of our project, but when assessing the far-field capacity of the Mediterannean Sea to assimilate the projected 11 m^3/sec of wastewater from Alexandria's outfalls, it is well to know the approximate load to be expected from neighboring areas. It is likely that the total projected 2 m^3/sec of effluent from the coastal zone, if discharged to the sea from a number of well-designed outfalls along the strip, would be a tolerable addition to the 11 m^3/sec discharged from Alexandria outfalls.

Toxic Materials

Agricultural Pesticides. Agricultural pesticides may be found in waters draining from agricultural lands, eventually finding their way to the sea. At present, pesticides in seawater are not yet evident. Gas chromatograph tests on water collected from the Mex Bight and off Anfushi showed no evidence of any of the pesticides sought (endrin, aldrin, dieldrin, DDE, and DDT).

On the one hand, if pesticide concentrations increase to noticeable levels, it will happen first in the agricultural drains, long before it will be noticed in the ten- to fifty-fold diluted plumes from drainage discharge points at Hanoville, Mex and Tabia. On the other hand, pesticides can be accumulated in fish and other marine life to concentrations far in excess of those in the surrounding seawater. Periodic monitoring of fish flesh for pesticides is therefore advisable.

Industrial Toxic Wastes. The unregulated disposal of industrial toxic materials, including heavy metals, could have a severe impact on the Mediterranean Sea. In order to minimize the impact of toxic wastes discharged into the sea, pretreatment of these wastes at their source will be necessary. The Master Plan Technical Report[1] contains a recommended sewer ordinance which would give the General Organization for Sewerage and Sanitary Drainage (GOSSD)

Camp Dresser and McKee Inc., Charles T. Main International Inc., Arab Technical and Economical Consulting Office, Alexandria Wastewater Master Plan Study, Volume II, Technical Report, 1978.

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the authority to set limits on the types and quantities of materials that could be discharged to the sewer system. Implementation and strict enforcement of the sewer ordinance will be the key to the achievement of adequate disposal of industrial toxic wastes.

Presently, Camp Dresser and McKee Inc. and Charles T. Main International, Inc. are involved in two studies concerning industrial waste disposal. One study, during the summer of 1978, is being conducted to prepare cost estimates for the pretreatment of industrial wastes at about 50 industrial plants in Alexandria. The cost estimates are to be based on standard industrial treatment practices. Specific treatment process designs are not included in this study but should be established at the time that pretreatment is to be implemented at a plant. The design criteria for the pretreatment facilities will be based on the requirements set forth in the sewer ordinance in effect at that time.

A second study by CDM is focusing on the institutional, management, and training needs that will enable GOSSD to operate effectively as a wastewater authority. (As a part of this study, recommendations are to be made that will provide the framework within GOSSD for implementing and enforcing a sewer ordinance.)

Presently no enforceable criteria exist for the diposal of wastewater into the Mediterranean Sea at Alexandria. However, current research by the MED POL program (described in the next section) is intended to provide the background concentration, c_o, and the maximum permissible concentration c_r, in seawater for each material of concern. Values of c_o and c_r, selected as receiving water quality standards by GOSSD, should be coordinated with those established by the MED POL Program.

Once water quality standards are established, the permissible effluent concentration, c_e, of each material to be discharged, can be determined

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by the formula:

$$c_e = c_o + S\ (c_r - c_o) \qquad \text{ea. (4-1)}$$

where c_e, c_r, and c_o are as stated above, and S is the dilution ratio provided by the outfall. Means of controlling industrial discharges so that c_e is not exceeded in the collection system can then be established.

CDM-MAIN engineers believe that the enforcement of the recommended sewer ordinance and the pretreatment of industrial wastes by standard industry practices will enable the sewerage authority to discharge wastes through ocean outfalls and meet whatever quality standards are proposed, assuming the standards to be about as stringent as those proposed in 1977 for California, USA.

Fisheries

With outfalls designed to provide sufficient dilution to prevent serious oxygen depletion, and to disperse settleable solids effectively, and with toxic materials effectively controlled at their sources, there should be little adverse effect in the fisheries; in fact, there may well be a net benefit from the nutrients (note the large numbers of pole fishermen found daily near the present Kait Bey outfall and the other sewer discharge points). Curtailing the pollution in Abu Kir Bay may greatly improve the fishery there and in Lake Idku.

There is not a great shellfish industry near Alexandria, but some shellfish and sea urchins are taken by individuals from nearshore waters. The main danger of pathogenic organisms in seawater, apart from the danger to bathers, is that many types of shellfish concentrate them to levels many times greater than found in the ambient seawater.[1] The danger to human consumers is particularly great if the shellfish are eaten raw, as is often popular. Cooking the shellfish greatly decreases the danger, but is not always sufficient

[1] Petrilli, De Flora and Lemori, "Pollution of Coastal Waters in Italy--Bacteriological and Virological Research, Marine Pollution and Marine Waste Disposal, Pergamon Press, 1975.

to inactivate the pathogens entirely. It is best, therefore, to eliminate discharges from regularly harvested shellfish areas. Routing wastewater through long outfalls and providing a high dilution ration, rather than discharging at the shoreline with little dilution, will greatly reduce the contamination of shellfish near the shore.

Monitoring

The preliminary outfalls designs to be presented in Chapter 5 represent a sound and safe solution to Alexandria wastewater disposal problems. However, it is always prudent to monitor the performance of a disposal system to ensure that public health and other criteria are adequately met.

Bacterial levels at beaches should continue to be measured as they have been for several seasons past. The accumulation of heavy metals and toxic material in bottom sediments and organisms, including fish and shellfish should be monitored. Although the accumulation of toxic levels of these wastes is not anticipated, periodic sampling should be conducted in and over the sediments surrounding the outfalls, as well as in areas where shellfish are regularly harvested, to make sure that toxic concentrations are not reached. Benthic organisms should be monitored for size and chemical composition. Should monitoring show that accumulation of heavy metals or other toxic wastes are reaching dangerous levels, requirements for source control of these wastes would then be strengthened. Further suggestions for a suitable monitoring program may be found in the MED-POL Guidelines.[1]

[1] Coordinated Mediterranean Pollution Monitoring and Research Programme, Guidelines for Health Monitoring of Coastal Water Quality, World Health Organization, 1977.

4.2 Programs to Develop Water Quality Criteria

Existing Water Law

Regulations concerning the discharge of liquid wastes are contained in Egyptian Law No 93 of 1962, issued by the Ministry of Housing and Reconstruction. The law covers the implementation and management of sewerage works in general. Chapter 6 of the law specifies standards for the discharge of industrial and domestic wastes into: (1) the general sewage system, (2) the Nile River and its branches, and (3) open drains and channels. In addition, the law contains standards for the reuse of wastewater for irrigation.

While assigning some specific criteria for discharge to sewers, rivers, and canals, the law lists no specific standards for discharges to lakes or the sea; it states only that discharges are permitted if they do not contain any matter which may adversely affect swimming beaches. Because it is not specific about discharges to lakes and the sea, the law is impracticable to enforce, as is evident from the gross pollution observed at several beaches and in much of Lake Maryut.

Furthermore, in the sixteen years since Law No 93 of 1962 was drafted, considerable research has been carried out around the world into the effects of pollutants discharged via wastewater outfalls into natural waters. This research is enabling more rational, extensive, and specific water quality criteria to be developed. Many countries have adopted such criteria, tailored to local conditions; it would be well if Egypt were likewise to update and improve its existing water law.

The MED POL Program

At Monaco in September 1974, the United Nations Environmental Program (UNEP), together with agencies of UNESCO, FAO, and the International Commission for the Scientific Exploration of the Mediterranean (ICSEM), sponsored an International Workshop on Marine Pollution in the Mediterranean. The workshop defined the pollution of coastal waters as the main environmental problem of the Mediterranean Sea. This pollution was attributed to the

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general lack of adequate systems for the treatment and disposal of domestic and industrial waste, to the input of pesticides and petroleum hydrocarbons and to the presence of pathogenic organisms.

Based on the recommendations of the Monaco Workshop, the Intergovernmental Meeting on the Protection of the Mediterranean in Barcelona approved in February 1975, a coordinated Mediterranean Pollution Monitoring and Research Program (MED POL) as part of a wider Mediterranean Action Plan. The MED POL Program consists of seven pilot projects designed to monitor selected metals, pesticides, and other toxic materials in fish, study the effects of pollutants on fish and on ecosystems, monitor the levels and patterns of oil pollution, examine how pollutants enter and are transported off the shores of the Mediterranean.

In the three years since the inception of MED POL, there have been numerous meetings; staff members of the High Institute of Public Health, the Oceanography Department, Faculty of Science, and Institute of Oceanography and Fisheries, all from Alexandria, have taken active roles in the proceedings. In 1976, a MED POL conference in Barcelona approved a protocol against pollution by dumping from ships and aircraft, specifying a "black list" of prohibited substances and a "grey list" of substances to be dumped only by special permit, and requiring a general permit for the dumping of all other matter. In February 1977, in Athens, conference participants began preparation of a draft Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources. It is expected that this protocol will, like the first, include a "black list" of substances whose discharge should be prevented, and a "grey list" of materials whose discharge would require special care and strict limitation.

Egypt may be expected to sign forthcoming protocols and conventions by MED POL. Their criteria and recommendations should be observed in future planning and design of collection and discharge systems for wastewater at Alexandria.

HIPH/EPA Epidemiological Study

The High Institute of Public Health at Alexandria University (HIPH), in conjunction with the United States Environmental Protection Agency (EPA), has conducted extensive epidemiological studies in Alexandria during the 1976, 1977, and 1978 summer bathing seasons in an attempt to establish a relationship between the presence of microbial indicator ogranisms in the sea and adverse health effects on bathers.[1,2,3] The EPA involvement is a continuation of an epidemiological-microbiological study which has been conducted at New York City beaches in recent years, and currently on a beach on Lake Pontchartrain, Louisiana, USA.[4] Stated very briefly, the procedure at Alexandria has been to select a relatively unpolluted beach, a moderately polluted beach, and a heavily polluted beach for study; to sample the water at each beach regularly and frequently for concentrations of thermotolerant E. Coli and Enterococci; and to interview large samples of swimmers and non-swimmers at each beach, recording their medical histories through weekly follow-up interviews for a number of weeks. The rate at which swimmers subsequently complain of certain illnesses (in excess of the rate at which non-swimmers complain of these illnesses) is then compared with the concentration of indicator organisms in the associated bathing water. Some of the results are discussed further in the next section.

Such epidemiological studies producing relatively coherent, rational, and useful results are only very recent. They have yet to stand the tests of

[1] Hakim, K.E., "Study of Relationship of Microbial Indicators to Health Effects at Alexandria Bathing Beaches," Progress Report covering the period 1 July 1976 to 30 September 1976, HIPH, Alexandria.

[2] Hakim, K.E., "Study of Relationship of Microbial Indicators to Health Effects at Alexandria Bathing Beaches," Progress Report covering the period October 1976 to 31 December 1977, HIPH, Alexandria.

[3] Cabelli, V.J., "Evaluation of Recreational Water Quality, the EPA Approach," paper presented at International Symposium on Biological Indicators of Water Quality, University of Newcastle upon Tyne, England, 12-15 September 1978, 1978 (Draft).

[4] Cabelli, V.J., et al, "Relationship of Microbial Indicators to Health Effects at Marine Bathing Beaches," Health Effects Research Lab., Cincinnati, USEPA, 1976 (Draft).

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accumulated reproducibility and utility, and critical examinations of procedure and rational significance. Still, they are a most welcome and promising addition to the admittedly otherwise meager store of tools available to the designer of wastewater facilities to meet public health requirements for bathing areas. These epidemiological studies are particularly relevant to this study, becuase so much of the research work was done on the very beaches that must be protected by adequate measures in the design and construction of the Alexandria outfalls.

4.3 Criteria and Guidelines Adopted Herein

At present (1978), there are no specific quantitative criteria for discharges from land-based sources to the sea, either in Egyptian law or in MED POL proceedings. For present design purposes, therefore, water quality criteria are adopted herein which reflect sound and widely-held opinion elsewhere in the world. They must, of course, be reviewed and approved by relevant Egyptian authorities.

Bacteria and Viruses

A review of recent research concerning the infectivity and viability of viruses and bacteria in seawater was conducted to determine the most suitable and practical criterion presently available for establishing safe microbial levels for seawater bathing. This literature review is presented in Appendix E. From this review, it was concluded that fecal coliforms, and specifically E. Coli, are, at present, the most suitable indicator organism for the purpose. Furthermore, it appears that an E. Coli concentration of 1000/100 ml is an approximate threshold concentration below which viruses and pathogenic bacteria are far less likely to be present than otherwise.

Table 4-1 is a compilation of standards developed for bathing waters by various countries and organizations, as reported in the proceedings of two recent conferences. At both the 1973 San Remo Conference and the 1974 Bilthoven Conference, the standards for all countries listed did

TABLE 4-1

BACTERIAL STANDARDS FOR BATHING WATERS ADOPTED ELSEWHERE

Location	Criteria	Authority	Source of Information
Greece	A. Safe for bathing 0- 50 B. Acceptable, with reservations 51- 500 C. Doubtful 501-1000 D. Unsafe >1000 (Units: E. Coli/100 mL)	Health Regulation No. 221 of 1965	"Guides and Criteria for Recreational Quality of Beaches and Coastal Waters," report of working group convened by the Regional Office for Europe of the World Health Organization, Bilthoven, Netherlands, 28 October 1974 - 1 November 1974.
Italy	Swimming allowed in seawater with fewer than 100 E. Coli/100 mL	Not specified	"
Belgium	Satisfactory if E. Coli counts are: 50% < 200/100 mL 95% < 1000/100 mL 99% < 2000/100 mL	No national legislation; these standards only recommended to regional public health authorities	"
Netherlands	Grade I < 100 E. Coli/100 mL Grade II 100-1000 E. Coli/100 mL Grade III >1000 E. Coli/100 mL	National Health Council	"
Denmark	Swimming allowed when fewer than 5% of samples show E. Coli 1000/100 mL	Not specified	"
Sweden	Suitable < 100 E. Coli/100 mL Unsuitable > 1000 E. Coli/100 mL	National Board of Health and Welfare	"
Poland	E. Coli < 1000/100 mL	Not specified	"
USSR	Coliforms < 1000/100 mL	Regulations for the Sanitary Protection of Coastal Regions, USSR Ministry of Health. 1964	"

TABLE 4-1
(Continued)

Location	Criteria	Authority	Source of Information
-	Highly satisfactory if E. Coli counts are consistently $<$ 100/100 mL Acceptable if E. Coli counts are not consistently $>$ 1000/100 mL	Bilthoven Conference Consensus	"Guides and Criteria for Recreational Quality of Beaches and Coastal Waters," report of working group convened by the Regional Office for Europe of the World Health Organization, Bilthoven, Netherlands, 28 October - 1 November 1974.
Yugoslavia	Acceptable if coliform MPN is less than 2000/100 mL	Federal Law on Inter-Republican and International Waters	J. Stirn in Proceedings of the 2nd International Congress, San Remo, Italy, 17-21 December 1973.
Isreal	Coliforms should be fewer than 1000/100 mL in 80% or more of the samples	G. Shelef et al, 1972, "Seawater Quality Criteria"	G. Shelef, San Remo Congress.
California	Coliforms MPN should not exceed 1000/100 mL in 80% of samples; maximum should not exceed 10,000/100 mL	State of California Water Resources Control Board 6 July 1972	E.A. Pearson, San Remo Congress.
USA	Fecal coliforms MPN should not exceed: Monthly geometric average 200/100 mL Weekly geometric average 400/100 mL	US Environmental Protection Agency, effective 1 July 1977	E.A. Pearson, San Remo Congress.
Philippines	Maximum allowable coliforms 1000/100 mL	National Water and Air Pollution Control Commission	H.F. Ludwing, San Remo Congress.

not vary greatly from the Bilthoven Conference consensus guidelines[1]: that highly satisfactory bathing areas should show E. Coli concentrations of consistently less than 100 per 100 mL, and to be considered acceptable, bathing waters should have E. Coli concentrations not consistently greater than 1000 per 100 mL.

Some of the results of the HIPH/EPA epidemiological study[2] are presented on Figure 4-1, in a plot of highly credible gastro-intestinal (GI) symptom rate versus E. Coli concentration. "Highly credible GI symptoms" includes all cases of vomiting; cases of diarrhea either accompanied by a fever or requiring the individual to stay home, stay in bed, or seek medical advice; and cases of stomach ache or nausea accompanied by a fever. For low E. Coli densities of 10 to 40 per 100 mL, the symptom rate for all beaches and populations was 0.4 to 0.8 percent. For greater E. Coli densities, the symptom rate appeared to increase most rapidly with density at New York and Lake Pontchartrain beaches, and for Cairo tourists at Alexandria. The symptom rate increased somewhat more slowly for Alexandria residents at their local beaches. Three regression lines appear in the figure. The long-dash line is for the New York City, Lake Pontchartrain and Cairo tourists at Alexandria, with a correlation coefficient of $r = 0.94$. The short-dash line is for Alexandria residents, with $r = 0.91$. The solid line is for all data, with $r = 0.79$.

A relationship such as that shown on Figure 4-1 would enable a governmental regulating agency to set an E. Coli standard for recreational marine water quality with some insight as to the associated symptom rate to be expected by adherence to that standard. The agency must make the (perhaps

[1] "Guides and Criteria for Recreational Quality of Beaches and Coastal Waters," report of working group convened by the Regional Office for Europe of the World Health Organization, Bilthoven, the Netherlands, 28 October 1974 - 1 November 1974.

[2] Cabelli, V.J., "Evaluation of Recreational Water Quality, the EPA Approach," paper presented at International Symposium on Biological Indicators of Water Quality, University of Newcastle upon Tyne, England, 12-15 September 1978.

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politically difficult) decision as to what symptom rate is acceptable. The costs of wastewater disposal may tend to make the agency seek a high permissible E. Coli concentration; agitation by people concerned about public health may tend to force the agency to set a very tight E. Coli standard associated with a symptom rate of, or close to, zero.

At this point, it is appropriate to observe that there is generally a non-zero background concentration of E. Coli near most beaches, even with no sewage outfalls in the vicinity. In Los Angeles, the coliform concentrations in the surf zone at numerous stations along Santa Monica Bay is usually not less than 6 to 40 per 100 mL, no matter how close or far from a point of sewage discharge.[1] For the relatively unpolluted beach at Maamura, Alexandria, the mean E. Coli concentration in May through August of 1977 ranged from 14 to 600 per 100 mL.[2] On Figure 4-1, the plotted points show mean E. Coli densities rarely less than 10 to 40 per 100 mL. The regulating agency may, therefore, rest in the knowledge that it is pointless to specify a coliform standard of less than, say 30 to 40 per 100 mL, a typical background level that, according to Figure 4-1, implies a symptom rate of slightly less than one percent. The Bilthoven Conference consensus guideline "highly satisfactory" concentration of 100 E. Coli per 100 mL implies an only slightly greater symptom rate of 1.2 percent; the Bilthoven "acceptable" value of 1000 E. Coli per 100 mL implies a symptom rate of about two percent, which perhaps could be called significantly greater than background.

It should be noted that Katzenelson and Shuval[3] suggest that due to remaining uncertainties about the viability and infectivity of pathogens, it is prudent to lessen one's reliance upon the coliform criteria by

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[1] Betz, J., from information presented at the Meeting to Discuss Proposed Ocean Outfalls in Alexandria, Egypt, Alexandria Governorate Palace, 29 August 1978.

[2] From Hakim, K.E., "Progress Report: Study of Relationship of Microbial Indicators to Health Effects at Alexandria Bathing Beaches," 1978.

[3] Katzenelson, E., and Shuval, H.I., "Viral Pollution Considerations in Marine Waste Disposal," Proceedings of the 2nd International Congress, San Remo, Pergamon Press, 17-21st December 1973.

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providing the wastewater with a high physical dilution ratio, such as 1:1000. This physical dilution ratio of 1:1000 will be adopted as a requirement to be met by a plume before it reaches a bathing beach. As for coliform bacteria, hard and fast standards will not be adopted at this point. Rather, these considerations of symptom rate criteria, commonly accepted standards, and background levels will be carried over into Chapter 5, where they are considered jointly with frequency distributions of coliform concentrations associated with various lengths of outfall.

Rationale for Guidelines for Other Parameters

The approach will be to establish, for each contaminant considered, an ambient concentration, c_r, which should not be exceeded. Background concentrations, c_o, and effluent concentrations, c_e, believed typical for each contaminant, will also be established. The required dilution, S, will then be calculated according to the formula:

$$S = \frac{c_e - c_o}{c_r - c_o} \qquad \text{eq. (4-2)}$$

This formula may be interpreted in this manner: "The discharge carrying a contaminant at concentration c_e, may, after dilution S, be allowed to raise the ambient concentration from its background level, c_o, to no more than the criterion level, c_r." This approach has been proposed for heavy metals discharge criteria in California.

The contaminants so considered herein are BOD, SS, P, and N. For each, it is judged whether the dilution, S, must be attained in the initial dilution process, or may include the secondary dilution process, or may include a systematic decay factor. The summary of water quality criteria adopted is shown in Table 4-3, at the end of this section.

Oxygen Demand

The concentration of dissolved oxygen (DO) is an important water quality parameter. For a good fishery to exist, the DO concentration must be at

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least 5 mg/L. Most fish, and many other forms of marine life, will die if the DO is less than 1.2 to 2.0 mg/L. DO is also important in the natural process of assimilating sewage, when aerobic bacteria decompose sewage into nutrients which feed marine life.

As shown in Table 3-21, average monthly DO values recorded in the program were 6.4 mg/L or greater. The lowest value recorded was 3.5 mg/L, found near a shoreline sewer overflow, in a subsurface zone with poor mixing. The two lowest values, recorded more than 5 km from shore, were 4.8 and 5.7 mg/L. For design purposes, the mean value of 6.4 mg/L observed in August and September will be adopted.

Table 2-3 shows projected flows and loads for the year 2000. For the Sidi Bishr outfall, the projected flow is 560 ML/day, bearing 270 tonnes per day of BOD, and 540 tonnes per day of COD, for concentrations of 480 mg/L and 960 mg/L of BOD and COD, respectively. For the Kait Bey outfall, the concentrations of BOD and COD will be 510 and 1020 mg/L, respectively.

Most COD in excess of BOD is oxidized slowly, over a period of days, or weeks, if ever. Accordingly, for initial dilution considerations, only BOD need by considered, not COD, since initial dilution occurs on a time scale of minutes, and is followed by secondary dilution processes within hours.

As shown in Table 3-40, the background value, c_0, of BOD_5 in nearby seawater is less than 1.0 mg/L (higher values were found in the Western Harbor and at the surface in the neighborhood of the present Kait Bey sewer discharge). For initial dilution considerations, a conservative background value of 1.0 mg/L will be adopted. For far-field dilution considerations, the background value will be neglected, since it will be effectively countered by oxygen diffusing downward from the sea surface (see Appendix D).

The criteria adopted here and shown in Table 4-3 are:

1. Initial dilution shall be sufficient that BOD, if fully exerted, will not depress DO levels from 6.4 mg/L to less than 2.0 mg/L. The allowable BOD concentration c_r, is therefore 4.4 mg/L. With a background concentration, c_o, of 1.0 mg/L, the required dilution ratios are 141 for Sidi Bishr and 150 for Kait Bey.
2. Far-field dilution shall be sufficient that neither BOD nor COD, if fully exerted, will depress DO levels from 6.4 mg/L to less than 5.0 mg/L. The allowable BOD or COD concentration, c_r, is therefore 1.4 mg/L. With background concentration neglected, the required dilution ratio for COD at the Kait Bey outfall, for example, is 730.

Suspended Solids

From Table 1-3, 335 000 kg/day of suspended solids (SS) from the Sidi Bishr outfall and 210 000 kg/day from the Kait Bey outfall are the projected average values for the year 2000, with screening and grit removal provided. Accordingly, the projected concentrations, c_e, are 600 mg/L and 536 mg/L for Sidi Bishr and Kait Bey, respectively.

Suspended solids are the source of turbidity that may impair biological photosynthesis, as well as the aesthetic attractiveness of the sea. The background turbidity of the sea near Alexandria can be very low with observed Secchi disc depths occasionally on the order of 40 to 50 m at 10 km offshore. On other occasions, the water is far less clear due to discharge plumes or plankton blooms.

To develop a criterion for suspended solids that will serve to maintain the clarity of the receiving waters, the following rationale has been adopted.

1. Traditionally, the turbidity of a suspension of 1.0 mg/L of Sio_2, meeting certain specifications of particle size, has been adopted as the standard for one unit of turbidity.[1]

[1] Sawyer and McCarty, Chemistry for Sanitary Engineers, McGraw-Hill, 1967.

2. The turbidity of 1.0 mg/L of suspended sewage solids may be expected to at least roughly comparable to the turbidity of 1.0 mg/L of standard SiO_2 suspension.
3. The distance through which light can penetrate water with a given suspended solids concentration may be related to turbidity units by an equation such as:

$$\text{Turbidity Units} = \frac{2434}{(\text{Light Path, cm})^{1.07}}$$

This equation was derived from a table for graduation of candle turbidimeter.[1]

An analytical chemist might object that the SiO_2 standard is an outmoded means of turbidity measurement; that turbidity of SiO_2 cannot practicably be related to sewage (SS) concentration; and the candle turbidimeter light path is not the same as Secchi disc depth. Still, the rationale does provide some guidance in relating water clarity to sewage SS concentration and will be retained until replaced by a superior one.

An SS concentration of 0.1 mg/L thus would imply a Secchi disc depth of many tens of metres, while a value of 1.0 mg/L would imply a depth of the order of 10 m. A background value, c_o, of 0.1 mg/L, and a criterion value, c_r, of 1.0 mg/L are adopted herein. The dilutions required to meet the criteria are 667 and 595 for Sidi Bishr and Kait Bey, respectively.

Suspended solids are also the source of settleable solids that may be deposited near a diffuser. As for the settling solids, it is difficult to assess the rate at which sediment will accumulate in the neighborhood of an outfall, or to predict with any precision, the impact of sedimentation on the benthic life near a particular proposed outfall. For the most part, the swift currents off the coast of Alexandria will remove suspended solids from the outfall area, but the areal extent of sedimentation around an outfall may be estimated approximately as follows:

[1] Standards Methods for the Examination of Water and Wastewater, 14th Edition, 1975.

A primary clarifier with an overflow rate of 37 m/day (about 900 US gpd/ft^2) will normally remove up to 60 percent of the settleable solids from typical domestic sewage. That is to say, a very large fraction of the particles in sewage have settling velocities of 37 m/day or greater. In the buoyant discharge plumes issuing from the diffuser,the settleable particles, along with the rest of the wastewater, are carried to an initial height, h, above the sea bottom. They then begin to settle at velocity, w, which varies with particle size but for the most part is not less than 37 m/day. Carried by an ocean current of horizontal velocity, u, the particles travel distances of up to $x = uh/w$ before reaching the sea bottom.

For discharges at 40 to 44 m depth, the height of rise of the heavier particles would be 20 to 30 m. With the median horizontal current speed of 0.10 m/sec, the particles would travel $x = uh/w = 4700$ to 7000 m, in both directions from the discharge site, parallel to the coast, and settle in a band perhaps 1 km wide.

It has been assumed that settling velocities in the ocean will be the same as in a treatment plant clarifier. Although the salt in the seawater will tend to reduce the settling velocity of a particle of given size by increasing the ambient density, the salinity is also known to encourage coagulation and flocculation, and hence increase settling rates. The two effects are assumed to be mutually compensating.

This analysis defines an area of possible impact, but does not indicate the severity of impact. There may, in fact, be little problem with solids accumulation, to judge from the present Kait Bey discharge. Despite a flow of about 125 000 m^3/day of raw sewage, grab samples of bottom materials within 1000 m of the outfall have shown clean sand, and no evidence of anaerobic deposits.

Nitrogen and Phosphorus

The addition of the nutrients nitrogen and phosphorus from sewage may be expected to increase the level of marine productivity. A small, widespread

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increase may be considered beneficial to a fishery; an excessive increase may lead to nuisance levels of growth of seaweed, and the threat of anoxic conditions where rapid reaeration is not possible.

Background concentrations of nitrogen and phosphorus in the eastern Mediterranean are low, and may limit the total biomass and, therefore, the overall productivity of this sea. The "Icthyolog" cruise in the autumn of 1970 detected no phosphate in the 5 mile circumlittoral zone;[1] the maximum level recorded was 0.45 microgram-atoms/litre in the spring of 1971, following several months of high rates of discharge from the Nile at Rosetta. Typical phosphate levels range from 0.09 to 0.014 microgram-atoms/litre.[2]

Reported nitrate values in the top 100 m of the southeastern Mediterranean generally vary from nil to about 0.05 microgram-atoms/litre (mcg-at/L), with values up to 0.4 observed in the spring after high discharges from the Nile. Nitrite concentrations also vary from nil to about 0.05 mcg-at/L, with a high of 0.16 in Abu Kir Bay in the spring.[1]

Typical background values for ammonia were not found in the literature; but if values are of the same order of magnitude as for NO_3, one may estimate that the concentration of total inorganic nitrogen (nitrate plus nitrite plus ammonia) will range between nil and 0.15 mcg-at/L.

These values are listed in the second column of Table 4-2. From them, single values of background concentration, c_0, have been selected for purposes of analysis. These are listed in the third column.

Near the shore, on the other hand, the present discharges of sewage may be considered to provide nutrients at a rate that causes a mild nuisance

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[1] Bulletin of the Institute of Oceanography and Fisheries. Volume 5, Alexandria, Egypt, 1975.

[2] Haedrich, R.L., "Fishes and the Fishery at Alexandria, Egypt," Appendix to Special Report No. 1, Oceanographic Studies, CDM, 28 February 1977.

TABLE 4-2

PHOSPHORUS AND NITROGEN CONCENTRATIONS

Constituent	Reported Values for Mediterranean Offshore	Adopted Background Value, C_o	Values 1 km (d) Off Anfushi 13 Oct 1977	Values in Wastewater, C_e Measured 1977(e)	Values in Wastewater, C_e Projected 2000(f)
PO_4	0.1 - 0.4(b)				
	0.09 - 0.14 (Typical)(c)	0.12	0 - 2.6	323	217
	0.45 (Max)(c)				
NO_3	0 - 0.05(c)	0.03	-	-	-
NO_2	0 - 0.05(c)	0.03	0 - 7.6	-	-
NH_3	-	0.04	3.6 - 12.9	2070	1600
Albuminoid N	-	-	11 - 25	570	320
Estimated Total Inorganic N	0 - 0.15	0.10	3.6 - 28.1	2200	1700
Inorganic N:P	0.7	0.8	12	6.8	7.8

Notes: (a) Units are microgram - atoms per litre as P or as N.
(b) Fairbridge, R.K., Enclopedia of Ocranography.
(c) Bulletin of the Institute of Oceanography and Fisheries, A.R.E., Alexandria, Egypt, Vol. 5, 1975.
(d) From Section 2.5, this report.
(e) From Table 3-2, Master Plan Technical Report, Volume II.
(f) From Table 2-4, this report.

in the region between the coast and 2 km offshore. The seawater there supports heavy growths of seaweed on rocks and moored buoys, while benthic flora beneath the photic zone of heavy growth are much less abundant at 2 km than 10 km from shore.

Seawater samples taken 1 km off Anfushi on 13 October 1977 (fourth column, Table 4-2), showed values of phosphate and nitrate far in excess of the values reported for offshore sampling (second column, Table 4-2). The estimated N:P ratio is about 12. The maximum phosphate level was 2.6 mcg-at/L, and the estimated maximum inorganic N level was 28 mcg-at/L. Such values may be expected in that area, where there is an admixture of one part sewage to roughly 50 parts of seawater.

Whether or not the stimulated growth is considered a nuisance per se, it places a demand on the dissolved oxygen supply which is in addition to the traditional BOD and COD considered earlier in the chapter. For example, from an addition of phosphorus and available nitrogen to final concentrations of 0.050 and 0.363 mg/L respectively, in the receiving water, enough organic material could be produced to remove 6.9 mg/L of oxygen from the water.[1]

The rate at which a given increase in N or P will increase the aquatic biomass is difficult to predict, since the ability to assimilate nutrients and convert them into cell material depends on a number of factors. Nitrogen, phosphorus, carbon, and several trace elements must be present. A bioassay of the receiving waters is required to establish definitively which is the limiting factor. However, in many instances, and apparently in Alexandria, nitrogen is the growth-limiting nutrient because:

1. Carbon and trace elements are readily available in the seawater.
2. Among the background levels indicated in Table 4-2, the atomic inorganic N:P ratio is of the order of unity.

[1] National Academy of Sciences and National Academy of Engineering, Water Quality Criteria, 1975, Washington, Environmental Protection Agency, 1975.

According to Ryther and Dunstan,[1] an N:P ratio of less than 10 to 15 is an indication that nitrogen is the growth-limiting nutrient, a situation often found in coastal marine waters.

Phosphorus levels thereby become a less important water quality parameter, and will not be considered further herein. For nitrogen, the organic forms and proteinaceous material and urea as well as nitrate and nitrite can be utilized by microorganisms to form nitrogen species which can be utilized by algae, plankton, and other marine growths. Thus, all of the nitrogen discharged should be available for biological uptake. Little or no nitrogen gas will be formed and lost to the atmosphere if aerobic conditions are maintained.

Ammonia can be toxic to fish life in the receiving water. Factors which may increase ammonia toxicity at a given pH are: high DO and CO_2 concentrations, elevated temperature, bicarbonate alkalinity, and the degree of dilution afforded the initial wastewater discharge. Reported levels at which acute toxicity is detectable have ranged from .01 mg/L to 2.0 mg/L for molecular ammonia-nitrogen.

Another factor to be considered is the oxygen demand placed on the receiving water by the oxidation of ammonia to nitrite and nitrate. Stoichiometric relationships indicate a requirement of 4.6 mg/L of oxygen to oxidize 1.0 mg/L of ammonia-nitrogen.

A criterion value of c_r = 2.0 mcg-at/L = .028 mg/L is adopted for total nitrogen. No c_r value is set for phosphorus. The rationale is as follows:

1. Levels of N now prevalent in near-shore waters appear to be stimulating growth to an undesirable degree. The proposed c_r is one-tenth of these levels.

[1] Ryther, J.H. and Dunstan, W.M., "Nitrogen, Phosphorus and Eutrophication in the Coastal Marine Environment," Science, Volume 171, pp 1008-1013, 12 March 1971.

2. The proposed c_r will minimize the threat of oxygen depletion by organic material whose growth has been stimulated by the nutrients
3. Even if all discharged N were to be in the form of ammonia, the toxic un-ionized fraction would be at most .0056 mg/L (at pH = 8.5, T = 30°C).[1] Levels less than 0.01 mg/L present minimal risk of deleterious effects.[2]
4. Since nitrogen appears to be the growth-limiting nutrient, the level of phosphorus is of relatively minor concern.

The last two columns of Table 4-2 contain effluent values, c_e, measured in 1977 (from Table 3-2, Master Plan Report, Vol. 11 and projected for the year 2000 (from Table 2-4, this volume). The values have been converted from mg/L to mcg-at/L.

Design Dilution Values

In Table 4-3, the values of required initial dilution for the Sidi Bishr and Kait Bey outfalls range from 56 to 300. The outfalls shall be designed to provide an initial dilution ratio of 150, principally to match the requirement for BOD_5. A dilution ratio of this magnitude is also advisable to lessen the impact of hydrogen sulfide, as is discussed in Chapter 5.

The outfalls shall be placed far enough at sea that the effluent plume can, on the average, attain a far-field dilution of 1000, sufficient to meet all requirements listed. The meanings of the terms "initial dilution" and "far-field dilution" are discussed further in Chapter 5.

Toxic materials should be controlled at their source to the extent required by the procedure described in Section 4.1, with these design dilution values applied.

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[1] National Academy of Sciences and National Academy of Engineering, Quality Criteria for Water, Washington, Environmental Protection Agency, 1976.

[2] National Academy of Sciences and National Academy of Engineering, Water Quality Criteria, Washington, Environmental Protection Agency, 1975.

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TABLE 4-3

SUMMARY OF WATER QUALITY CRITERIA ADOPTED

Constituent	Adopted Background Value, C_o	Adopted Ambient Criteria, C_r	Conditions	Sidi Bishr Outfall: Typical Effluent Value, C_e	Sidi Bishr Outfall: Required Dilution, S[a]	Kait Bey Outfall: Typical Effluent Value, C_r	Kait Bey Outfall: Required Dilution, S[a]
Fecal Coliforms per 100 mL	30 to 40	-	(See Sections 4.3 and 5.2)	10^9	10^3 dilution	10^9	10^3 dilution
					10^3 dilution		10^3 dilution
BOD_5	1 mg/L	4.4 mg/L	Initial dilution	480 mg/L	141	510 mg/L	150
	Nil	1.4 mg/L over background	Far-field dilution	480 mg/L	343	510 mg/L	364
COD	Nil	1.4 over background	Far-field dilution	960 mg/L	686	1020 mg/L	730
SS	0.1 mg/L	1 mg/L	Far-field dilution	600 mg/L	667	536 mg/L	595
N	0.0014 mg/L	0.028 mg/L	Far-field dilution	31 mg/L	1165	24 mg/L	902
Adopted design dilution			Initial		150		150
			Far-field		1000		1000

Note: (a) $S = \frac{C_e - C_o}{C_r - C_o}$

CHAPTER 5

OUTFALL PLANNING AND DESIGN

CHAPTER 5

OUTFALL PLANNING AND DESIGN

5.1 Introduction

The flows and loads that must be disposed of have been presented in Chapter 2. The marine environment has been described in Chapter 3. The basic approaches to marine disposal, and the specific criteria to be met, have been discussed in Chapter 4.

In this Chapter, the outfalls are planned and a preliminary design, to meet the adopted criteria, is presented based on the following premises:

1. There are two long ocean outfalls proposed, one off Sidi Bishr with a design flow of 6.5 m^3/sec, and the other off Kait Bey with a design flow of 4.5 m^3/sec.
2. The most suitable alignments for these two outfalls, as determined in the geophysical studies portion of the program, appear to be Profile 2 and Profile 8 shown on Figure 3-36.
3. To meet water quality criteria established in Chapter 4, each outfall should be designed to provide an initial dilution ratio of 150 at design flow; and the overall far-field dilution ratio of discharges from the two outfalls should be of the order of 1000.
4. Multiport diffusers will be required to attain the desired initial dilution.

The outfall planning process presented herein will begin with large-scale, far-field considerations in order to determine discharge location, and then proceed to the near-field considerations of spreading effluent plumes in order to specify diffuser length. This is followed by considerations of internal hydraulics, structure, and operation and maintenance.

In Section 5.2 on far-field considerations, steps are taken to ensure that:

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1. Discharges will take place beyond the low salinity lens sometimes observed within a few kilometres of the shore.
2. Discharges will be sufficiently far from shore that onshore winds cannot drive surface-layer components of the sewage plume ashore before bacteria have been allowed to decay or otherwise disappear, to an adequate extent.
3. Discharges will be located sufficiently far to sea that effluents will be dispersed rapidly enough to maintain far-field effluent concentrations below target levels.
4. Discharges will be located so that the effluent plume from one outfall is not likely to interfere with the effluent plume from another outfall.

Section 5.3 on near-field considerations, includes analyses of initial and secondary dilution, and of plume submergence beneath the pycnocline. Diffuser lengths are determined.

In Section 5.4, the internal hydraulics of diffusers are considered in derivation of port sizing and spacing. Structural and operational considerations are discussed in Section 5.5, and the resulting preliminary designs for the two outfalls are summarized in Section 5.6.

5.2 Far-Field Considerations: Appropriate Distance of Discharge from Shore

Low-Salinity Layer

The lower-salinity lens occasionally observed lying along the shore, and attributed to the Mex Canal discharge, is usually 3 to 4 km wide. Outfall discharges should be at least 4 km from shore to avoid being trapped within or under this lens.

Onshore Winds and Currents; Bacterial Decay

Onshore winds, which along the Alexandria coastline means winds from sectors 270° - 300° - 330° - 360° - 30°, are a very important environmental feature in outfall design, since they can drive surface waters and pollutants therein towards shore. In this subsection, shoreward surface current travel times are considered jointly with bacterial

decay rates to determine how far from shore the points of discharge should be to meet the criteria adopted in Chapter 4.

The long-term seasonal wind data presented in Tables 3-1 to 3-4 show that from May to October the prevailing winds are onshore. In the winter, from November to April, winds are more evenly distributed around the compass, but still are most often from a generally northwesterly direction.

For winds in the summer bathing season, Table 5-1, Column A, was prepared using the seasonal data in Tables 3-2 and 3-3 (May-July; August-October), with the frequencies for winds parallel to shore and offshore (60° to 240°) counted as calm. The difference between nighttime and daytime wind speeds was considered small enough to be negligible.

Onshore wind-driven currents will have a speed two to three percent as great as the wind speed. A ration of 0.029 is used, from a value in a table by Wiegel[1], for 30° latitude and a wind speed of 5 m/sec. The frequency distribution for surface current speeds appears in Column B of Table 5-1. In Columns C through G of Table 5-1, the travel times to shore at each speed are calculated for 6, 8, 10, 12, and 14 km of travel, respectively. The travel times are conservatively short for any winds not driving at right angles to the shore.

Rate of Bacterial Disappearance. In Section 4.4, fecal coliforms were selected as the bacterial indicator organism. The bacterial standard concentration, c_r, to be attained for bathing waters were of the order of 100 to 1000 per 100 mL, which requires a reduction by a factor of 10^7 to 10^6 from the adopted effluent concentration $c_e = 10^9/100$ mL. Some of the required reduction is possible by physical dilution; in fact, a physical dilution factor of 10^3 is an adopted requirement. The remaining 10^4 to 10^3-fold reduction must be by bacterial disappearance.

Time is needed to achieve a given factor of reduction by exponential decay. The rate of decay depends on many factors, but recent evidence suggest a strong dependence on solar radiation; hence, decay is more rapid in daytime than at night.

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[1]Wiegel, R.L., Oceanographical Engineering, Prentice-Hall, 1964.

TABLE 5-1

FREQUENCY DISTRIBUTION OF ONSHORE WINDS IN SUMMER [a]

	A	B	C	D	E	F	G
			Travel Time to Shore, hours				
Percent[b]	Wind Speed	Surface Speed	From 6 km	From 8 km	From 10 km	From 12 km	From 14 km
10	0 m/sec[c]	0 m/sec	∞	∞	∞	∞	∞
20	1.81	.05	33.3	44.4	55.5	66.6	77.8
30	2.89	.08	20.8	27.8	34.7	41.6	48.6
40	3.83	.11	15.2	20.2	25.3	30.4	35.4
50	4.50	.13	12.8	17.1	21.4	25.6	29.9
60	5.18	.15	11.1	14.8	18.5	22.2	25.9
70	5.93	.17	9.8	13.1	16.3	19.6	22.9
80	6.88	.20	8.3	11.1	13.9	16.6	19.4
90	7.82	.23	7.2	9.7	12.1	14.4	16.9
100	19.0	.55	3.0	4.0	5.1	6.0	7.1

(a) From Tables 3-2 and 3-3.

(b) Percent of time that wind speed is less than value in Column A.

(c) Winds of all speeds from the 60° - 240° sector are counted as calms.

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This diurnal variation is accounted for in a procedure which largely follows that of Bellair et al.[1] In Column A of Table 5-2, a diurnal schedule gives a T_{90} value for each clock hour of the day. It is based on a fundamental nighttime T_{90} value of 40 hours, a fundamental daytime T_{90} value of 1.5 hours, and smoothly varying intermediate values for morning and evening, according to a curve developed by Bellair et al., adjusted to T_{90} values for Alexandrian sewage and seawater as determined in the present study (see Section 3.4).

(The bacterial decay experiments, reported in Section 3.4, indicate that a nighttime T_{90} value of 40 hours may be conservatively high for Alexandria. Certainly, the tests did not indicate that 40 hours is too low a value. However, since the nighttime tests were not extensive enough to define a different value, the value of 40 hours will be retained. The daytime T_{90} value of 1.5 hours was derived from the tests reported in Section 3.4, and is intended to be a conservative representation of Alexandrian conditions.)

In Column B of Table 5-2, each T_{90} value is inverted to give the fraction of a logarithmic cycle of decay that is attained each hour. For any time period of several hours, the sum of the Column B values gives the number of log cycles of decay in that time period.

In Column C, the value given for each hour is the length of the time period, terminating at the given hour, required to achieve decay through one logarithmic cycle. For example, the value of 2.0 hours given for 9 AM means that one must collect Column B values for two hours, starting with 0.667 for 9 AM, then adding 0.333 for 8 AM, to get a total of 1.0, for one log cycle of decay. Alternatively, Column C values may be thought of as the quantity $T_2 - T_1$ in the summation:

$$\sum_{n = T_1}^{T_2} \text{(Column B values)} = 1.0 \text{ (log cycles)}$$

where T_2 is the clock hour at which a given Column C value is entered.

[1] Bellair, Parr-Smith, and Wallis, "Significance of Diurnal Variation in Fecal Coliform Die-Off Rates in the Design of an Ocean Outfall," Journal Water Pollution Control Federation, September 1977.

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TABLE 5-2

TIME INTERVALS NEEDED FOR VARIOUS DEGREES OF BACTERIAL DECAY[a]

Hour	A T_{90} hr	B $1/T_{90}$[b]	C 1 Log Cycle hr	D 2 Log Cycles hr	E 3 Log Cycles hr	F 4 Log Cycles hr	G 5 Log Cycles hr	H 6 Log Cycles hr
1	40	.025	8.6	10.5	12.0	13.5	15.0	16.5
2	40	.025	9.5	11.5	13.0	14.5	16.0	17.5
3	40	.025	10.4	12.5	14.0	15.5	17.0	18.4
4	40	.025	11.4	13.4	14.9	16.4	17.9	19.4
5	40	.025	12.3	14.4	15.9	17.4	18.9	20.4
6	20	.050	13.2	15.3	16.8	18.3	19.8	21.3
7	8	.125	13.7	16.1	17.6	19.1	20.6	22.1
8	3	.333	13.2	16.5	18.1	19.6	21.1	22.6
9	1.5	.667	2.0	15.7	18.1	19.6	21.1	22.6
10	1.5	.667	1.5	11.2	17.7	19.6	21.1	22.6
11	1.5	.667	1.5	3.0	16.2	19.5	21.1	22.6
12	1.5	.667	1.5	3.0	5.0	18.7	21.1	22.6
13	1.5	.667	1.5	3.0	4.5	14.1	20.7	22.6
14	1.5	.667	1.5	3.0	4.5	6.4	19.0	22.5
15	1.5	.667	1.5	3.0	4.5	6.0	8.0	21.7
16	2.0	.500	1.7	3.2	4.7	6.2	7.7	20.0
17	2.8	.357	2.2	3.7	5.2	6.7	8.2	11.0
18	4.0	.250	2.8	4.3	5.8	7.3	8.8	10.7
19	5.6	.179	3.4	5.1	6.6	8.1	9.9	11.0
20	8.0	.125	4.2	5.9	7.4	8.9	10.4	11.9
21	12.0	.083	5.0	6.8	8.3	9.8	11.3	12.8
22	18.0	.056	5.9	7.7	9.2	10.7	12.2	13.7
23	21.0	.048	6.7	8.6	10.1	11.6	13.1	14.9
24	40.0	.025	7.7	9.6	11.1	12.6	14.0	15.5

[a] Decay rates based on nighttime T_{90} of 40 hours and daytime T_{90} of 1.5 hours.

[b] $1/T_{90}$ equals the fraction of a log cycle decayed in one hour.

Similarly, values in Columns D through H are for time intervals $T_2 - T_1$ required to achieve, by hour T_2, decay through 2, 3, 4, 5 and 6 log cycles, respectively.

Attainable Degree of Disappearance, Compared to Criteria and Standards. Table 5-1, showing the frequency distribution of onshore wind speed and available surface drift travel times, and Table 5-2, showing required decay times, are now applied jointly in a series of tables, one example of which is Table 5-3. The table is a matrix with ten rows (one for each tenth-percentile of wind speed) and 24 columns (one for each hour of the day). All points in the matrix, over a 24-hour day, have an equal opportunity to represent both the travel time and the hour of the day.

To each hour of the day is assigned the time required for the given number of log cycles of decay, from the appropriate column in Table 5-2. For each matrix point, the travel time (for the row) and the required time (for the column) are compared: if travel time exceeds the required time, no mark is made; if travel time is less than the required time, the matrix point is marked with "*", or with "x" for borderline point. Borderline points are considered to be events during which travel time is sufficient about half the time.

The number of unmarked points plus half the number of "x"-marked points, divided by the matrix area of 240, is the fraction of the time in a 24-hour day in which there is adequate time to provide the requisite number of log cycles of disappearance.

This fraction, so computed for 1, 2, 3, 4, 5 and 6 log cycles, is plotted on the top part of Figure 5-1 for travel distances (hence, outfall lengths) of 6, 8, 10, 12 and 14 km. The plotted curve for each travel distance represents a cumulative frequency distribution of degrees of bacterial disappearance attainable for that distance.

The implications of these descriptions of outfall performance in reducing bacterial concentrations are shown in the middle and lower parts of Figure 5-1. The abscissa of the middle part, "fecal coliforms per 100 mL," is related to the abscissa of the top part, "log cycles of disappearance," by the assump-

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TABLE 5-3

COMPUTATION OF FREQUENCY OF SUFFICIENT TRAVEL TIME FROM 10 KM OUTFALL TO BEACH ,3 LOG CYCLES

Percent[a]	Travel Time hour[b]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	O'clock Hours Required[c]
		12	13	14	15	16	17	18	18	18	18	16	5	5	5	5	5	5	6	7	7	8	9	10	11	
10	∞																									During 24 hr
20	55.5																									Insufficient travel time 33 times out of 240, or 14 % of time.
30	34.7																									
40	25.3																									
50	21.4																									
60	18.5																									Between 6 am and 9 pm, Insufficient travel time 22.2 times out of 160, or or 14 % of time.[d]
70	16.3						x	x	x	x	x															
80	13.9			x	x	x	*	*	*	*	*	x														
90	12.1		x		*	*	*	*	*	*	*	*														
100	5.1		x	*	*	*	*	*	*	*	*	*							x	x	x	x	x	x		

[a] Percent of time travel time exceeds values indicated in Column 2.

[b] From Table 5-1, Column E.

[c] From Table 5-2, Column E.

[d] Matrix points "x" are borderline and assigned half value; matrix points "*" are counted as full value.

tions (a) that the undiluted effluent concentration is 10^9 per 100 mL, and (b) that a 1000-fold physical dilution has been obtained (at least approximately) by the time the plume has traveled from the point of discharge to the beach, in all cases considered. For example, effluent with an original concentration of 10^9 per 100 mL, having undergone physical dilution of 10^3, would have a bacterial concentration of 10^6; four log cycles of disappearance would bring the concentration down to 10^2 per 100 mL.

For each of the curves in the upper part of Figure 5-1, the geometric mean coliform concentration is computed, and plotted in the middle part as "geometric mean due to discharge alone." The values range from less than 1 per 100 mL for 14 km to 100 per 100 mL for 6 km of travel distance.

However, it is appropriate to recognize that levels rarely fall as low as one or even 10 per 100 mL; typical ranges of background values are shown in the lower part of Figure 5-1 for Los Angeles beaches [1] and for the relatively unpolluted Maamura Beach at Alexandria. [2] For computation purposes, a value of 32 per 100 mL is chosen, and a curve is plotted showing the predicted geometric mean bacterial concentration due to the outfall discharge plus this background level. The values range from about 400 per 100 mL for 6 km to about 50 per 100 mL for 14 km.

Also on the lower part of Figure 5-1 are the consensus of the Bilthaven Conference on Recreational Water Quality (see Table 4-1 and its discussion), and the symptom rate vs E.Coli relationship developed by Cabelli from recent research work done in Alexandria as well as elsewhere (see Figure 4-1 and its discussion).

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[1] Betz, J., from information presented at the Meeting to Discuss Proposed Ocean Outfalls in Alexandria, Egypt, Alexandria Governorate Palace, 29 August 1978.

[2] From Hakim, K.E., "Progress Report: Study of Relationship of Microbial Indicators to Health Effects at Alexandria Bathing Beaches," 1978.

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One may now observe that:

1. Background levels are generally not much less than, and occasionally greater than, the Bilthoven "highly satisfactory" standard of 100 per 100 mL.
2. A background level of 32 per 100 mL implies a symptom rate of 0.8 percent.
3. A 6-km outfall would provide bacterial concentrations with a geometric mean greater than the "highly satisfactory" 100 per 100 mL, at a symptom rate of 1.7 percent. Thirty-five percent of the time, levels would exceed the Bilthoven "acceptable" standard of 1000 per 100 mL.
4. A 10-km outfall would provide a geometric mean concentration equal to the "highly satisfactory" 100 per 100 mL, with an associated symptom rate of about 1.2 percent. Fourteen percent of the time, levels would exceed 1000 per 100 mL.
5. A 14-km outfall would provide a geometric mean concentration slightly less than 100 per 100 mL and slightly greater than background, with an associated symptom rate of about 1.0 percent. Five percent of the time, levels would exceed 1000 per 100 mL.

It is reasonable to conclude that the 10-km and 14-km outfalls can be said to meet the Bilthoven standards and increase the symptom rate by only a small amount over the background level. The 6-km outfall, while meeting the "highly satisfactory" 100 per 100 mL about 55 percent of the time, exceeds the "acceptable" 1000 per 100 mL somewhat too often.

Due to the variable and very incompletely understood nature of the processes involved, this analytical procedure should not at this time be taken too seriously or relied upon too finely. Nevertheless, it is offered as a useful and informative tool to enable one to judge that an outfall length of <u>about</u> 10 km is necessary and sufficient to meet bacterial requirements at the beaches.

<u>Dilution Water Available</u>

The outfalls are to be designed to provide an initial dilution of 150 and a subsequent total dilution of 1000. Detailed analyses for initial

and secondary dilution will be presented in Section 5.3. First, however, it is important simply to see how large a section of the ocean must be involved in the dilution process.

Dilution Volume Analysis. The approach will be to adopt a crude but informative fill-and-draw analysis, in which (a) the effluent is assumed to be dispersed throughout a large but limited volume of the sea around the points of discharge, with (b) periodic complete flushing of this volume. The far-field dilution ratio is thereby:

$$\frac{\text{Seawater volume}}{\text{Flushing period}} \div \text{Sum of flow rates for both outfalls.}$$

Note that the two outfalls are considered together in this reckoning, as the horizontal extent of the seawater volume considered may be several times the 10 km distance separating the two outfall alignments.

The seawater volume is the product of the area, A m^2, of a vertical cross-section normal to the coast extending Ƶ m from the coast to the point of discharge, multiplied by a distance, 2E, parallel to the coastline. The cross-sectional area, A, is derived as a function of Ƶ on Figure 5-2. The bottom depth profiles at the Sidi Bishr and Kait Bey alignments, approximately perpendicular to the coastline, are shown on Figure 5-2A. The area in the vertical plane above the bed, below the sea surface, and between the shoreline and each distance Ƶ from the coast, is plotted on Figure 5-2b. In Table 5-4, values of A, intermediate between those for Kait Bey and Sidi Bishr, are listed for Ƶ = 4, 6, 8, and 10 km.

Now, a plume originating at the sea bed at Ƶ km from shore will, in general, not mix uniformly and completely with the water shoreward of Ƶ. For a typical plume that has undergone initial plus secondary dilution, some water shoreward of Ƶ will remain uninvolved, while some water seaward of Ƶ will be mixed in. Furthermore, the shoreward area, A, and the plume area will not be precisely equal in size. Yet is is maintained that the dilution afforded by the plume area cannot be much greater than the dilution afforded by the shoreward area, A. To obtain A (Ƶ), the discharge point must be at least Ƶ from shore.

The coastwise extent of the seawater volume, 2E, and the flushing period, T, are computed as follows. The analyses for current persistence, presented and discussed in Section 3.1, show that the fortnightly medium current excursions are of the order of 20 km (Table 3-24), and are most likely to be northeasterly or southwesterly (Figure 3-11). This medium current excursion length of 20 km will be adopted for E, since, on the average, currents will carry the effluent to points as far as E km northeast and E km southwest of the point of discharge. The total coastwise extent of the affected seawater volume is therefore: 2E = 40 km.

TABLE 5-4

FAR-FIELD DILUTIONS AS A FUNCTION OF DISTANCE FROM SHORE[a]

Distance from Shore, Z, km	Area A m^2	Flushing Rate, m^3/sec	Dilution For 11 m^3/sec
4	0.8×10^5	2 646	241
6	1.6×10^5	5 291	481
8	2.4×10^5	7 937	722
10	3.3×10^5	10 913	992

[a] Median Excursion Length E = 20 km, Flushing Period T = 14 Days.

Table 3-24 furthermore shows fortnightly 80 percentile excursions of the order of 40 km. This is to say, at least once a fortnight there is an excursion of at least 40 km, which will serve to flush the volume clear of accumulating sewage effluent.

The third column in Table 5-4 lists the flushing rate: 2 EA/T for each value of A, where E = 20 km, and T - 14 days. In the final column is the dilution, equal to the flushing rate divided by the year 2000 average discharges of Sidi Bishr plus Kait Bey outfalls (11 m^3/sec). The table shows that only when the outfall is about 10 km long can an ultimate dilution of the order of 1000 be obtained.

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Interference Between Two Outfalls. To best promote uniform dispersion of the effluent, it would be well to place the points of discharge from the two outfalls such that the plume from one will not, for the most part, pass over the discharge site of the other.

Current meter stations 1 BU and 1 AU, 10 m below the surface on the Ramleh alignment, and station 2 BU, 10 m below the surface on the Kait Bey alignment, were considered to be closest to the probable points of discharge. The azimuth directions of the current excursions from these stations were plotted in a frequency distribution on Figure 5-3. Also plotted were the average directions taken by drogues set during the course of the program near 10 km from shore on the Kait Bey and Ramleh alignments.

The resulting direction distribution shows principal modes at 60° and 240°, for both drogues and current meters. There is little difference between the distributions obtained by current meters on the two alignments. The drogue data show a mode at 180°, in addition to 60° and 240°, in part due to onshore surface currents that influence near-surface drogues but not the sub-surface current meters.

The task at hand is to find two gaps in the distribution, 180 degrees apart, each direction to be the bearing from one discharge point to the other. The range of choice is limited by the fact that both points of discharge should be in the neighborhood of 8 to 10 km from shore.

The values that are hereby adopted are 47° and 227°, which can be attained with discharge at 11 km from shore on the Sidi Bishr alignment, and 8 km from shore on the Kait Bey alignment.

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5.3 Plume Mechanics: Appropriate Diffuser Length and Orientation

Initial Dilution

For each outfall, discharge should be through a multiport diffuser. This may simply consist of the final offshore portion of the outfall pipe with ports made in the pipe wall at regular intervals, and a cap on the end of the pipe in order to force the effluent to emerge through the ports. A diffuser begins the process of dispersing the effluent by producing many small effluent streams to mix with the ambient sea water, rather than just one.

The discharge per unit length of diffuser pipe should be approximately constant over the length of the diffuser, as will be discussed in Section 5.4. The diffuser section should be normal to the predominant current direction if possible; since currents are principally parallel to the coast, the diffuser may be an extension of the outfall pipe on its alignment, with no bends. The diffuser should, if possible, be on a horizontal alignment. It should not be buried, but lie bedded on the ocean floor, with the ports a major fraction of a metre above the bottom.

Computations of the initial, buoyancy-driven dilution afforded the effluent from a multiport line diffuser are based on the work of Roberts.[1] The initial dilution is taken to be Robert's "minimum surface dilution," S_m:

$$\frac{S_m q}{UH} = 0.27\ F^{-1/3} \qquad \text{(eq. 5-2)}$$

[1] Roberts, "Dispersion of Buoyant Wastewater Discharged from Outfall Diffusers of Finite Length," W.H. Keck Laboratory of Hydraulics and Water Resources, California Institute of Technology, 1977.

for F less than 0.1, and:

$$\frac{S_m q}{UH} = 0.6, \text{ approximately} \qquad \text{(eq. 5-3)}$$

for F greater than 0.1, and with the diffuser axis oriented perpendicular to the direction of the ambient current, where:

$$F = U^3/g^1 q \qquad \text{(eq. 5-4)}$$

and:

U = ambient current speed

q = discharge of effluent per unit length of diffuser

H = water depth at the point of discharge

g^1 = gravitational acceleration, g, multiplied by the difference in density between the effluent and the seawater, divided by the effluent density.

On Figure 5-4, minimum surface dilution, S_m, is plotted against diffuser length for the Sidi Bishr and Kait Bey outfalls. The ambient current speeds used are: U = 0.05 m/sec and U = 0.18 m/sec, typical 20 and 80 percentile speeds, respectively. Actually, S_m, as computed by equations 5-2 and 5-4, is independent of current speed, so the lower pair of curves on Figure 5-4 may be said to apply for any U less than 0.06 m/sec, the range of U for which F is less than 0.1.

The figure shows that to maintain an S_m of at least 150, the Sidi Bishr diffuser should be 400 m long, and the Kait Bey diffuser should be 450 m long.

Submergence

Submergence of the outfall discharge plume is possible when a sufficiently large density gradient exists in the ocean. The freshwater discharge is initially lighter than the surrounding seawater and so rises towards the surface; but in doing so mixes with heavier seawater. If the mixture of sewage and lower-level seawater becomes heavier than seawater in layers near the surface, the plume will cease to rise, and will spread out in a layer beneath the surface.

Brooks'[1] analysis for the maximum height of rise of a submerged plume in terms of the density profile and discharge characteristics, based on a linear approximation of the measured profile, was applied to determine whether submergence is possible off Alexandria.

On the right-hand side of Figure 5-5 there are four curves: (A) and (B) are for a point-source plume, such as emanates from a single diffuser port, while (C) and (D) are for a line-source plume, such as emanates from a long multiport diffuser, with many ports close together. The graph ordinate is the density difference, Δ_t, between the discharge point and the maximum height of rise, y_{max}, above the diffuser that is required for the plume to rise no higher than y_{max}. The curves relate this required density difference to the discharge strengths: Q m^3/sec for point sources, and q m^2/sec for line sources (for target values of 30 m and 40 m for y_{max}). The graph is constructed for g = 9.8 m/sec^2, $g^1 = g\Delta\rho/\rho$ = .2842 m/sec^2, and wastewater density at the point of discharge of ρ = 998 kg/m^3.

On the abscissa for single port discharge, schedules of port diameters for the Kait Bey and Sidi Bishr outfalls are shown. For each outfall, the schedule was derived from the projected year 2000 average discharge, the proposed outfall diameter, and the internal distribution criterion that the area of each port, multiplied by the total number of ports, should not exceed 0.75 times the pipe cross-sectional area. For sewage that is notorious for carrying large quantities of stringy solids, and subjected only to screening that may not always be effective, it is not advised to have ports smaller than 25 cm, or at least 20 cm in diameter, lest they clog with solids. On the abscissa for line-source discharges, the values for discharge per unit length for the two outfalls are indicated.

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[1] Brooks, N.H., "Dispersion in Hydrologic and Coastal Environments," Final Report to National Coastal Pollution Research Program, USEPA, Grant No. 16070DGY, December 1972.

Note that for 25 cm ports on the Sidi Bishr outfall, for example, the density difference required is about 0.9 and 1.5 sigma-t units for y_{max} of 40 m and 30 m, respectively; while for a 400 m line plume carrying the Sidi Bishr discharge of 6.5 m^3/sec, the required differences are 0.44 and 0.60 sigma-t units. Which of the two pairs of sigma-t values is applicable?

Brooks[1] advises that the higher of the two density difference values for a given y_{max} be chosen; the fact that the point-source analysis demands a greater density difference for a given y_{max} probably means that the diffuser discharge will behave more like many individual point-sources than like a continuous line-source for this range of flow values.

On the left-hand side of Figure 5-5 measured density differences between the surface and 40 m depth, and for the 30 m interval between 10 m and 40 m depths, are plotted against calendar time, January through December (although the data for the second half year were collected first, since the sampling program began in July 1977).

For the autumn and winter period, September through March, the density differences for both the 30 m and the 40 m depth intervals are small, ranging between zero and 0.4 sigma-t units. For the most part, these values are less than the required density difference, as shown by the curves A,B,C, and D for the range of Q and q rates shown. The plume cannot, therefore, be expected to remain submerged beneath the surface, between September and March.

Beginning in early April, however, the density differences increase, due to the seasonal warming of the upper water layers. Differences as great as 1.7 sigma-t units, between zero and 40 m, and 1.2 sigma-t units, between 10 and 40 m, were measured in May. Inner envelope curves have been sketched for the two depth intervals; these are curves which, for a given calendar time, represent the lower end (or nearly so) of the range of

[1] Brooks, N.H., "Dispersion in Hydrologic and Coastal Environments," Final Report to National Coastal Pollution Research Program, USEPA, Grant No. 16070DGY, December 1972.

density differences plotted for that time. The curves, roughly parabolic in shape, span the months April through August; for the zero-to-40 m interval, the curve as sketched attains a peak of 1.0 sigma-t units in June, while the 10-to-40 m interval curve, as sketched, attains a peak of 0.4 sigma-t units, also in June.

From comparison of curve B with the inner envelope curve for surface-to-40 m, it appears that the outfall plumes, discharged at or below 40 m depth through 25 cm diameter ports, will be submerged for a month or two in late spring. The submergence depth may be less than 10 m beneath the surface. The use of more numerous, smaller ports would extend the period during which submergence could be counted upon. (This assessment of the potential for plume submergence is more positive than was made in earlier progress reports of this study.)

In early years of the life of the outfalls, when discharge rates are less than the design rates, submergence will extend over a longer season. The season will become shorter as discharges increase.

Submergence during June and part of July, and perhaps parts of May and August as well, will be a welcome added safety feature for keeping effluents away from bathing areas. However, since submergence cannot be counted upon between September and March, some of which time is still popular swimming season, care has been taken to design the outfalls to meet water quality criteria at the beaches even in the absence of submergence.

(A potential disadvantage of submergence is that downward diffusion of oxygen from the atmosphere is impeded by the density gradient. An estimate of the rate of downward diffusion of oxygen through the pycnocline to an oxygen-consuming sewage plume, presented in Appendix D, indicates that oxygen may diffuse downward through a typically strong density gradient at a rate insufficient to satisfy the oxygen demand. However, the initial dilution specified in Chapter 4 is designed to meet the oxygen demand with adequate oxygen-rich dilution water.)

Secondary Dilution

The Brooks[1] analysis for secondary dilution is used herein. The secondary dilution factor, S_2, is:

$$S_2 = 1 \text{ erf } [1.5/([1 + 8 K_o t/b^2]^3 - 1)]^{0.5}, \qquad \text{(eq. 5-5)}$$

where "erf" is the error function, K_o is the initial value of the coefficient of horizontal eddy diffusivity, t is the time, and b is the diffuser length. According to this analysis, the diffusivity coefficient increases in proportion to the 4/3 power of the nominal width of the plume. The initial value, K_o, is thus related to the initial plume width, which is the diffuser length, b:

$$K_o = Ab^{4/3} \qquad \text{(eq. 5-6)}$$

For K_o in cm^2/sec and b in cm, the value of the coefficient A may range from 0.0015 to 0.05.

It has long been recognized that current shear must have a significant effect on apparent horizontal diffusivity in the ocean.[2] In a recent study,[3] the coefficient, A, in equation 5-6, was expressly related to G sec^{-1}, the vertical gradient in horizontal velocity:

$$A = 0.25k^{1/3} G^{2/3} \qquad \text{(eq. 5-7)}$$

where k, cm^2/sec, is a constant value of the vertical diffusivity in the ocean. Koh and Brooks note that reported values for the vertical turbulent diffusion coefficient range from 0.04 cm^2/sec to 200 cm^2/sec. Csanady[4] reports that while in the top 30 cm of the ocean one may find a value of 30 cm^2/sec, the vertical diffusion coefficient a few meters below the surface decreases to about 5 cm^2/sec. The value adopted for use herein is 5 cm^2/sec.

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[1] Brooks, "Diffusion of Sewage Effluent in an Ocean Current," Proceedings, 1st International Conference Waste Disposal in the Marine Environment, Pergamon Press, 1960.

[2] Koh and Brooks, "Fluid Machanics of Wastewater Disposal in the Ocean," Annual Review of Fluid Mechanics, 1975.

[3] French, J.A., manuscript in preparation, 1978.

[4] Csanady, G.T., Turbulent Diffusion in the Environment, Reidel, 1973.

In this project, drogue studies were conducted to enable the vertical gradient in horizontal velocity, G, to be measured. Twenty-seven values of G in velocity components perpendicular to the mean current velocity were listed in Table 3-25. The 20, 50, and 80 percentile values of G from this sample are .0012, .0030, and .0084 sec^{-1}, respectively. Corresponding values of A are .005, .009, and .018. These values are within the range of values cited in the discussion of equation 5-6.

It is of interest to know how rapidly, and within how short a distance, the secondary dispersion process can increase the dilution ratio from its initial value, S_m, of 150 or more, to the far-field target value of 1000. In Table 5-5, the required time and distance to attain a dilution ratio of 1000 is listed for nine combinations of current speed, U, and diffusion factor, A, thus covering a very large percentage of potential advective and dispersive conditions. The three current speeds considered are 5, 10, and 18 cm/sec, adopted herein as typical values of 20, 50, and 80 percentile current speeds, based on the analysis of current meter records for the study year.

All times are 30 hours or less. By attaining the target initial-plus-secondary dilution of 1000 within a day and a half, one supplies the wastewater with ambient dissolved oxygen sufficiently rapidly that the BOD or COD values of 500 to 1000 mg/L will not be able to cause more than a very small depletion of the ambient DO.

All distances are less than 8 km, indicating that a physical dilution of 1000 will be attained by a plume before it reaches the beach, should it be tending onshore. (In Section 5.2, the point of discharge for the Kait Bey outfall was set at 8 km from shore, and the point of discharge for the Sidi Bishr outfall was set at 11 km from shore.)

Directions of currents have not yet specifically been considered in this secondary dilution analysis. It is considered sufficient to note that,

TABLE 5-5

TIMES AND DISTANCES REQUIRED TO ATTAIN OVERALL DILUTION $S_m S_2$ = 1000

a) Sidi Bishr outfall, diffuser length b = 400 m

Current Speed:	U_{20} = 0.05 m/sec	U_{50} = 0.10 m/sec	U_{80} = 0.18 m/sec
Initial Dilution:	S_m = 152	S_m = 203	S_m = 366
Req'd Secondary Dilution:	S_2 = 6.6	S_2 = 4.9	S_2 = 2.7
A = .005	t = 27 hr x = 4.9 km	t = 21 hr x = 7.5 km	t = 11 hr x = 7.4 km
A = .009	t = 15 hr x = 2.7 km	t = 12 hr x = 4.2 km	t = 6 hr x = 4.1 km
A = .018	t = 8 hr x = 1.4 km	t = 6 hr x = 2.1 km	t = 3 hr x = 2.0 km

b) Kait Bey outfall, diffuser length b = 450 m

Current Speed:	U_{20} = 0.05 m/sec	U_{50} = 0.10 m/sec	U_{80} = 0.18 m/sec
Initial Dilution:	S_m = 152	S_m = 239	S_m = 430
Req'd Secondary Dilution:	S_2 = 6.6	S_2 = 4.2	S_2 = 2.3
A = .005	t = 30 hr x = 5.4 km	t = 20 hr x = 7.2 km	t = 10 hr x = 6.8 km
A = .009	t = 17 hr x = 3.0 km	t = 11 hr x = 4.0 km	t = 6 hr x = 3.8 km
A = .018	t = 8 hr x = 1.5 km	t = 6 hr x = 2.0 km	t = 3 hr x = 1.9 km

as shown on Figure 5-3, currents 10 m or more beneath the surface (as indicated by metered current excursions) will proceed either northeasterly parallel to the coast (60°), or southwesterly (240°), in both cases normal to the diffuser alignment; hence equations 5-2 and 5-3 for initial dilution, S_m, apply to plumes rising from the ocean bottom to the vicinity of the surface. The drogue excursions shown on Figure 5-3, which represent current directions near the surface as well as at depth, show that a plume at or near the surface could be transported southward towards the shore (180°), as well as parallel to the coast, at speeds usually within the range of 5-10-18 cm/sec (Figures 3-12 to 3-15).

5.4 Multiport Diffuser Design

Ports

If practical, the ports should be bellmouthed, i.e., the inside edges of the ports should be smoothly rounded to promote uniform unseparated flow. To attain reasonable uniform discharge per unit length, the port diameter and spacing should be chosen according to Brooks' analysis;[1] in many practical cases, French's[2] graphical summary of Brooks' analysis is applicable.

To avoid serious interference between the plumes rising from adjacent ports, the port spacing should be about one-third of the height of rise predicted for the plumes when all ports are on one side of the pipe; if ports are on alternating sides of the pipe, the spacing may be less, but no less than one-sixth the height of rise.

Where essentially raw sewage is to be discharged, the diffuser ports should be quite large, so that they will not be blocked by solids. This is par-

[1] Koh, R.C.Y., and Brooks, N.H., "Fluid Mechanics of Wastewater Disposal in the Ocean," Annual Review of Fluid Mechanics, 1975.

[2] French, J.A., "Internal Hydraulics of Multi-port Diffusers," Journal Water Pollution Control Federation, 1972.

ticularly important with wastewater as full of stringy solids as Alexandria's is observed to be. Despite the fact that we recommend preliminary treatment to remove the large solids, the diffuser ports should not be smaller than about 250 mm in diameter.

Diffuser Design, Sidi Bishr

As noted in the Technical Report, a diameter of 2200 mm was selected for this outfall. This diameter is maintained throughout the length of the diffuser.

To maintain an approximately uniform value of discharge per unit length along the 400 m length of the diffuser, provide bellmouth ports 250 mm in diameter every 7.5 m, placed on alternating sides of the pipe. There are to be 54 ports in all, including the end port, as shown on Figure 5-6. The diffuser should be placed so that the offshore end has an elevation not more than 1 to 2 metres different from the inshore end, lest the flow distribution be affected by hydrostatic ambient pressure differences between the two ends.

Diffuser Design, Kait Bey

As noted in the Technical Report, a diameter of 1700 mm was selected for the Kait Bey outfall. This diameter is maintained throughout the length of the diffuser.

Again, to keep hydrostatic pressure difference effects to a minimum, the difference in elevation between the inshore and offshore ends of the diffuser should be no more than 1 to 2 metres.

For approximately uniform discharge per unit length, it is recommended that there be bellmouth ports, 250 mm in diameter, spaced every 10 m for the 330 m farthest offshore; then every 12 m, for the final 120 m; for a total of 43 ports, including the port at the end of the diffuser, as shown on Figure 5-6. The greater spacing at the inshore end is in order to offset the greater discharge rate per port expected there relative to farther offshore (from considerations of the internal hydraulics of multi-port diffusers).

5.5 Structural and Operational Considerations

Structural Considerations

Forces on the Outfall Pipe. A variety of forces act on the pipe, both during construction and after installation is completed. During construction, the pipe may be subjected to considerable tension if installed by the bottom-pull method. Before it is convered, it is susceptible to wave forces. If it is installed full of air to provide some buoyancy, care must be taken during the water filling process that air is not released too quickly, lowering the internal pressure and inviting collapse of the pipe.

When in service, the pipe must withstand the steady internal pressure due to the pumping head, and it must be able to withstand the transient positive and negative surge or water hammer pressures associated with rapid shutoff of the pumps upon power failure. At sufficiently sharp bends in the pipe there should be thrust blocks.

For the design significant wave derived in Chapter 3, with a height of 5 m and a period of 8.5 sec, the lateral forces on a circular cylinder lying on the sea bottom were computed for external diameters of 2.5 m (Sidi Bishr outfall) and 2.0 m (Kait Bey outfall), for a range of water depths. The Morison[1] equation was used:

$$f = C_m \rho \frac{\pi D^2}{4} \frac{dU_b}{dt} + C_D \frac{1}{2} \rho D U_b |U_b| \qquad \text{(eq. 5-8)}$$

(inertial forces) + (drag forces)

where:

- f = the force per unit length of pipe
- C_m = the inertial force coefficient
- ρ = the fluid density
- D = the external pipe diameter
- U_b = the bottom velocity
- C_D = the drag force coefficient

[1] Shore Protection Manual, Vol. 2, U.S. Army Coastal Engineering Research Center, 1973.

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The bottom velocity, U_b, was assumed to be sinusoidal, with period T, and related to the water depth via Figure 3-18. The value used for C_m was 1.5; the value used for C_D varied between 0.7 and 1.2. The force per unit length, f, was evaluated at the phase of the sinusoidal cycle that results in the maximum value of the right-hand side of equation 5-8, for each depth. On Figure 5-7, f is plotted against water depth for the Sidi Bishr and Kait Bey outfalls.

The calculations bear the assumption that the waves propagate in a direction perpendicular to the axis of the pipe, although many of the waves will be propagating in directions with components parallel to the pipe axis.

Extent of Burial. It will be necessary to bury the pipes throughout the surf zone, and offshore to a depth where wave forces and wave-induced sediment transport will not threaten the pipe. It is suggested that burial extend offshore to the 20 m depth contour; lateral wave forces on the pipes would thereby be kept below 700 kg wt per linear metre (Figure 5-7), and sediment transport would be confined to grain sizes conveniently less than sizes usable for bedding or revetment (Figure 3-18).

At the time of final design, a risk analysis should be made to determine the optimum burial depth for the outfalls. Wave forces can act on a buried pipe as well as on one that is not buried; the magnitude of the forces should be calculated.

Burial in the surf zone and across the beach will also prevent the pipe from being an aesthetic nuisance or a physical obstruction.

Materials. Often it is suitable to build outfalls of welded steel pipe, cement lined, with a coal tar and glass mat built-up coating, and an outer coat of reinforced concrete. Other materials, such as high density polyethylene, or fiberglass reinforced plastic, are sometimes considered, but the concrete-coated steel pipe usually best meets the two requirements of strength and weight. The weight of the pipe must

be sufficient such that, when the pipe is filled with fresh water of 1000 kg/m^3 density or less, there will be no danger of flotation, either with respect to the ambient seawater or to the soil in which the pipe may be buried. (Insufficiently heavy pipes have been known to "float" out of the soil in which they are buried when the soil has been fluidized by an earthquake or other jarring impulse.)

Construction and Installation. The pipe may be laid on the bottom and covered, or it may be laid in a trench and covered. In either case, it may be necessary to prepare a bedding of rock or of piles. In waters less than 10 m deep, sheetpiling may be used with the excavation.

For diameters of one metre or less, it is common to manufacture and assemble considerable lengths of pipe either on land or on a barge, and then install them by either bottom-pull or surface-pull methods. In the project area, surface-pull or flotation methods are not recommended due to the relatively swift currents prevailing, but the bottom-pull method appears to be quite feasible in most cases. For larger diameters, the relatively short sections of reinforced concrete must be placed individually, with the aid of divers.

Corrosion Protection. Corrosion Protection is a most important consideration if the pipeline is to be of steel. As noted in Section 3.6, the old Kait Bey outfall suffered extensively from corrosion.

The following paragraphs on corrosion control are taken largely from the Final Report of the ASCE Task Committee on Pipelines in the Ocean.[1]

There are two basic methods to achieve corrosion control of submarine pipelines: coating the pipe and applying cathodic protection. Commonly, a combination of coating and cathodic protection is used, with the coating system providing the basic protection and the cathodic protection system furnishing protection to those areas where defects exist in the coating.

[1] Final Report of the ASCE Task Committee on Pipelines in the Ocean, ASCE, New York, undated.

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Several effective and reliable pipe coating systems have been developed over the past several years. These systems range from thin film epoxy coating to thick mastic systems composed of fine aggregate (sand, limestone, and fiber) bound together by an asphaltic material. Weight coatings are commonly required to provide added stability to the pipe, especially for larger diameter lines. The addition of a weight coating affords extra protection to the underlying corrosion coating.

Cathodic protection can be provided in two ways: by electrically connecting the pipe to a more anodic material, or by connecting the pipe to an anode and impressing a direct current on the system from an external power source. In both cases, current flows from the anode to the pipe to be protected.

Sacrificial anodes are normally zinc or magnesium bracelets placed around the pipe at regular intervals. Zinc-to-steel has a smaller current output than magnesium-to-steel. Because of their lower current output, zinc anodes have a longer service life than magnesium anodes. Zinc is well suited for use on a coated pipeline where small cathodic protection currents are required. Bracelets of suitable size are commonly spaced on the pipeline at about 400 m intervals. It is important to design the cathodic protection system so that anode replacement is minimized during the life of the line.

An impressed current system usually consists of an ac power source, a rectifier to convert ac current to low voltage dc current, and an anode. The pipeline to be protected is connected to the negative side of the rectifier with the anodes connected to the positive side. An advantage of an impressed current cathodic protection system compared to sacrificial anodes is that the output voltage of the rectifier can be adjusted to any selected value. The disadvantage is the need to maintain the electrical system. With the sacrificial anode system, the output voltage is not variable and is determined by the type of anode used.

For the Alexandria outfalls, fundamental protection would be provided by bitumastic coatings reinforced by interior and exterior weight coatings

of concrete. Since occasional breaks in the coating may be unavoidable, zinc anode bracelets should be placed around the pipe every 400 m or so, in electric contact with the steel. Such bracelets should ensure many years of protection if breaks in the coating are few; yet it would be wise, at least in areas where the pipeline is exposed, to provide periodic (say, every year or two years) diver inspection of the anode bracelets, with replacement in whole or in part if necessary. Such inspection and maintenance could be easily done with personnel and resources available in Alexandria.

Quality Control

Whatever construction methods and materials are ultimately used, careful quality control of fabrication and installation is essential to ensure satisfactory performance over a long lifetime. A lot of money may be spent to achieve a design strength of pipe, which, if maintained over the length of the pipeline, will be most satisfactory; yet if even a few short sections of the line are substandard, and fail, the whole facility may be considered a failure. Therefore, the cost of ensuring close control over quality of production is money very well spent.

Local Experience

At least two undersea petroleum pipelines of reinforced-concrete-coated steel have recently been constructed near Alexandria by the bottom-pull method. Experience gained from construction, operation and maintenance of these pipelines will be valuable in the design of the wastewater outfalls.

Hydrogen Sulfide

Hydrogen sulfide (H_2S) is a gas that occurs in sewers and force mains where wastewater has insufficient oxygen, and is commonly detected by its "rotten egg" odor. Controlling H_2S production and release is important not only to control odors, but also because the gas is lethal to people at levels exceeding about 300 mg/L[1], and toxic in the marine environment at levels in excess of 0.01 mg/L.[2] In sewerage systems, H_2S can also form sulfuric acid (H_2SO_4) which is highly corrosive and can damage

[1]USEPA Process Design Manual for Sulfide Control in Sanitary Sewerage Systems.

[2]National Academy of Sciences and National Academy of Engineering, Water Quality Criteria, 1972, Washington, Environmental Protection Agency, 1972.

pipelines and other facilities.

H_2S is typically produced in sewerage systems where there is no dissolved oxygen (DO) in the wastewater, and where anerobic bacteria, contained in a slime layer attached to the walls, become active. The anerobic bacteria will not produce H_2S when there is dissolved oxygen present or when there is insufficient organic matter (measured as BOD_5).

Controlling H_2S production is usually achieved by maintaining the DO sufficiently high that the anerobic bacteria are inactive. In sewers flowing partially full, the DO is maintained in the wastewater through direct transfer from the atmosphere, at the water surface. The degree of oxygen transfer is dependent on the rate of turbulent diffusion in the flow.

In force mains, such as marine outfall, there is no atmospheric water surface so that oxygen regeneration is nearly zero. Therefore, steps must be taken to eliminate H_2S production for the entire length of the force main or H_2S will be released at the end. Methods often used include the addition of H_2O_2 or compressed air to maintain adequate DO, and addition of chlorine or other chemicals to eliminate the anerobic bacteria. However, these methods can be expensive, and may be impractical for large, long submarine outfalls.

Hydrogen sulfide released in the ocean at concentrations less than 0.005 mg/L may be considered to have minimal deleterious affects on the marine environment. H_2S at concentrations exceeding 0.01 mg/L may be considered a hazard to the marine environment.[1]

The concentration of H_2S released at the end of a force main or outfall is dependent on the length of time the wastewater in the pipeline is anerobic. Wastewater discharged through either the Kait Bey or Sidi Bishr outfalls will receive preliminary treatment consisting of screening, and grit and floatable solids removal. Aeration provided in the grit chamber

[1] National Academy of Sciences and National Academy of Engineering, Water Quality Criteria, 1972. Washington, Environmental Protection Agency, 1972.

ensures that the wastewater entering the outfall will be aerobic and not produce H_2S until the oxygen has been utilized by the organisms in the wastewater.

The estimated total travel time for wastewater entering the proposed outfalls to discharge at the diffuser is shown in Table 5-6. The estimated time that the wastewater remains aerobic was calculated based on a DO of 3 mg/L for wastewater leaving the treatment plant, and a BOD removal of about 8 percent in the treatment process. By subtracting the time the wastewater is aerobic from the total travel time, the time during which H_2S will be produced can be determined. The H_2S production time and the estimated concentration produced at the diffuser is also shown in Table 5-6.

The amount of H_2S produced will vary with the temperature of the wastewater, so that summer and winter values were calculated corresponding to wastewater temperatures of 28°C and 15°C, respectively.

The concentration of H_2S released from the outfall (shown in Table 5-6) will be diluted with sea water by the diffuser. The dilution that will keep the concentration of H_2S less than 0.005 mg/L is shown in Table 5-7.

The available initial dilution at the diffuser is also shown in Table 5-7. During the summer months, and particularly in the early years, the initial dilution alone will often not be sufficient to reduce the concentration of H_2S to the acceptable level of 0.005 mg/L, i.e., the available dilution is less than the indicated required dilution in Table 5-7.

For the Kait Bey outfall, the indicated available initial dilutions are never less than half the dilution required for 0.005 mg/L, which is to say that there will be little chance that concentrations will exceed the hazard threshold level of 0.01 mg/L. For the Sidi Bishr outfall, however, some of the indicated values for initial dilution are indeed less than half the indicated required dilution, so that hazardous levels will sometimes be

TABLE 5-6

HYDROGEN SULFIDE PRODUCTION IN OUTFALL LINES

Outfall Location	Flow mL/d	Total travel Time, hr	Time Wastewater in Aerobic, hr	H_2S Time of Production, hr	H_2S Concentration @ Diffuser, Summer mg/L	H_2S Concentration @ Diffuser, Winter mg/L
Sidi Bishr[a]						
1980 Average	261	4.19	0.78	3.41	6.15	2.55
1980 Peak	390	2.81	0.78	2.03	3.70	1.55
1990 Average	412	2.66	0.76	1.90	3.45	2.45
1990 Peak	619	1.77	0.76	1.01	1.83	0.79
2000 Average	560	1.95	0.75	1.20	2.15	0.92
2000 Peak	838	1.31	0.75	0.56	1.00	0.43
Kait Bey[b]						
1980 Average	263	1.66	0.76	0.90	2.19	0.90
1980 Peak	401	1.09	0.76	0.33	0.78	0.33
1990 Average	328	1.33	0.72	0.61	1.42	0.61
1990 Peak	492	0.89	0.72	0.17	0.45	0.17
2000 Average	392	1.11	0.71	0.40	0.95	0.40
2000 Peak	577	0.76	0.71	0.05	0.20	0.05

[a] Sidi Bishr Outfall is 11 km at sea plus 1 km on land.

[b] Kait Bey Outfall is 8 km at sea.

TABLE 5-7

REQUIRED DILUTION OF WASTWATER FOR ALLOWABLE H_2S CONCENTRATIONS

Location	Dilution Required to Reduce H_2S Concentration to 0.005 mg/L		Final Dilution Available with Ambient Current Speeds of:		
	Summer	Winter	V_{20} = .05/sec	V_{50} = .10/sec	V_{80} = .18/sec
Sidi Bishr Outfall					
1980 Average	1090	370	253	437	787
1980 Peak	600	170	194	292	526
1990 Average	550	350	187	277	499
1990 Peak	226	18	143	184	331
2000 Average	290	44	152	203	366
2000 Peak	60	-	117	136	245
Kait Bey Outfall					
1980 Average	298	40	198	355	639
1980 Peak	16	-	150	233	419
1990 Average	144	-	171	284	512
1990 Peak	-	-	131	190	341
2000 Average	50	-	152	239	430
2000 Peak	-	-	118	162	291

found there. The potential for hazard will increase if pretreatment facilities fail to provide the degree of aeration assumed in these calculations.

Measures to lessen the hazard would include reducing the outfall pipe diameter or shortening the outfall length to reduce travel times, as well as applying the DO-maintenance measures mentioned above. However, the judgment is made here that the H_2S toxicity threat is of less importance than the considerations otherwise governing outfall diameter and length. The region affected will be limited in extent to within a few hundred metres of the diffuser, since secondary dispersion processes will reduce concentrations further, and since H_2S is rather quickly oxidized by a group of bacteria that convert it to thiosulfates and water. The toxic effects are not cumulative.

As to odor due to H_2S in the sewage plume escaping to the atmosphere, it is estimated that even in the worst summer conditions, the lightest of breezes will be sufficient to keep concentrations at levels below minimum threshold value by a factor of 10.

Operational Design Considerations

In choosing the pipeline diameter, a compromise must be made between possibly conflicting requirements: the diameter should be great enough that design peak flows may be passed without developing excessive head, yet small enough that solids do not accumulate in the pipe at times of low flow. To prevent the long-term accumulation of solids, daily peak velocities in the early years of operation should be at least 1 m/sec, if possible.

A Manning "n" value of 0.016 is recommended for computing the pumping head associated with a given discharge and pipe diameter. This value, while somewhat greater than values observed for outfalls carrying primary and/or

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secondary effluent, is about equal to those often observed for outfalls carrying raw sewage. When analyzing potential water hammer pressures in the line, a conservatively low value, such as 0.012, should be used.

It is most desirable to keep air out of the outfall pipeline. It is, therefore, recommended that the portion of the outfall on land, running from the pump station to the shore, have a crown elevation low enough that the line will remain entirely full of water at zero flow. With freshwater sewage flowing into a saltwater sea such as at Alexandria, there is a hydrostatic pressure differential between the inside and the outside of the pipe at the sea surface. For an outfall discharging at 48 m depth, the differential head is about 1.5 m. The crown elevation of the land portion must, therefore, be kept below an elevation of 1.5 m above average sea level to remain filled with water.

For general access, and particularly for cleaning, manholes should be provided at regular intervals along the pipe where practicable. In particular, there should be a manhole in the outfall near the shoreline, particularly in those cases where there is a substantial portion of the line on land, between the pump station and the shoreline. So that the manhole may be opened without prolonged, upwelling spillage due to the hydrostatic pressure differential, the rim must be at least 1.5 m above sea level. An air release valve should be installed in or next to the manhole cover. The manhole must be able to remain closed and water-tight under internal pressures at which the outfall will operate (up to 30 m of head). Similarly, the junction box just downstream of the pumps at the pump station should be accessible, but with the pressure hatch higher than 1.5 m above sea level. The potential water hammer pressures that would occur in the line upon power failure at the pump station should be computed, and measures taken to ensure that neither the positive nor the negative pressure limits of the pipe can be exceeded.

The cap at the offshore end of the diffuser should be removable to facilitate cleaning. Trawlers presently frequent the areas 10 km off Anfushi and Sisi Bishr. It will, therefore, be necessary to place buoys at both

ends of the diffuser to warn trawlers against snagging their nets on the exposed diffuser and to protect the diffuser from danger should it be snagged.

5.6 Summary of Preliminary Design

Appropriate Discharge Locations

The proposed outfall alignments and diffuser sites are shown on Figures 5-8, 5-9 and 5-10. It is proposed that the Sidi Bishr outfall diffuser be located 11 km off Sidi Bishr, approximately 13 700 m north and 2900 m east of Kait Bey Fort; or at 958 800 m north, 511 500 m east on the coordinate system used by the Egyptian Government Mapping Service. The discharge depth is 55 m.

In Figure 5-8, two alternative routes are shown for the Sidi Bishr outfall, to the same proposed discharge location. Alternative 1, based on early Master Plan proposals, was surveyed in the Geophysical Studies portion of the program in 1977. Alternative 2, more appropriate to the Ras El Soda Preliminary Treatment Plant site as proposed in 1978, has not yet been surveyed.

It is proposed that the Kait Bey outfall diffuser be located 8 km off Anfushi, approximately 7400 m north and 3100 m west of Kait Bey Fort; or at 952 500 m north, 505 500 m east, on the Egyptian Government Mapping Service coordinate system. The discharge depth is 40 m. The discharge point 8 km off Anfushi is 10 km or more from any shoreline point not on the Anfushi Peninsula.

There are several reasons for placing the discharge points 10 km or so from shore. The analysis for bacterial decay and required travel time indicated that a 6 km long outfall could provide a 10^4 reduction in fecal coliforms at least 50 percent of the time, but that a 10 km long outfall was required to attain a 10^3 reduction in coliforms at least

80 percent of the time. The dilution volume analysis indicated that outfalls about 10 km long are necessary to attain a far-field dilution ratio of 1000. Secondary dispersion analysis indicates that drift distances of up to 8 km are required to achieve a dilution ratio of 1:1000 by initial and secondary dilution processes. At 10 km from the shore, the water depth is sufficient that the wastewater plumes can be kept submerged beneath the sea surface for at least a portion of the summer bathing season. Discharge 10 km from shore places the wastewater plumes beyond the lens of lower salinity water that sometimes lies along the coast.

Placing the Kait Bey discharge slightly closer to shore than 10 km, with the Sidi Bishr discharge slightly farther than 10 km, is intended to reduce the probability of mutual interference between the two plumes.

Dimensions

To attain an initial dilution ratio of 1:150, the Sidi Bishr outfall multiport diffuser should be 400 m long, with 54 ports each 250 mm in diameter placed every 7.5 m. The Kait Bey outfall diffuser should be 450 m long with 43 ports each 250 mm in diameter.

The Sidi Bishr outfall pipe and diffuser should have an internal diameter of 2200 mm. The Kait Bey pipe should have an internal diameter of 1700 mm.

Burial

The outfall pipelines should be buried from the shoreline, through the surf zone, and out to about the 20 m contour. For both the Sidi Bishr and Kait Bey alignments, the bottom terrain in this nearshore zone is generally rocky, requiring a number of vertical bends in the pipe of up to about 20 degrees. Trenching in rocky areas may require blasting.

Beyond the 20 m contour, the pipe need not be trenched, but may be laid on a prepared bed on the sea floor. Some of the terrain will be rocky, and some will be composed of sand, silt, shell or clay. It is believed that the unconsolidated soils encountered will everywhere have sufficient bearing capacity to support the pipeline.

Materials

The pipe material recommended is coal-tar coated steel with an internal mortar coating and an external coating of reinforced concrete. Cathodic protection of the steel is to be afforded by sacrificial zine anode bracelets installed at frequent intervals.

Design Flows

For design purposes, the projected year 2000 flows have been used in the calculations. At lesser flows, the degrees of dilution afforded will be generally greater, and the season during which the plume will be submerged will be longer. Hydrogen sulfide concentrations will be greater due to increased travel time, as shown in Table 5-6, but in all other respects outfall performance will be equal or better than that anticipated under design flow conditions.

A Final Note

The outfalls proposed in this report will have value only as part of the overall Wastewater Master Plan for Alexandria. The outfalls will not help improve conditions at the beaches unless the present shoreline sewer discharges are curtailed as part of the Master Plan.

The purpose of the Master Plan is to indicate how best to repair, extend and operate a system to collect wastewater from the residential, industrial and beach areas of the city. The purpose of the outfalls as designed is to provide a suitable and dependable means of disposal of the wastewaters once they are collected, consistent with maintaining a healthy fishery off the coast, and with maintaining safe and attractive conditions for bathing along the shore.

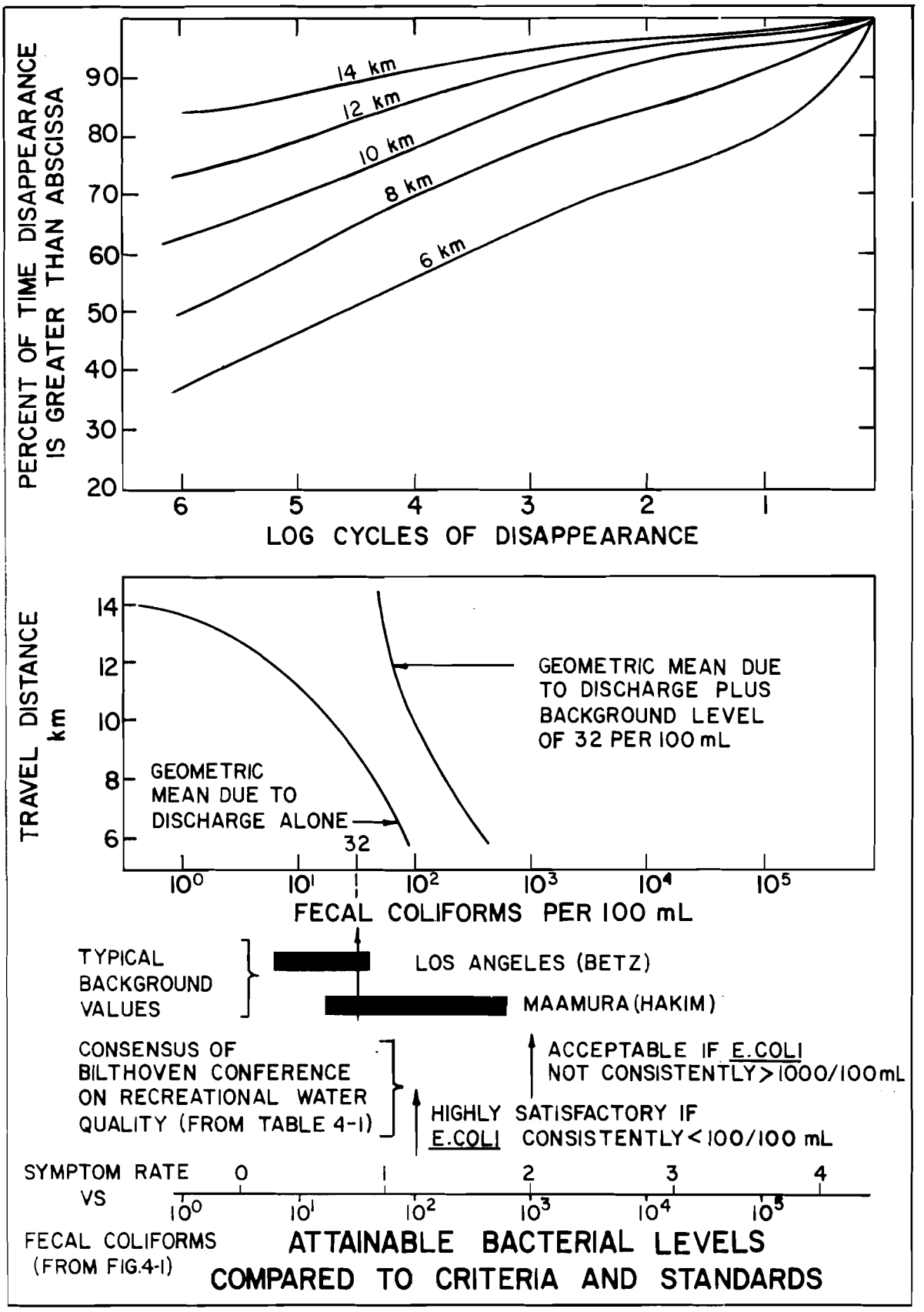
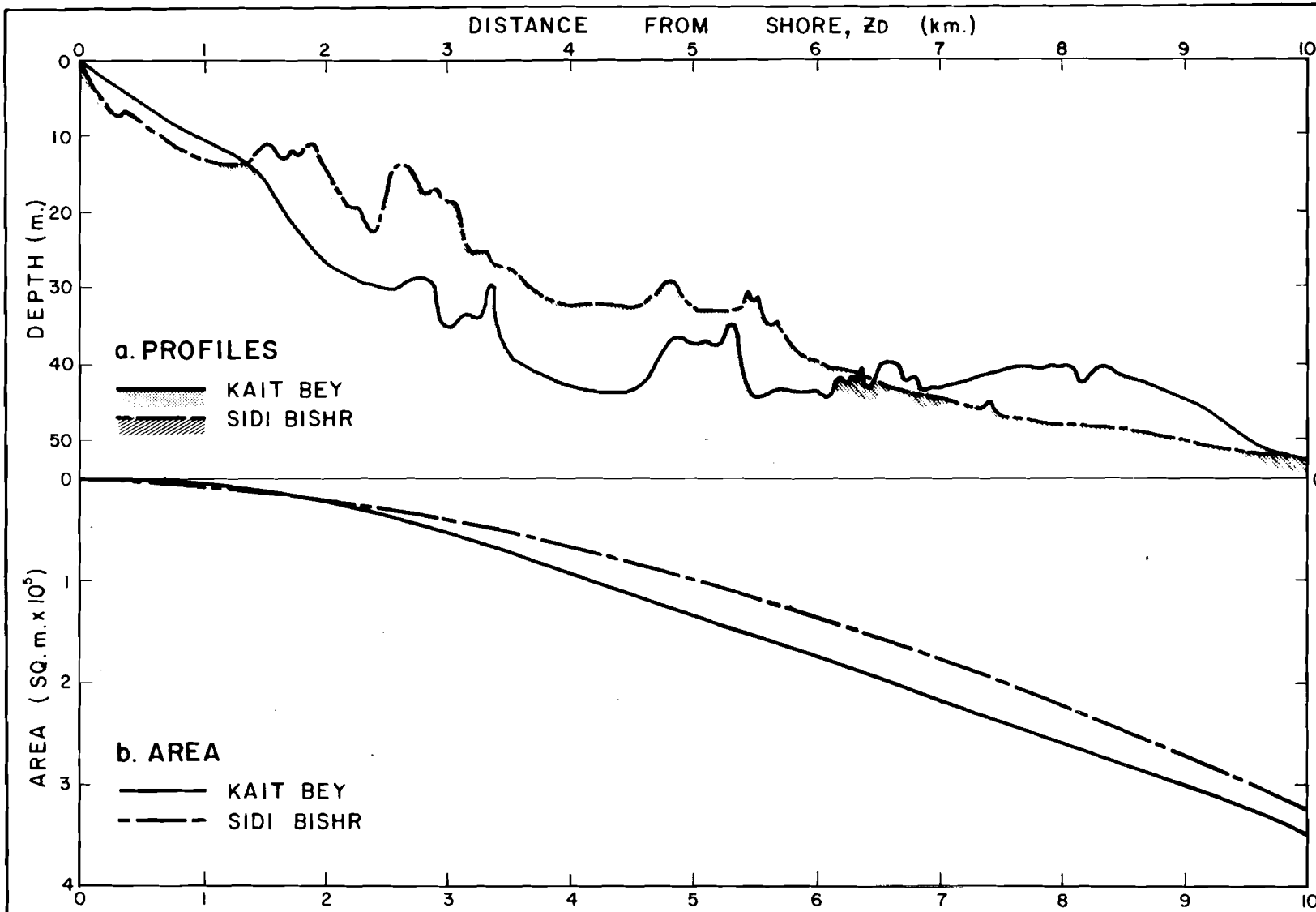

PERCENT OF TIME DISAPPEARANCE IS GREATER THAN ABSCISSA
90
80
70
60
50
40
30
20
14 km
12 km
10 km
8 km
6 km
6
5
4
3
2
1
LOG CYCLES OF DISAPPEARANCE
TRAVEL DISTANCE km
14
12
10
8
6
GEOMETRIC MEAN DUE TO DISCHARGE PLUS BACKGROUND LEVEL OF 32 PER 100 mL
GEOMETRIC MEAN DUE TO DISCHARGE ALONE
32
10^0
10^1
10^2
10^3
10^4
10^5
FECAL COLIFORMS PER 100 mL
TYPICAL BACKGROUND VALUES
LOS ANGELES (BETZ)
MAAMURA (HAKIM)
CONSENSUS OF BILTHOVEN CONFERENCE ON RECREATIONAL WATER QUALITY (FROM TABLE 4-1)
ACCEPTABLE IF E.COLI NOT CONSISTENTLY > 1000/100 mL
HIGHLY SATISFACTORY IF E.COLI CONSISTENTLY < 100/100 mL
SYMPTOM RATE VS FECAL COLIFORMS (FROM FIG.4-1)
0
1
2
3
4
10^0
10^1
10^2
10^3
10^4
10^5
ATTAINABLE BACTERIAL LEVELS COMPARED TO CRITERIA AND STANDARDS

FIGURE 5-1



PROFILE AND CROSS SECTIONAL AREA OF KAIT BEY AND SIDI BISHR ALIGNMENTS

FIGURE 5-2

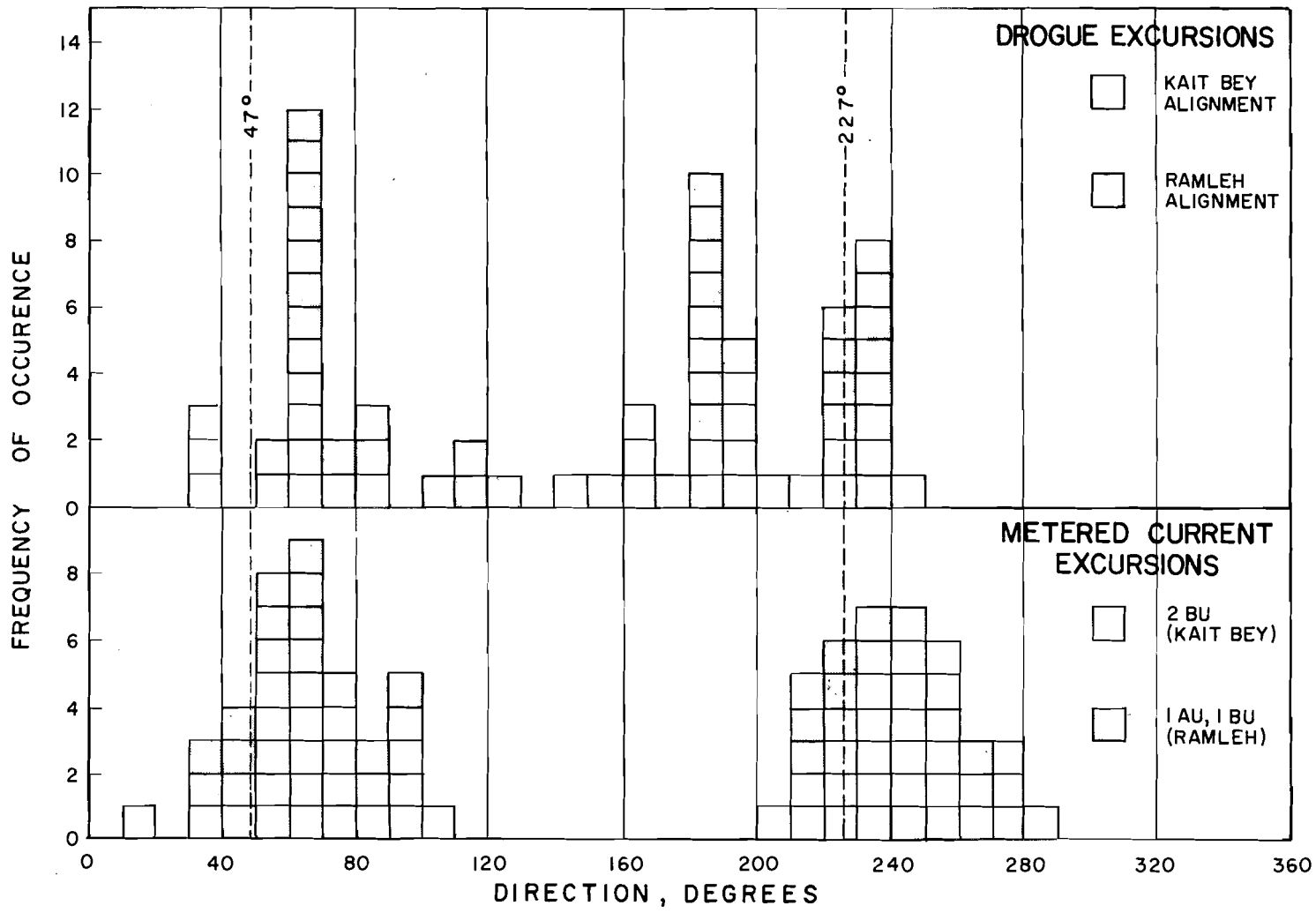
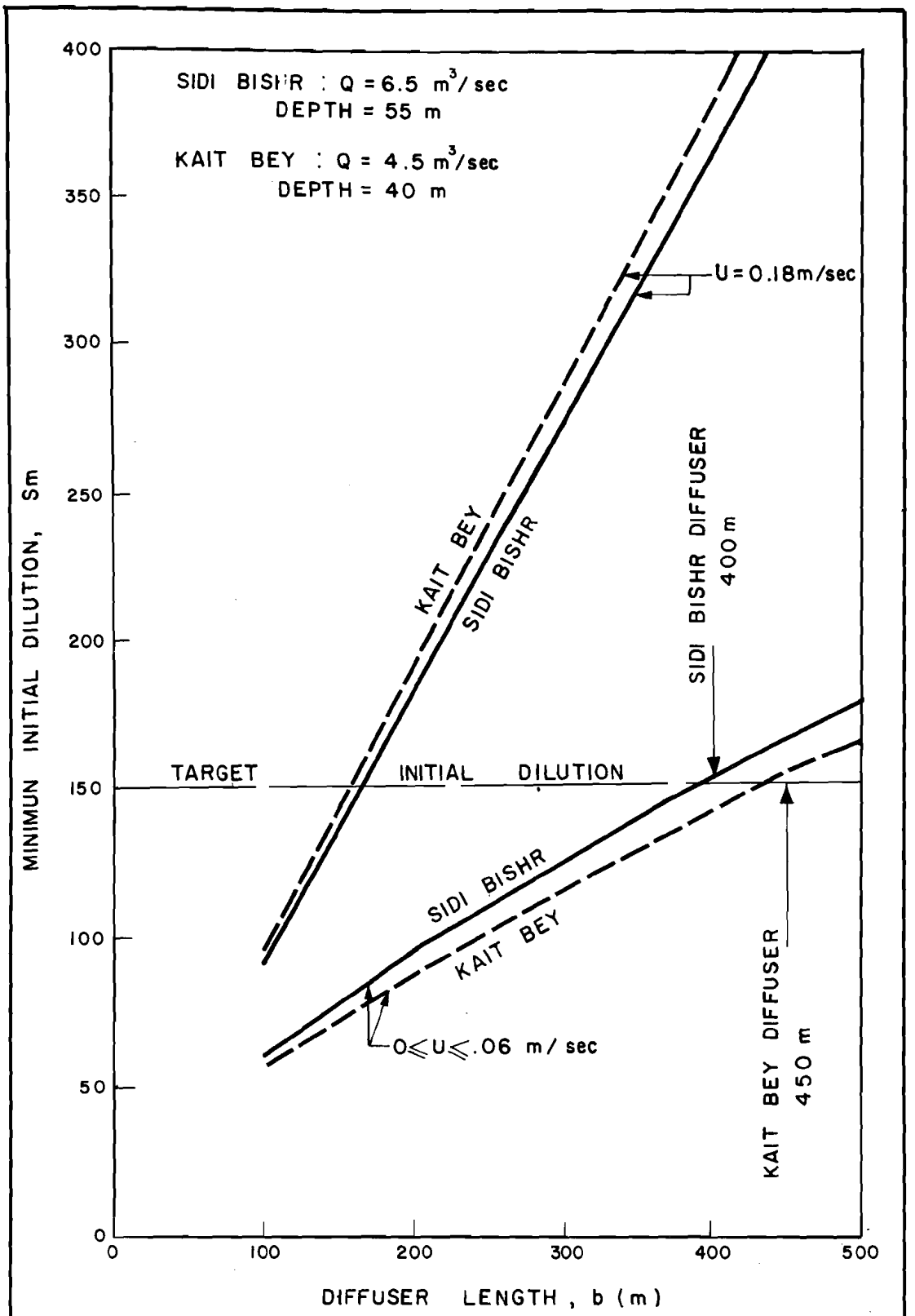


FIGURE 5-3

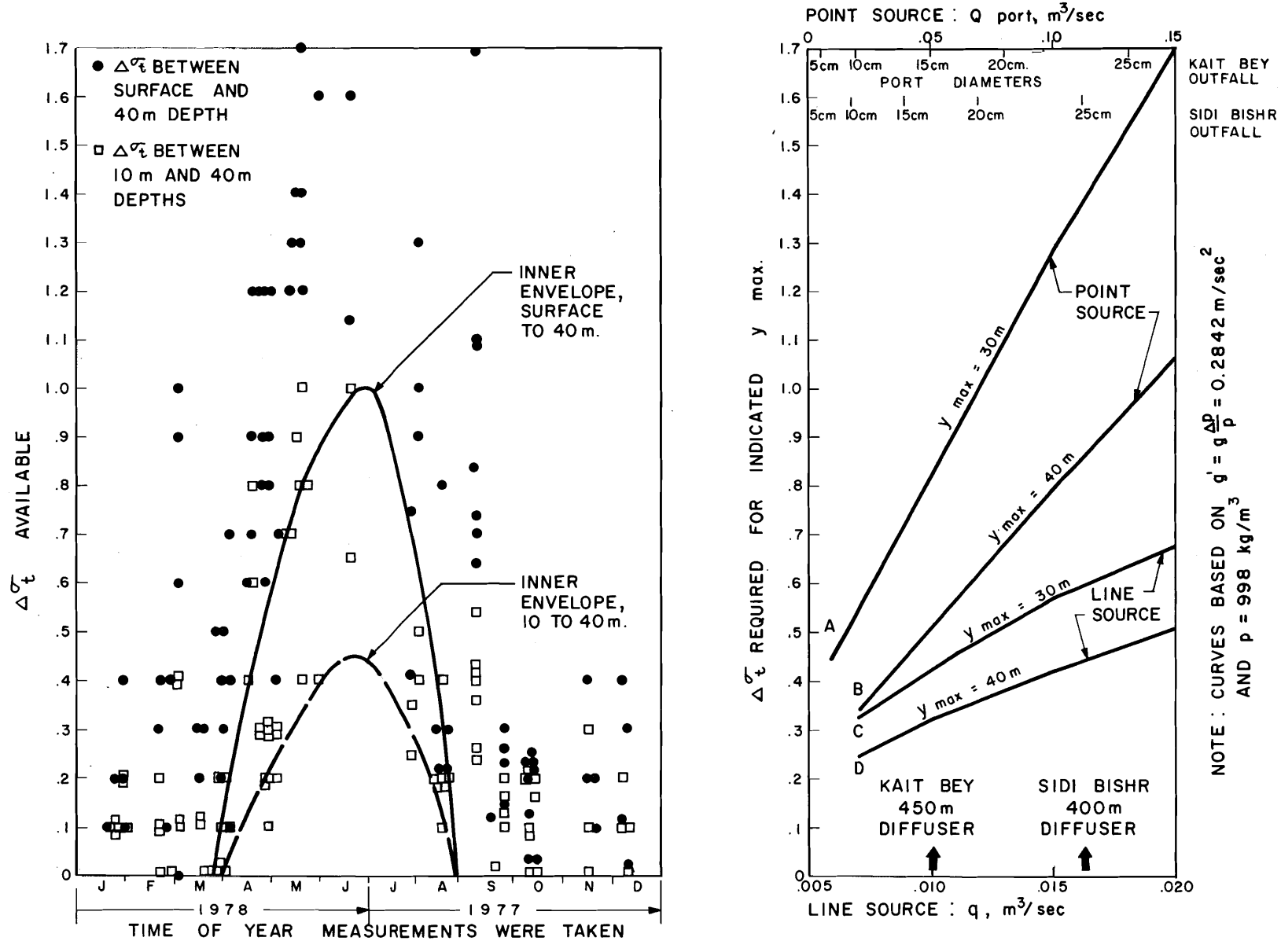
DISTRIBUTION OF CURRENT DIRECTIONS NEAR LIKELY DISCHARGE POINTS



INITIAL DILUTIONS AND
CHOICE OF DIFFUSER LENGTHS

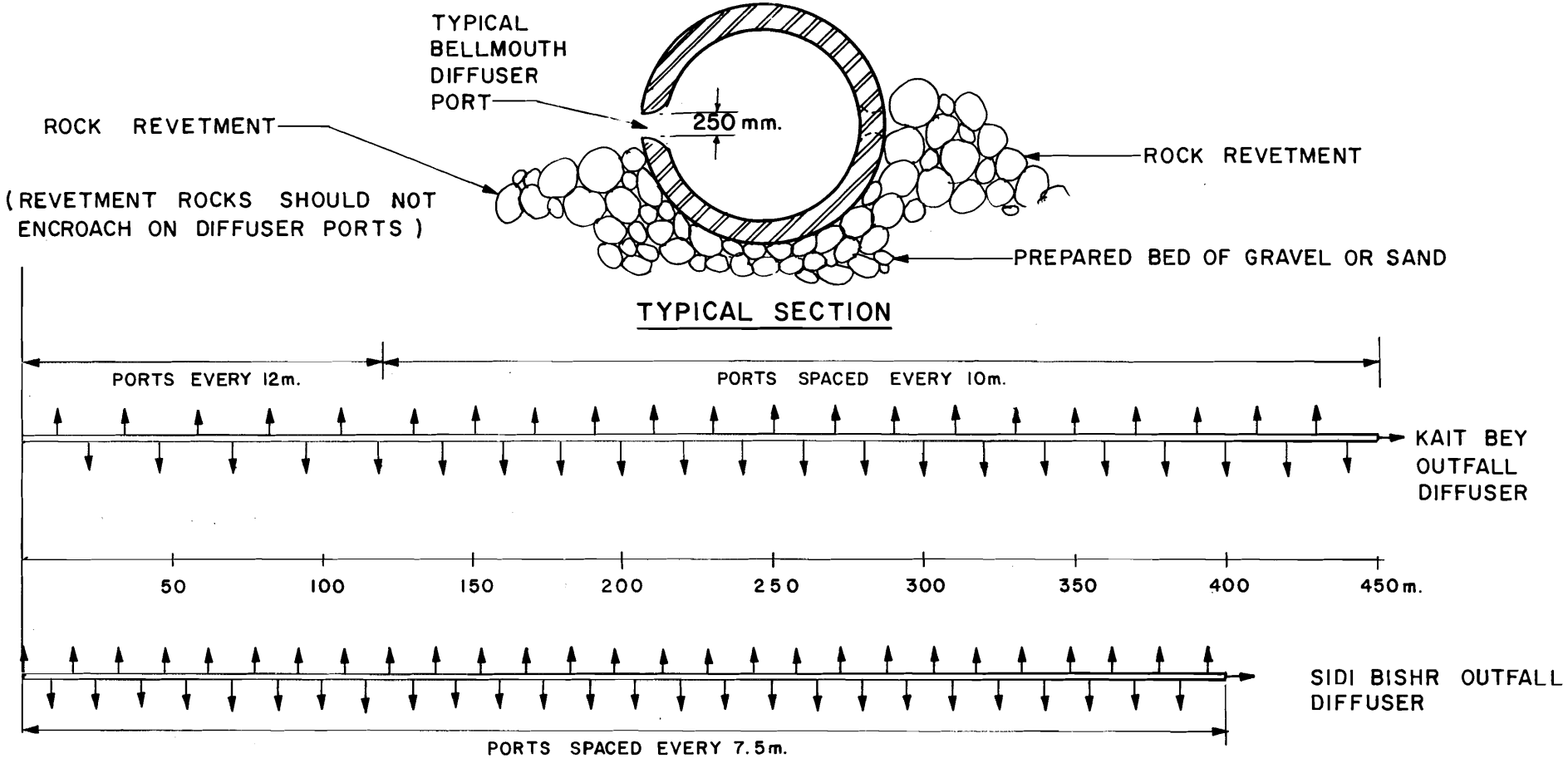
FIGURE 5-4

210



DENSITY DIFFERENCE REQUIRED, AND AVAILABLE, FOR PLUME SUBMERGENCE

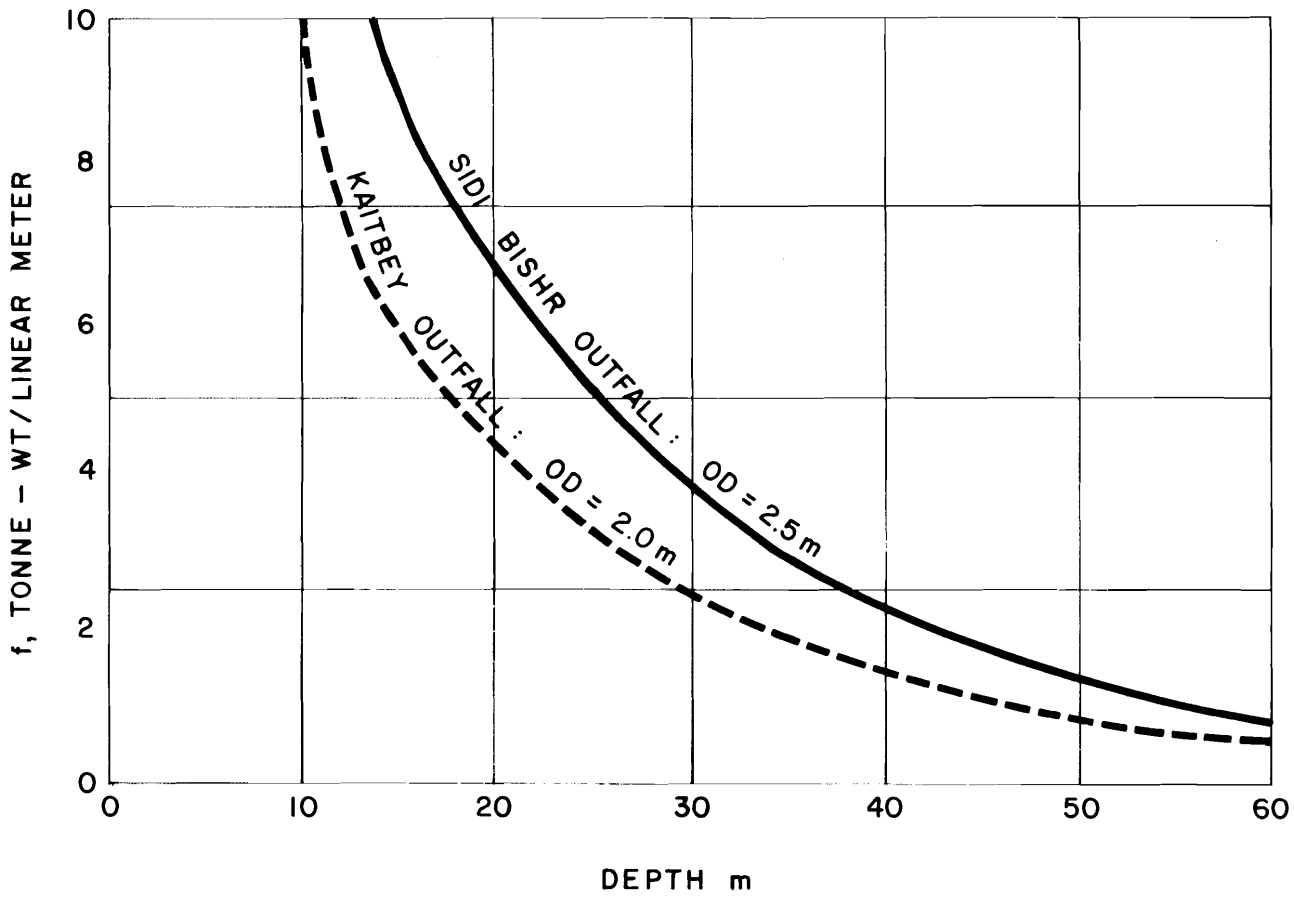
FIGURE 5-5



DIFFUSER LAYOUTS

FIGURE 5–6

212



LATERAL FORCE PER UNIT LENGTH, f, ON EXPOSED PIPE ON SEA BED, DUE TO DESIGN DEEPWATER WAVE

FIGURE 5–7

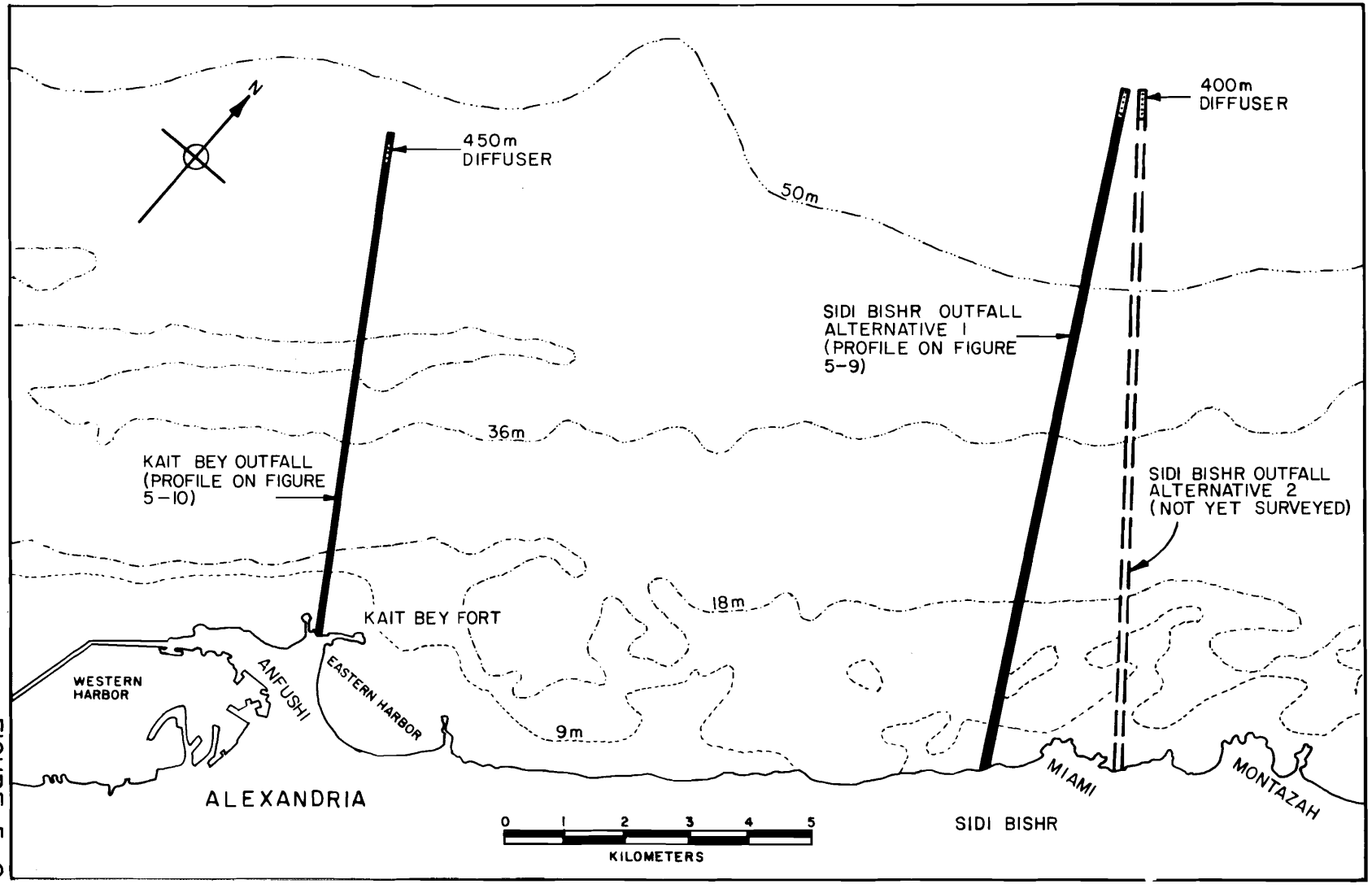


FIGURE 5-8

PROPOSED ALIGNMENTS FOR SIDI BISHR AND KAIT BEY OUTFALLS

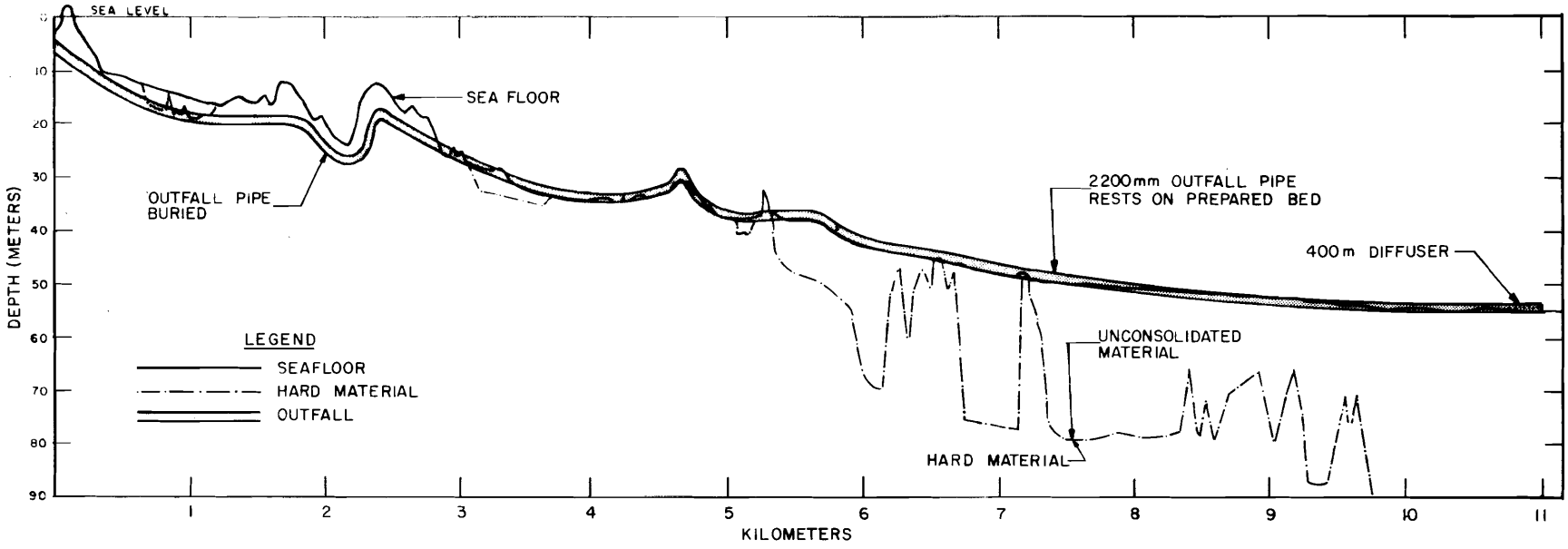


FIGURE 5-9 PROFILE OF PROPOSED SIDI BISHR OUTFALL ALIGNMENT (ALTERNATIVE I)

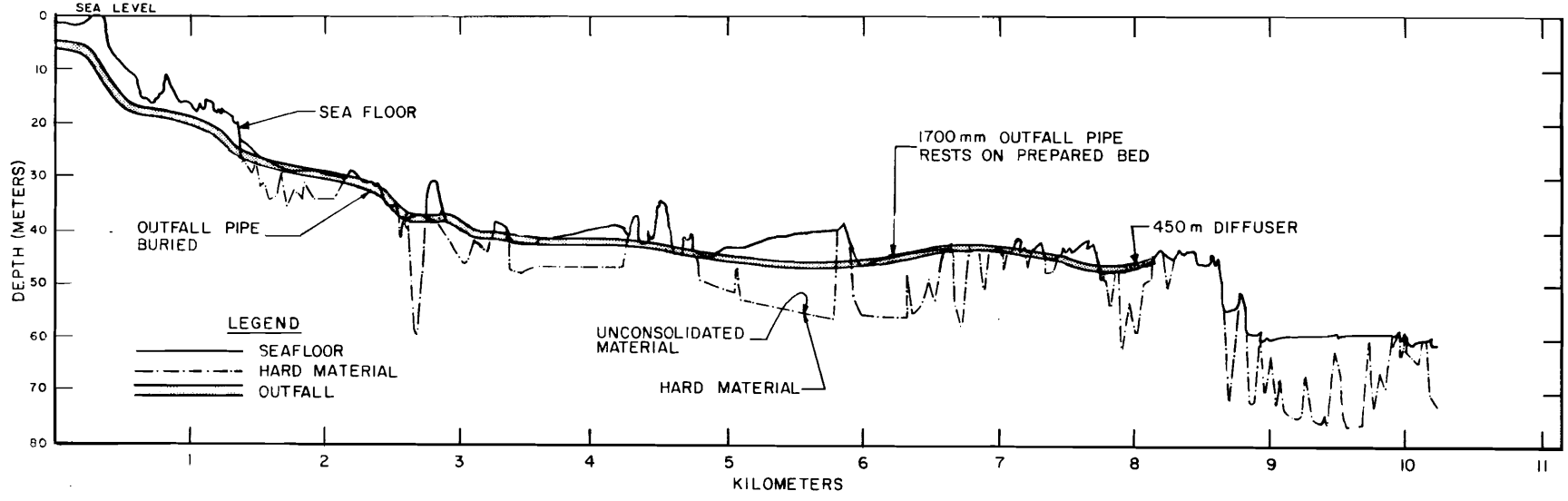


FIGURE 5-10 PROFILE OF PROPOSED KAIT BEY OUTFALL ALIGNMENT

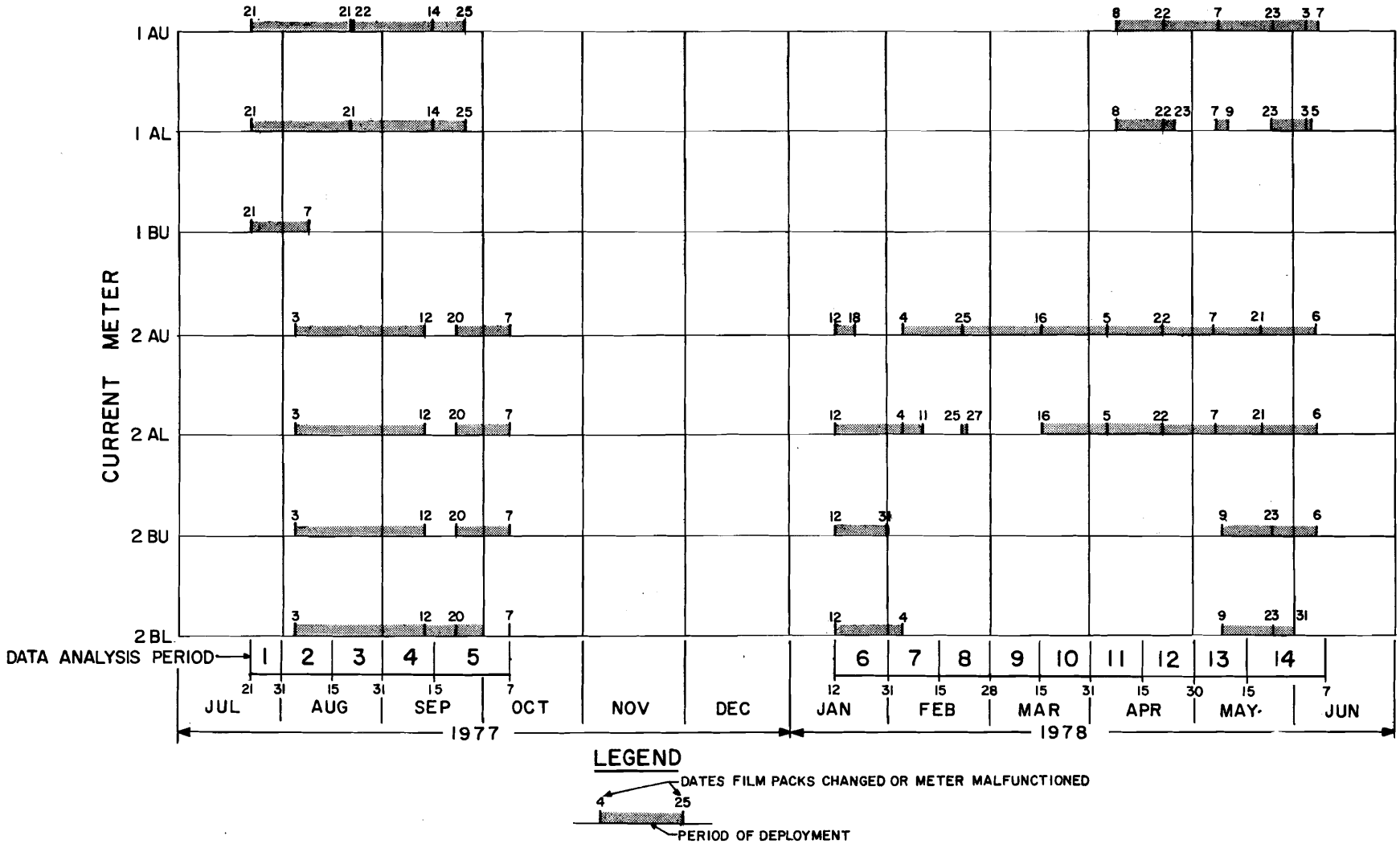


FIGURE 3-10

LOG OF CURRENT METER DEPLOYMENTS

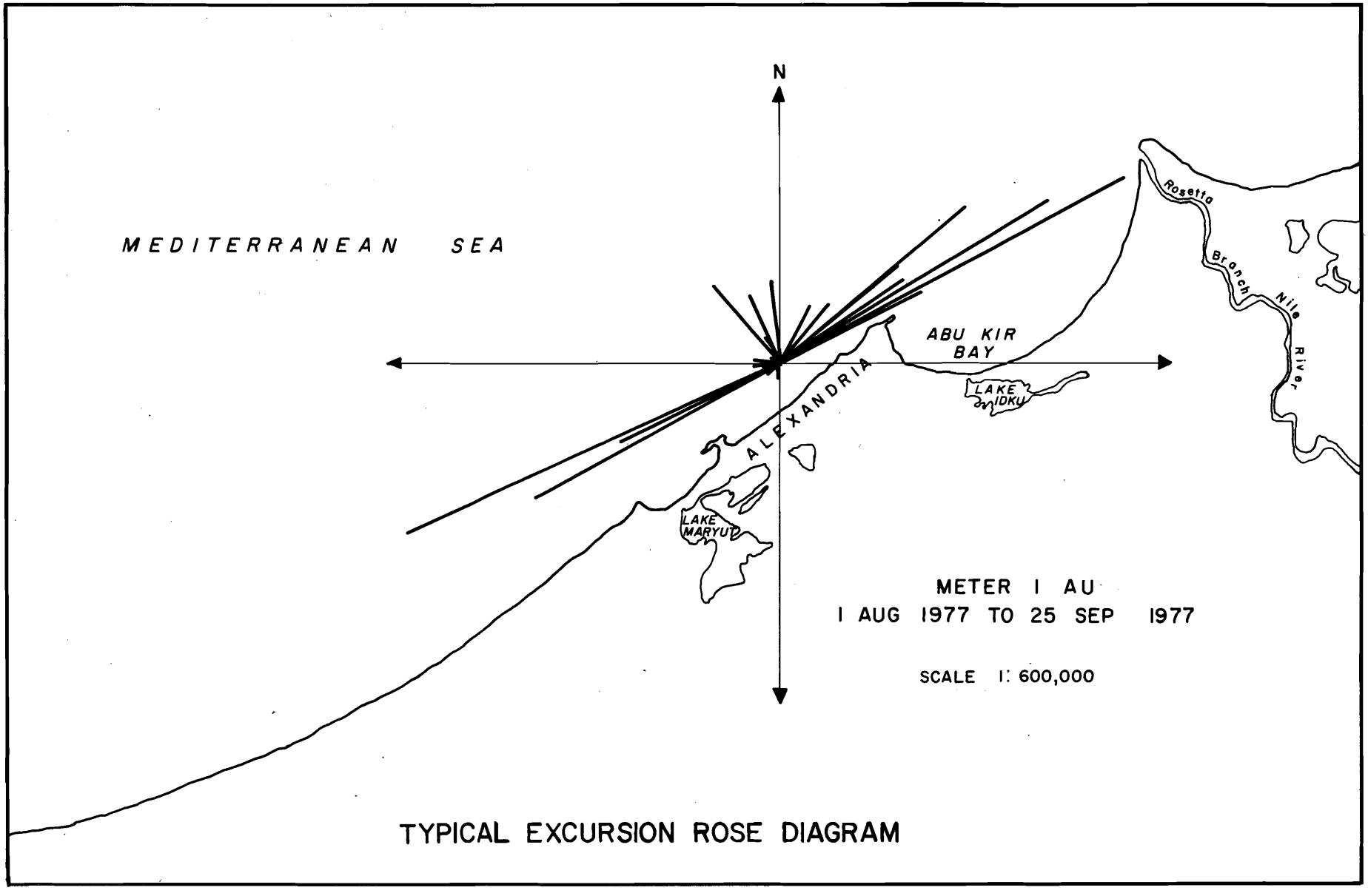
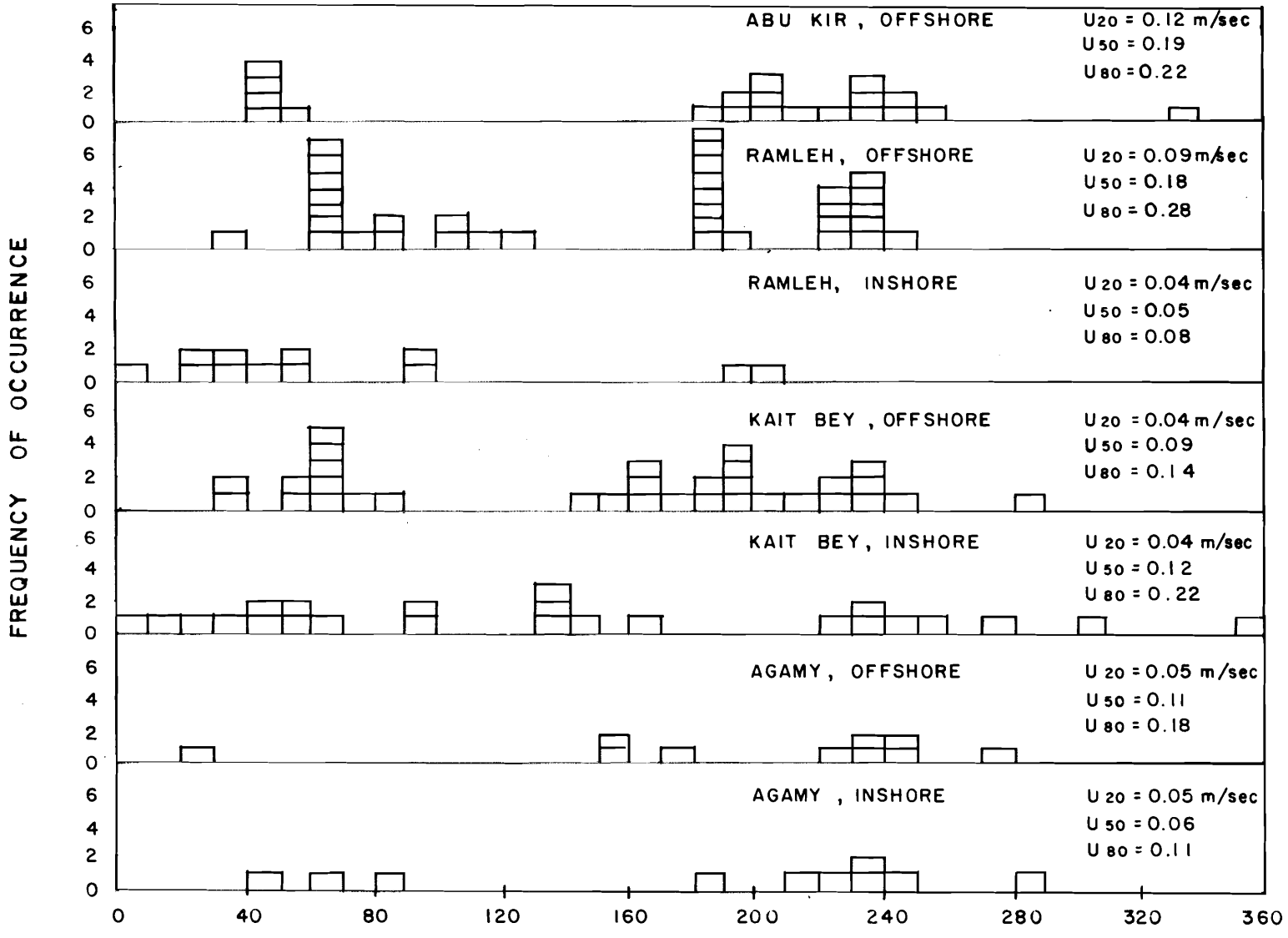


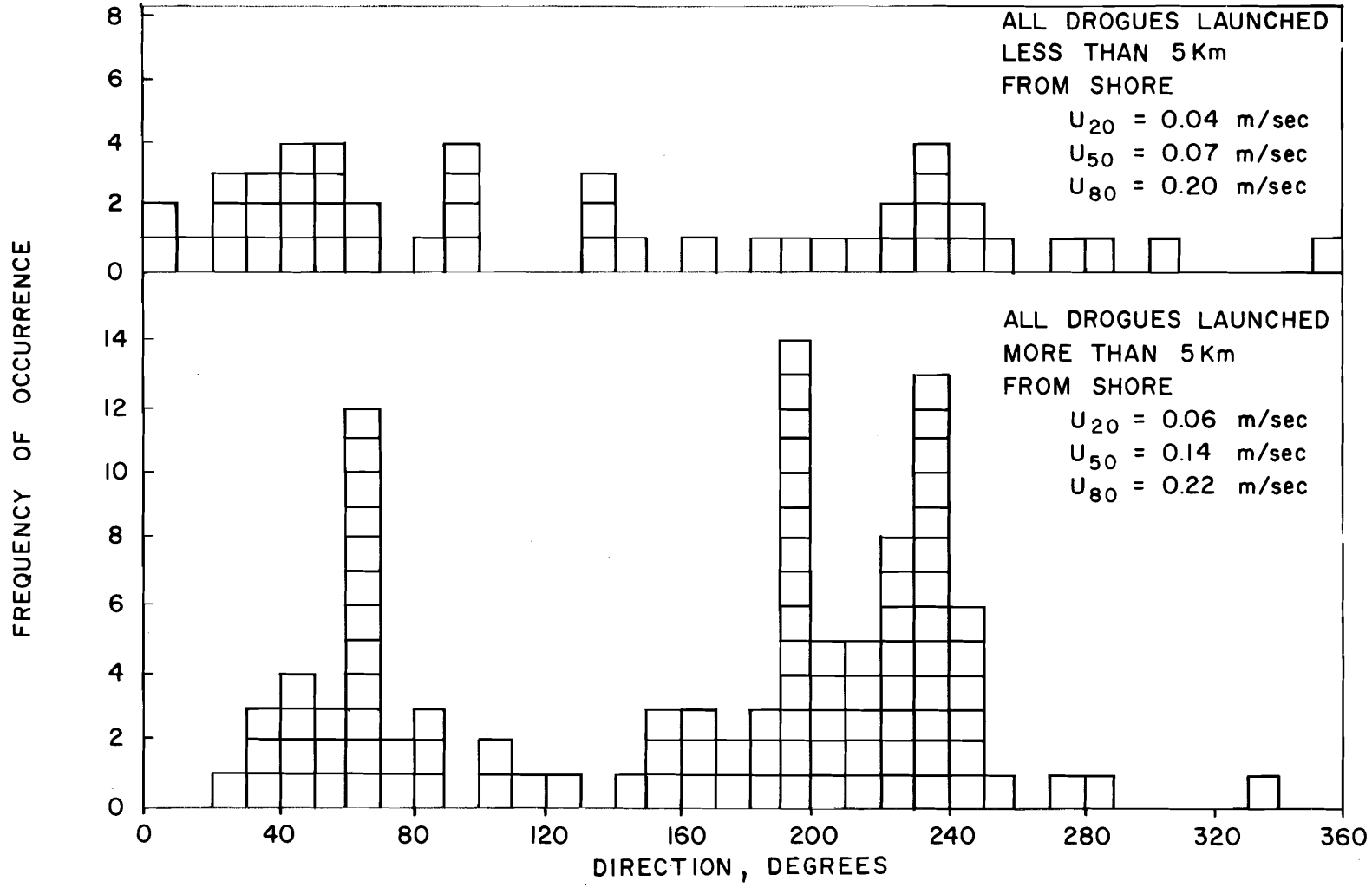
FIGURE 3-11

TYPICAL EXCURSION ROSE DIAGRAM



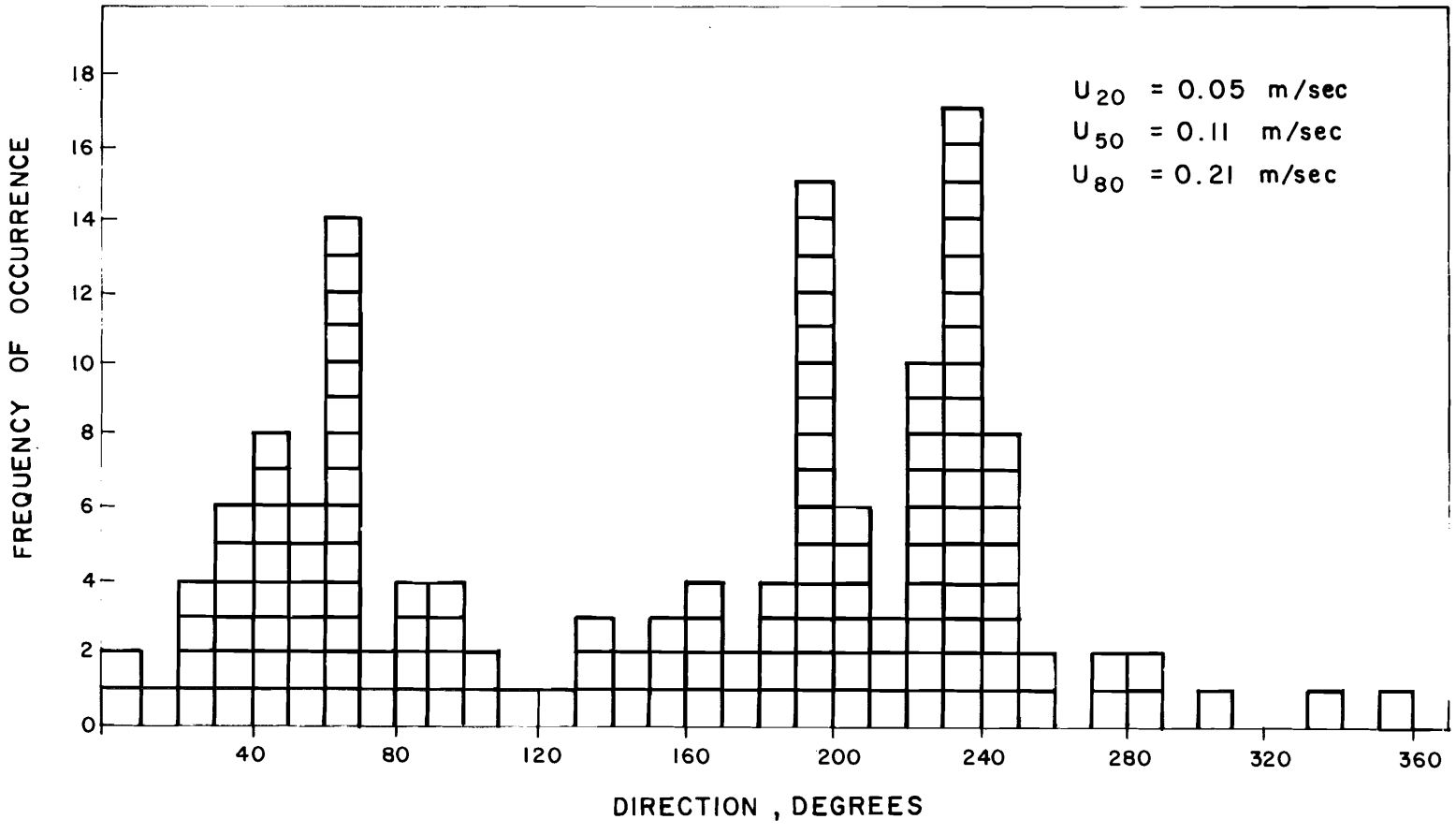
SPEED AND DIRECTION SUMMARY FOR DROGUE DATA

FIGURE 3—12



SPEED AND DIRECTION SUMMARY FOR INSHORE AND OFFSHORE DROGUES

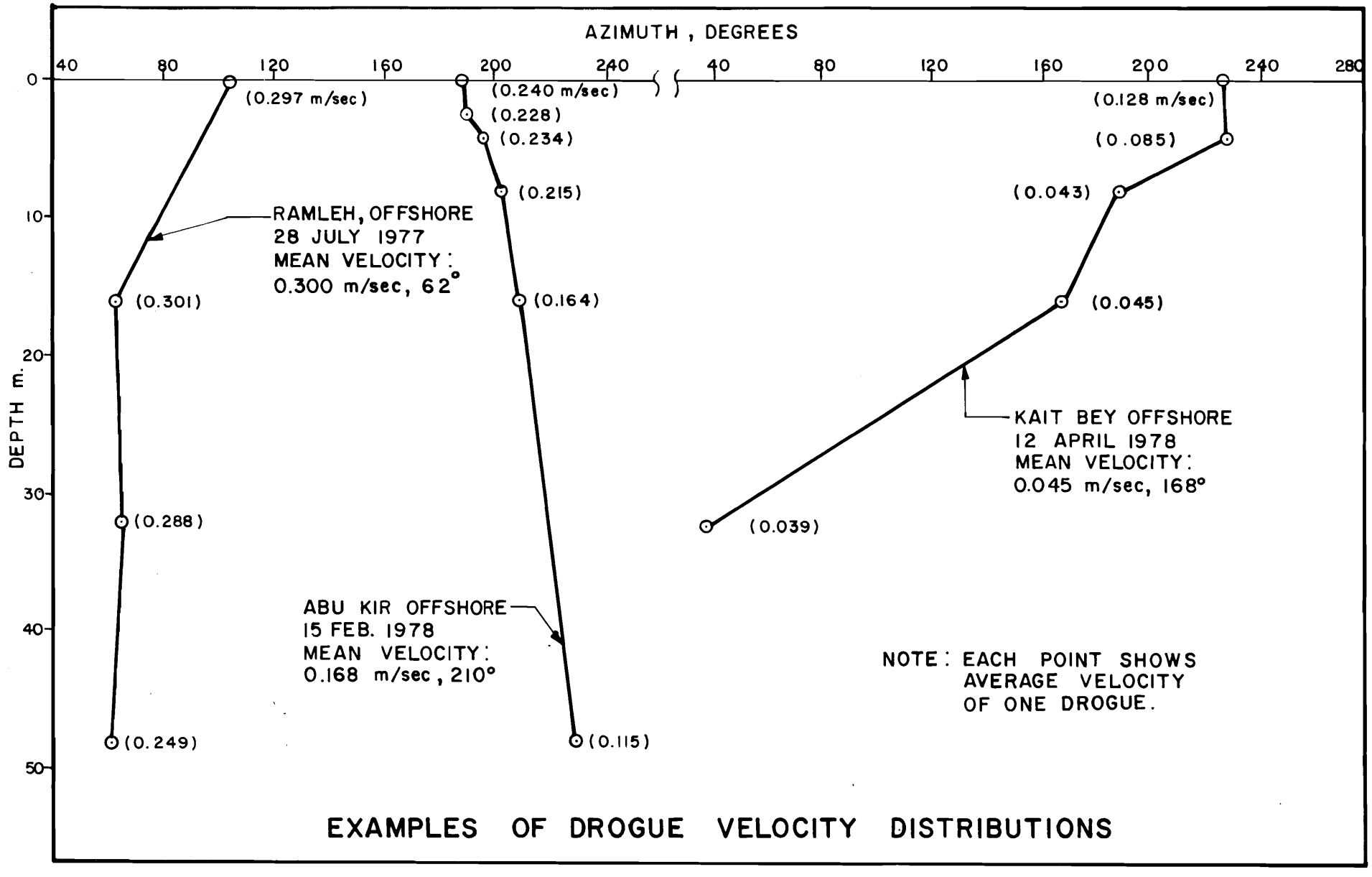
FIGURE 3-13



SPEED AND DIRECTION SUMMARY FOR ALL DROGUES

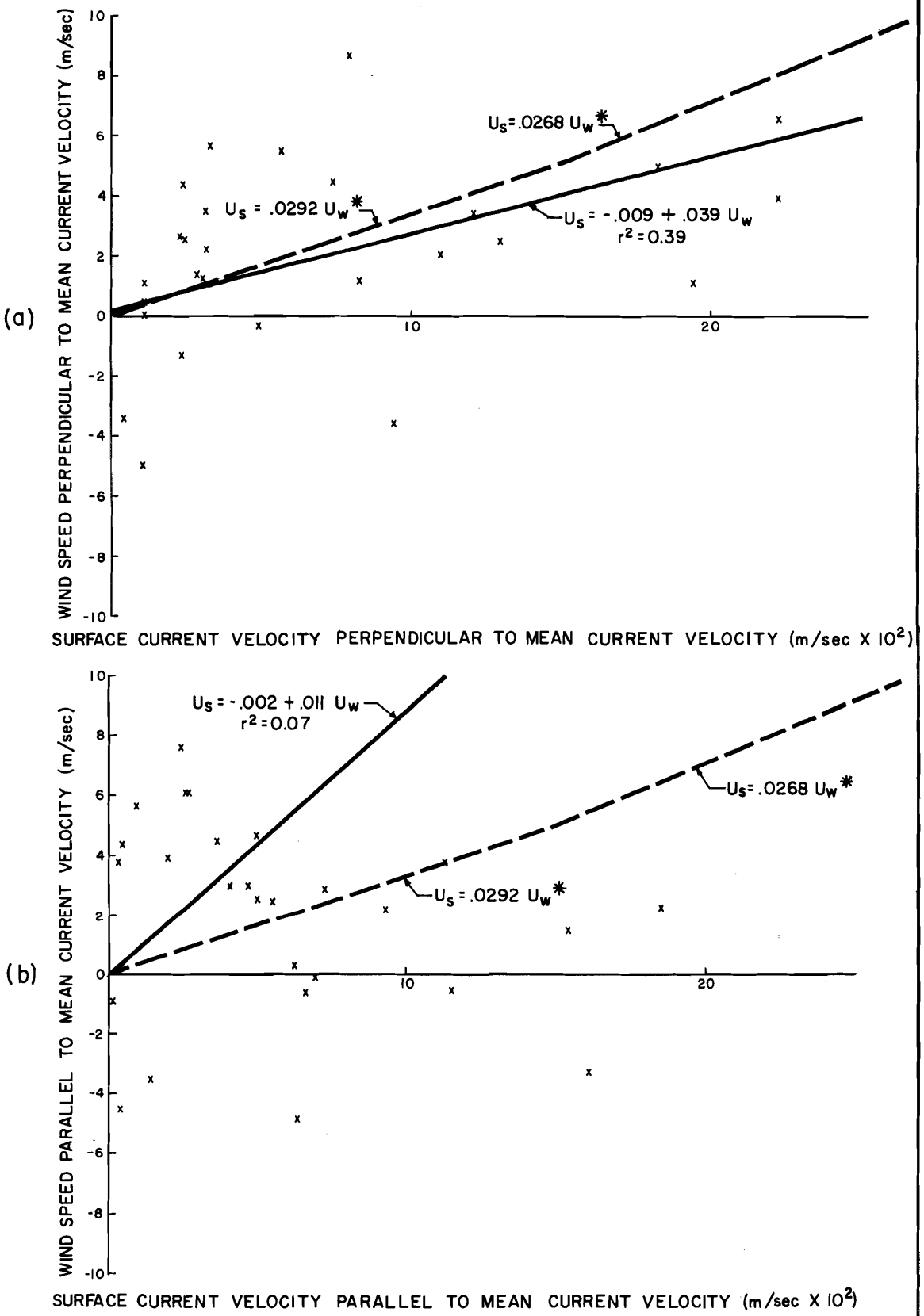
FIGURE 3-14

220



EXAMPLES OF DROGUE VELOCITY DISTRIBUTIONS

FIGURE 3-15



* From Oceanographical Engineering, Robert L. Weigel, Prentice - Hall, 1964.

COMPARISON OF WIND AND SURFACE CURRENT SPEEDS

FIGURE 3-16

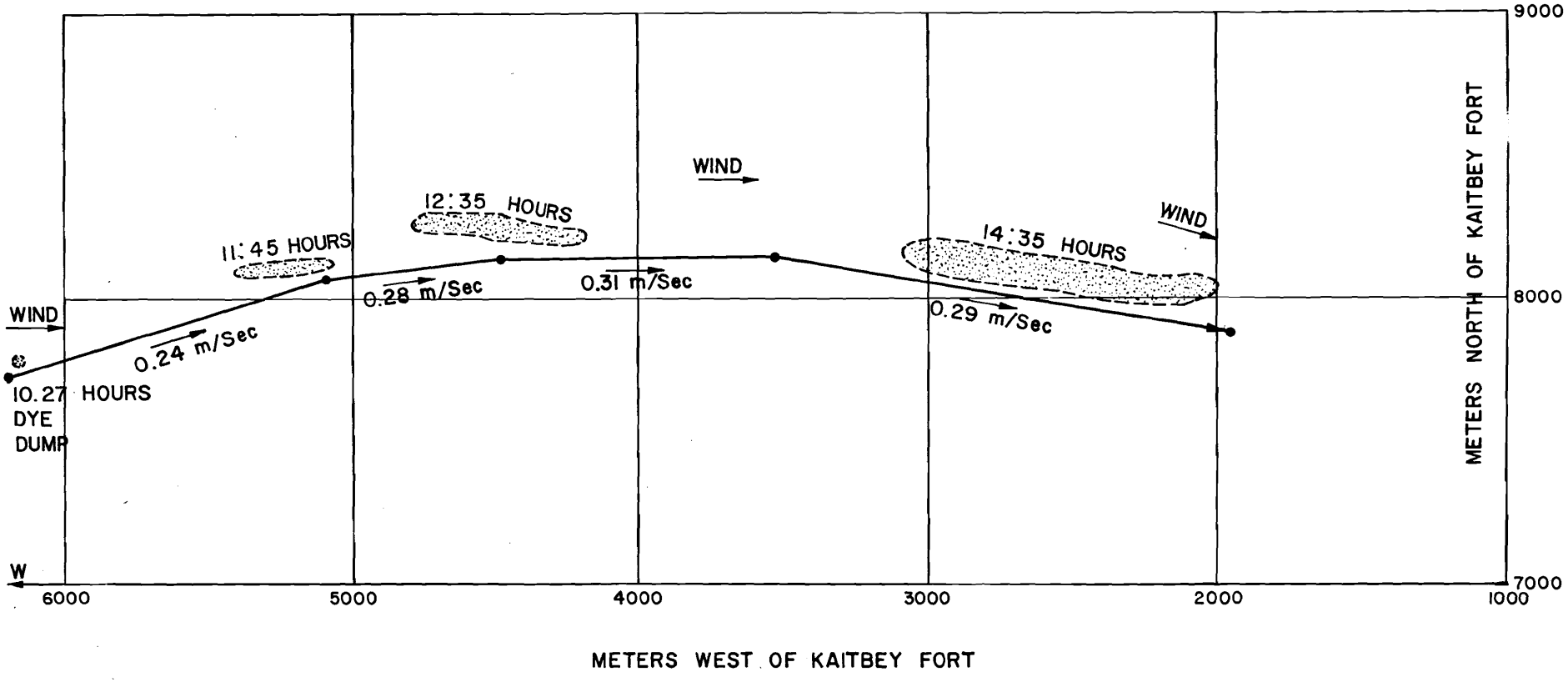


FIGURE 3-17

PROGRESS OF DYE PATCH IN SURFACE WATERS, AUGUST 31, 1977

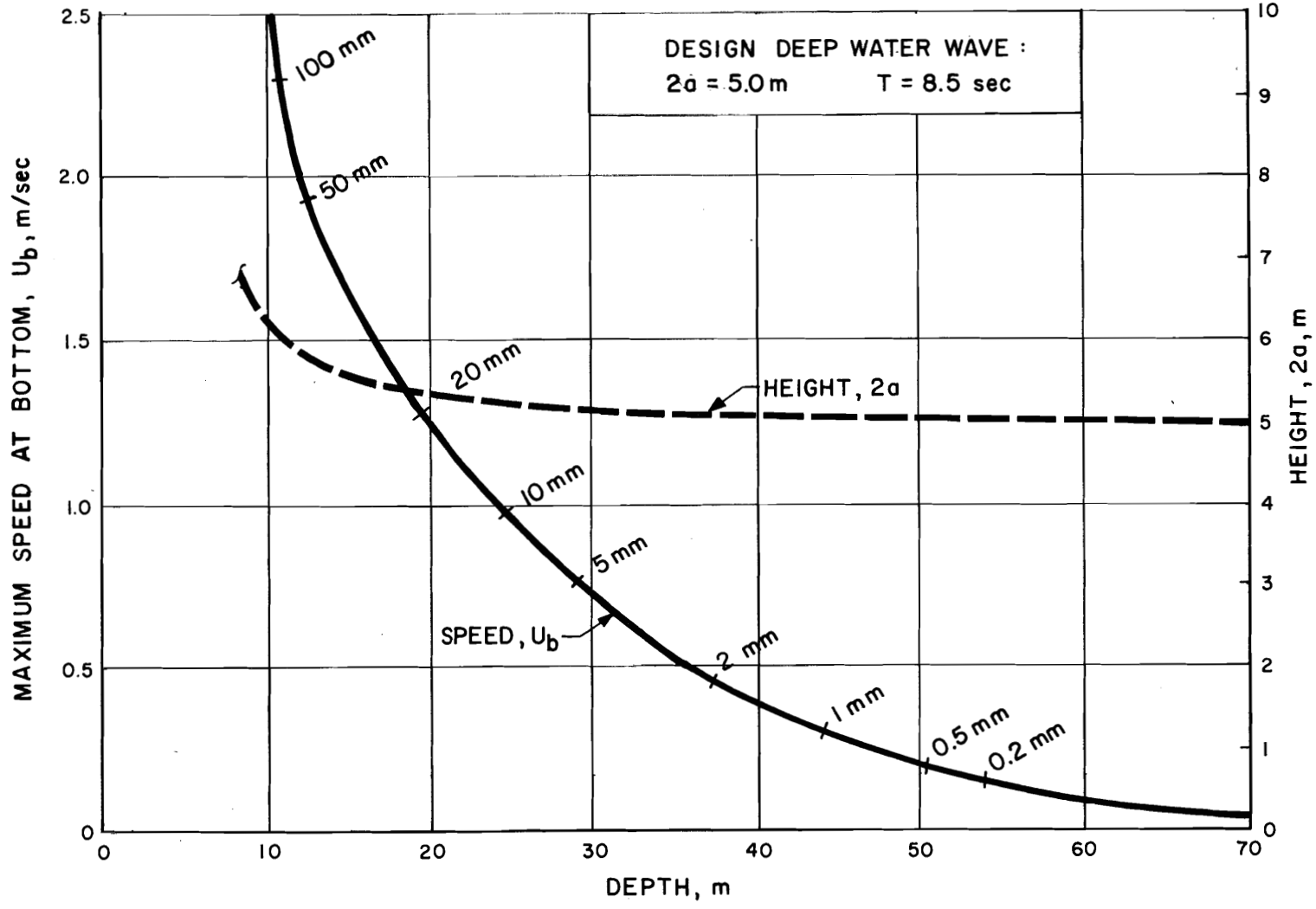


FIGURE 3-18

MAXIMUM BOTTOM SPEEDS, WAVE HEIGHTS, AND THRESHOLD GRAIN SIZES FOR CALCAREOUS SAND

225

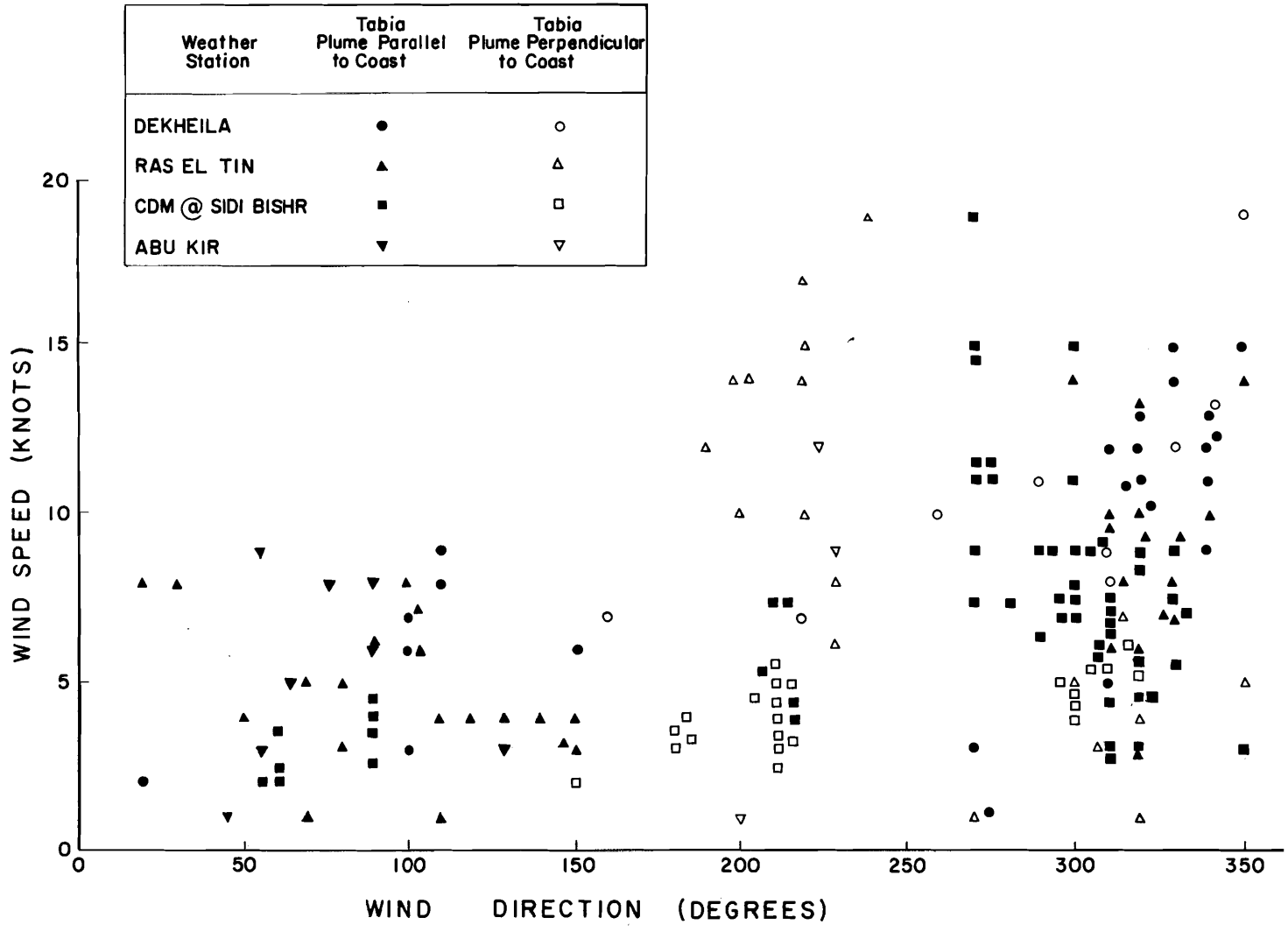
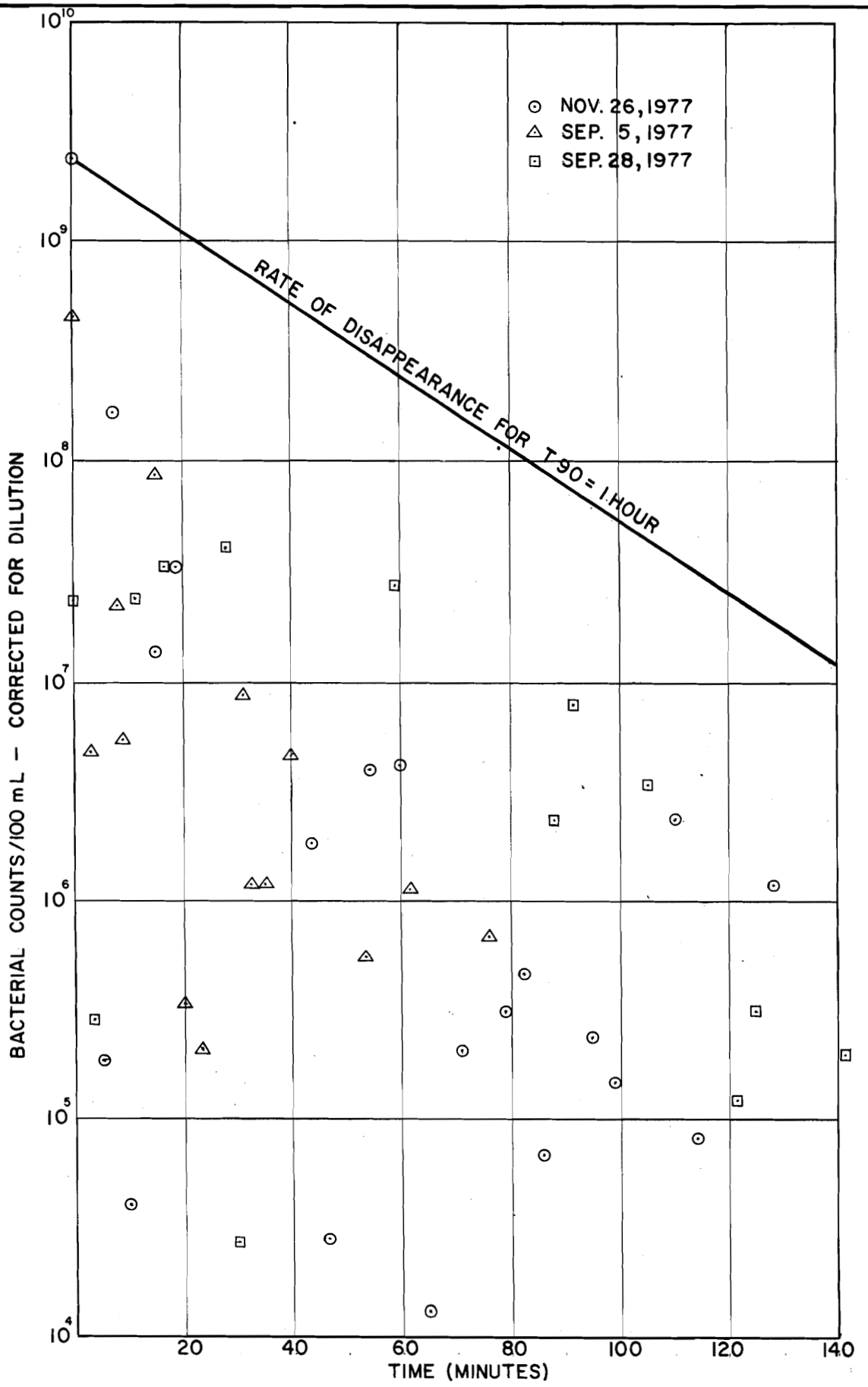


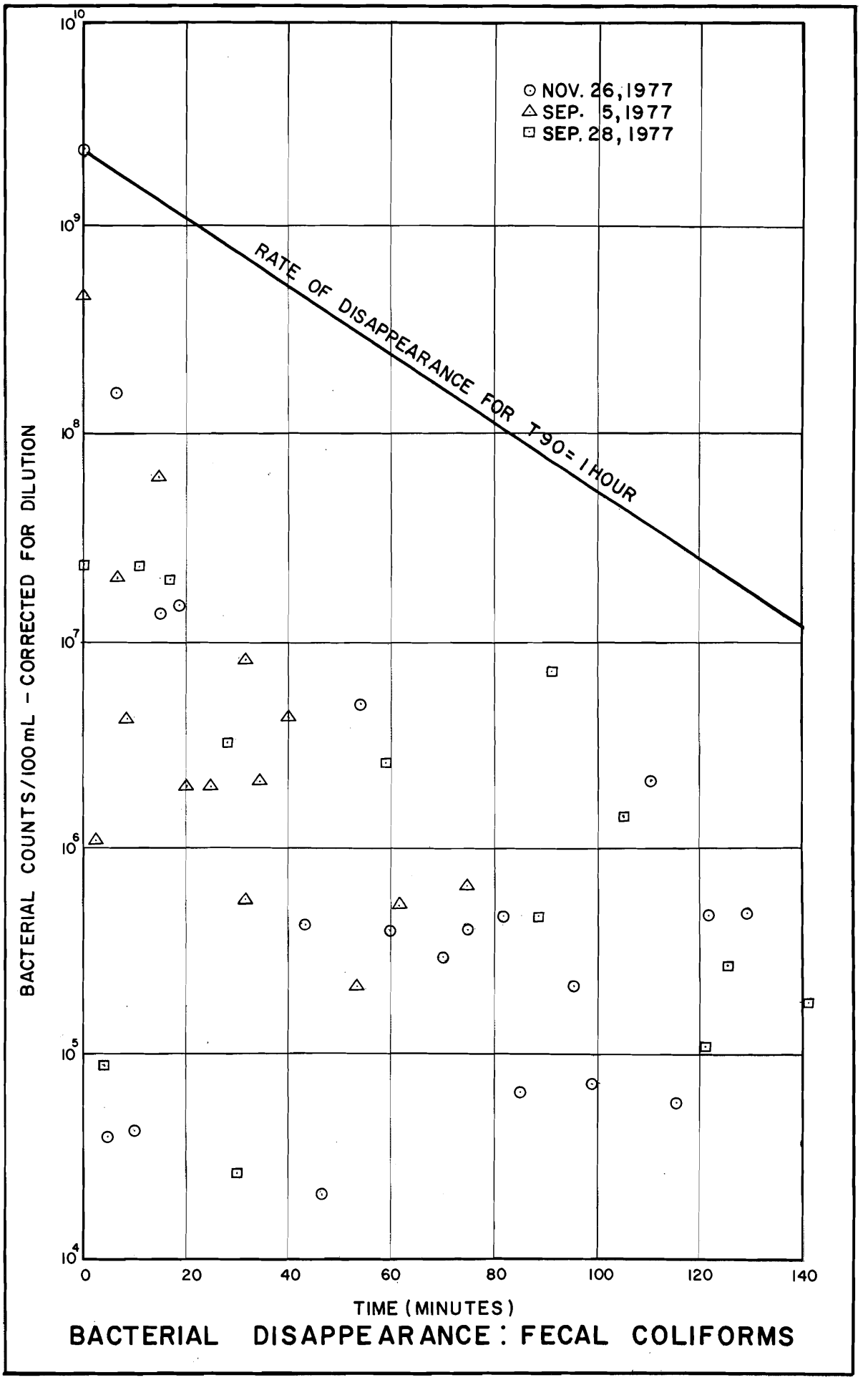
FIGURE 3-19

CORRELATION OF WIND SPEED & DIRECTION WITH DIRECTION OF TABIA PLUME



BACTERIAL DISAPPEARANCE : TOTAL COLIFORMS

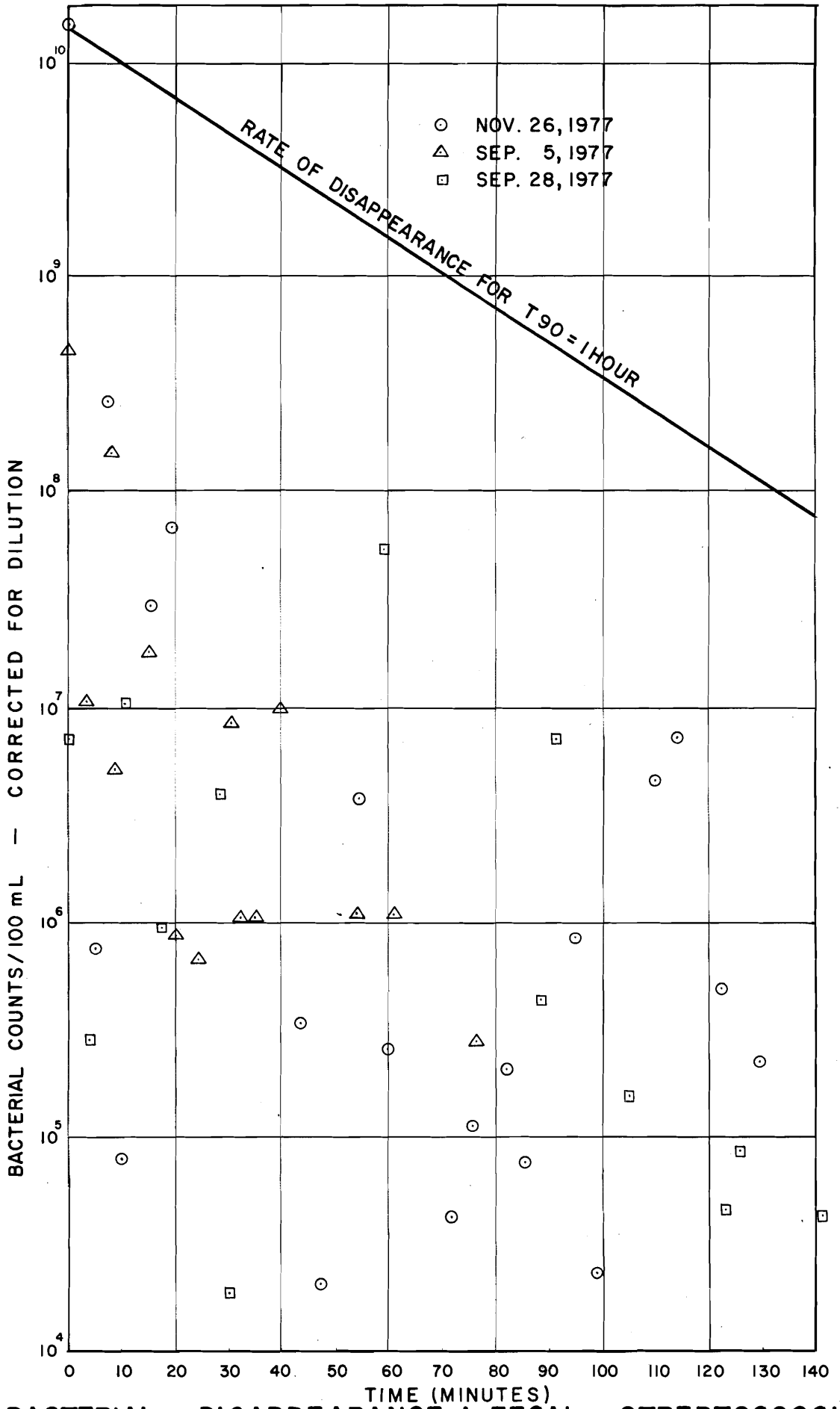
FIGURE 3–20



BACTERIAL DISAPPEARANCE: FECAL COLIFORMS

FIGURE 3—21

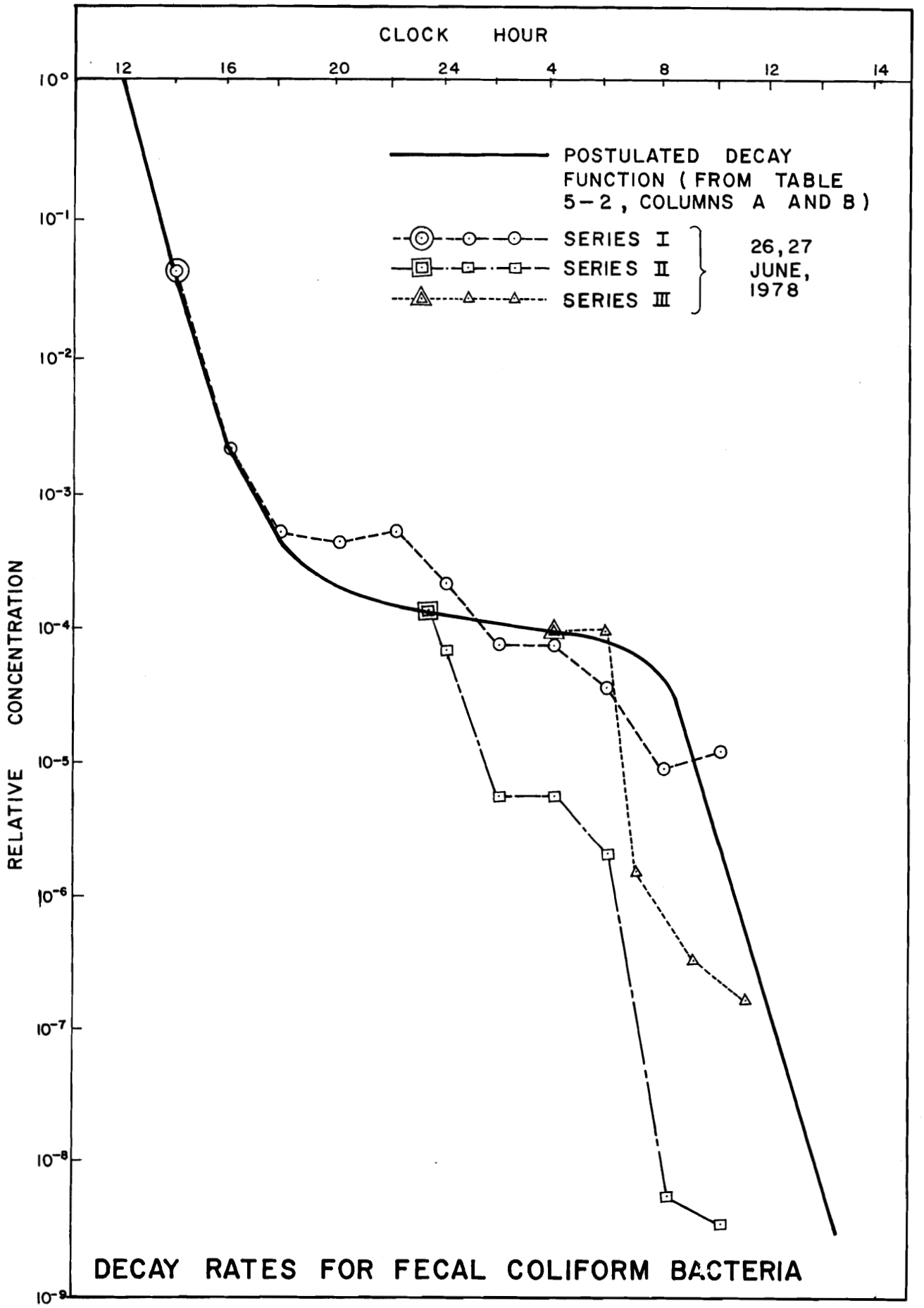
228



BACTERIAL DISAPPEARANCE : FECAL STREPTOCOCCI

FIGURE 3 – 22

229



DECAY RATES FOR FECAL COLIFORM BACTERIA

FIGURE 3-23

230

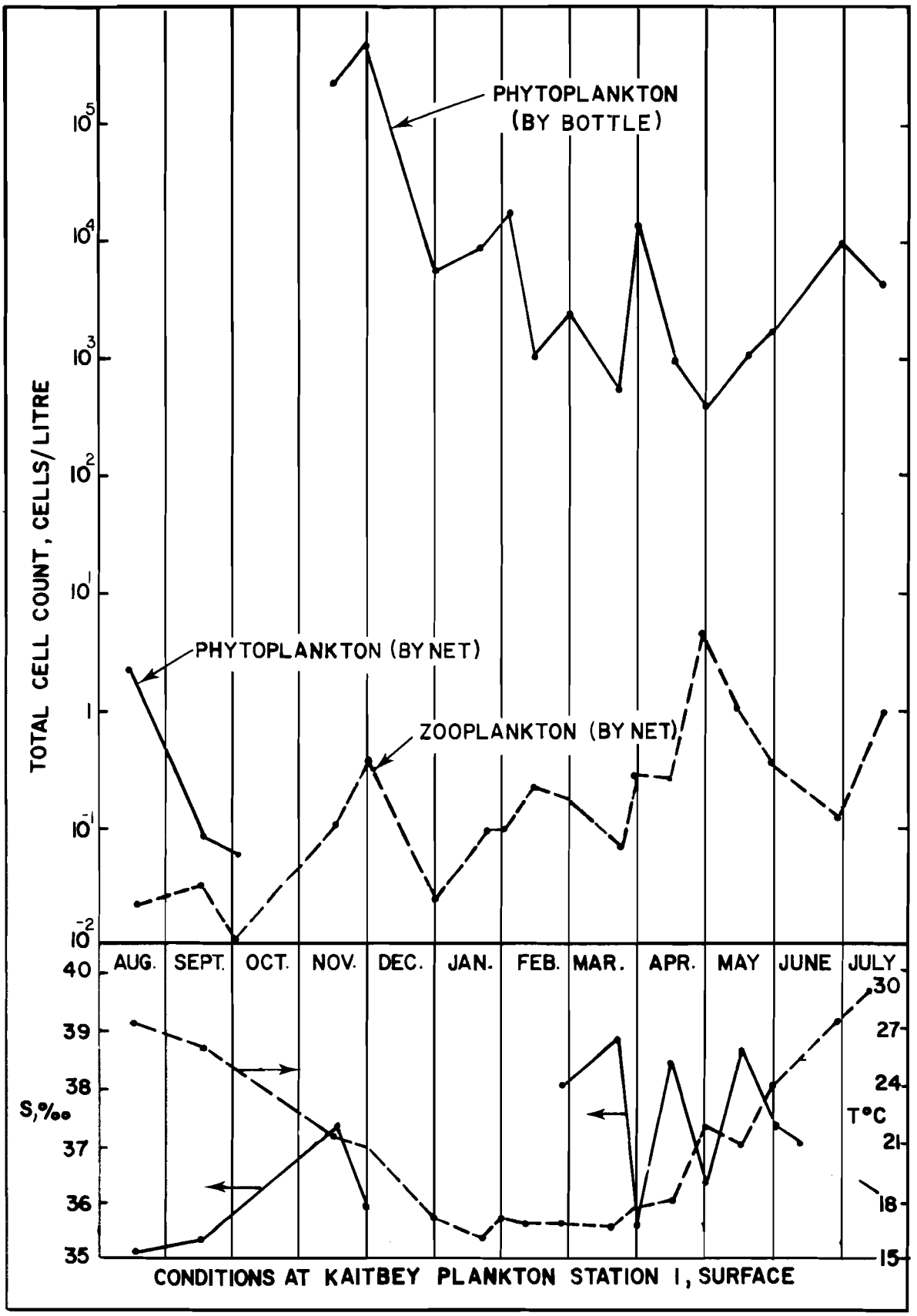

PHYTOPLANKTON (BY BOTTLE)
PHYTOPLANKTON (BY NET)
ZOOPLANKTON (BY NET)
TOTAL CELL COUNT, CELLS/LITRE
10^5
10^4
10^3
10^2
10^1
1
10^{-1}
10^{-2}
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
S,‰
40
39
38
37
36
35
T°C
30
27
24
21
18
15
CONDITIONS AT KAITBEY PLANKTON STATION 1, SURFACE

FIGURE 3-24

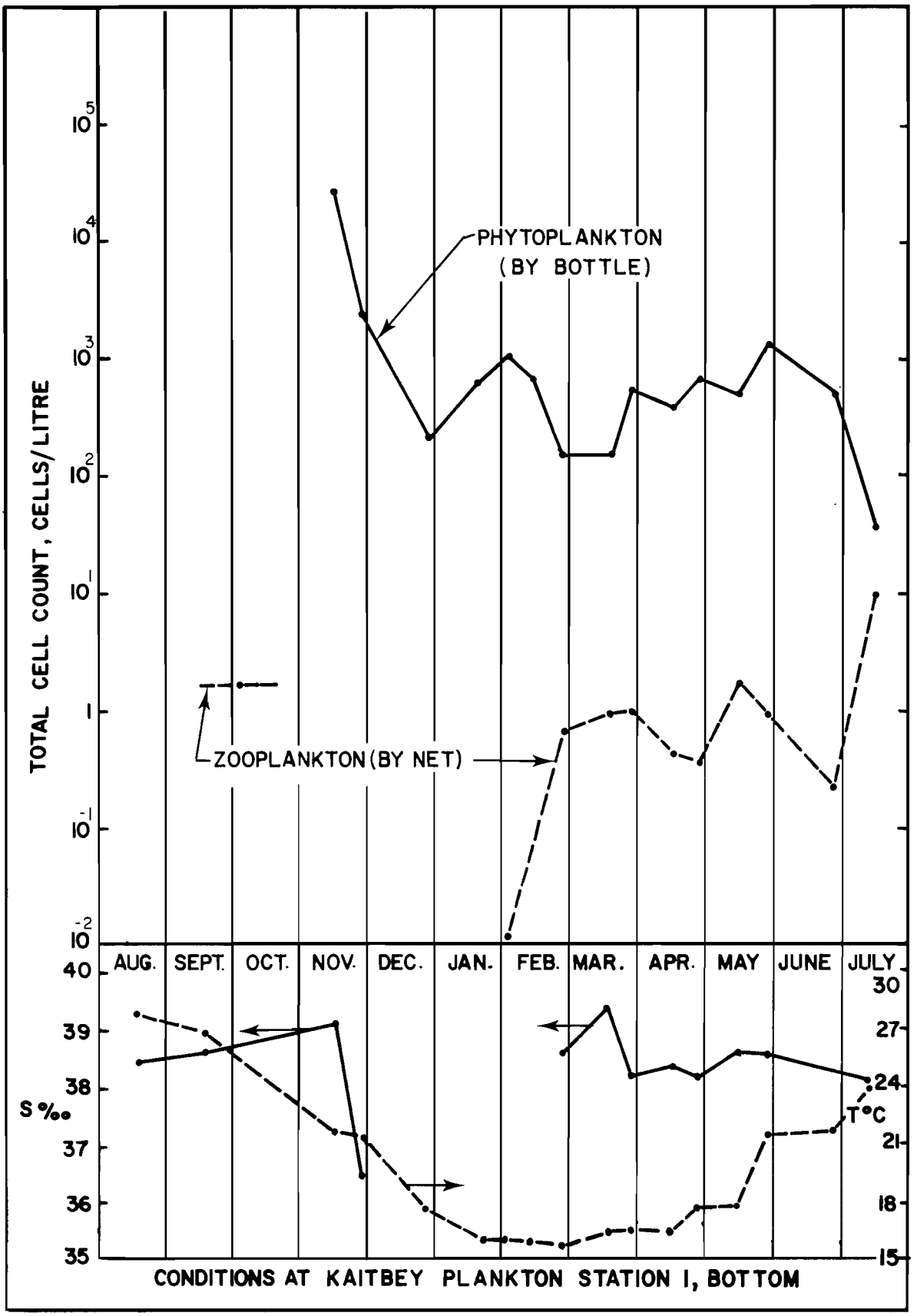


FIGURE 3-25

232

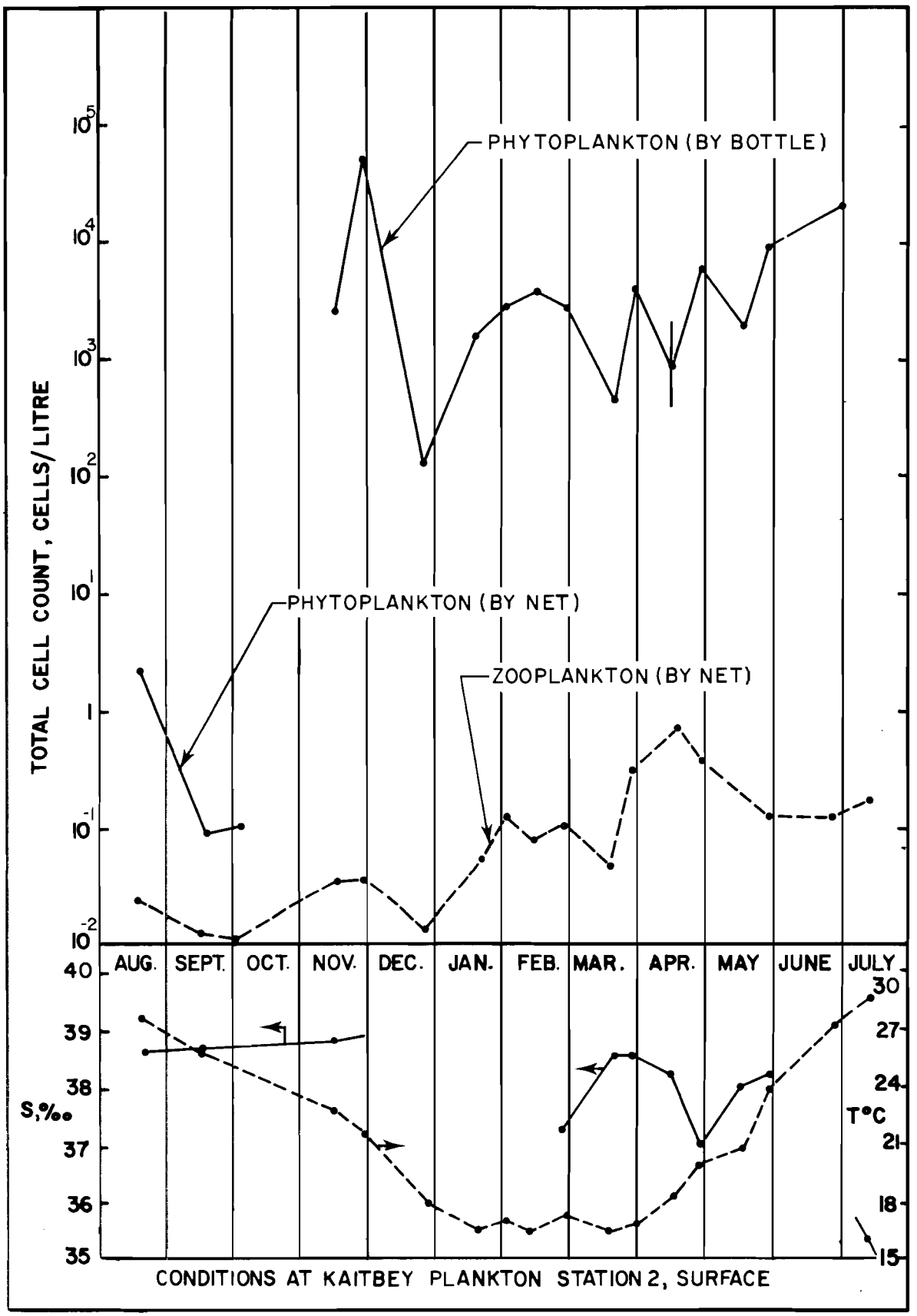

PHYTOPLANKTON (BY BOTTLE)
PHYTOPLANKTON (BY NET)
ZOOPLANKTON (BY NET)
TOTAL CELL COUNT, CELLS/LITRE
10^5
10^4
10^3
10^2
10^1
1
10^{-1}
10^{-2}
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
S,‰
40
39
38
37
36
35
T°C
30
27
24
21
18
15
CONDITIONS AT KAITBEY PLANKTON STATION 2, SURFACE

FIGURE 3-26

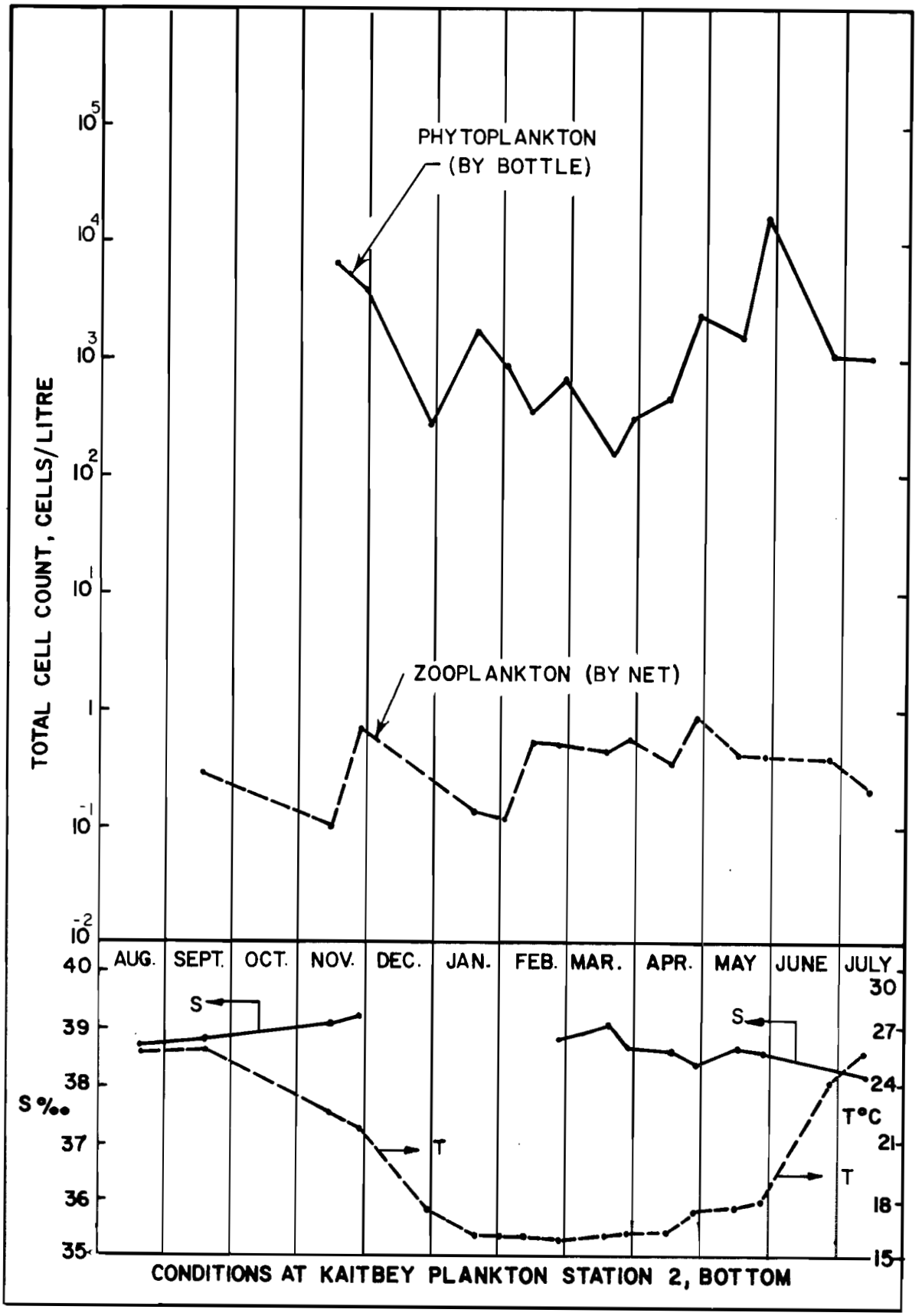


FIGURE 3-27

234

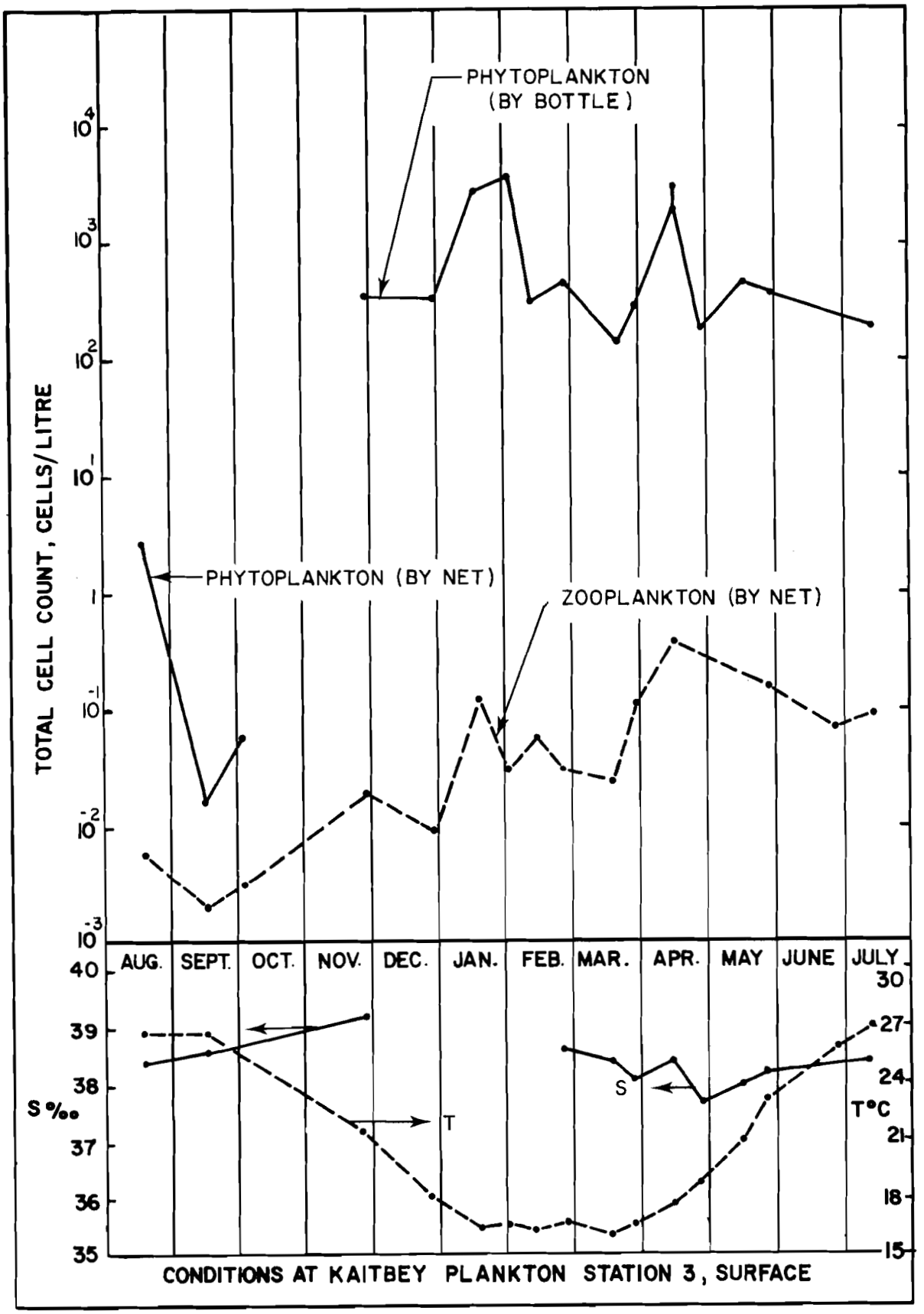


FIGURE 3-28

235

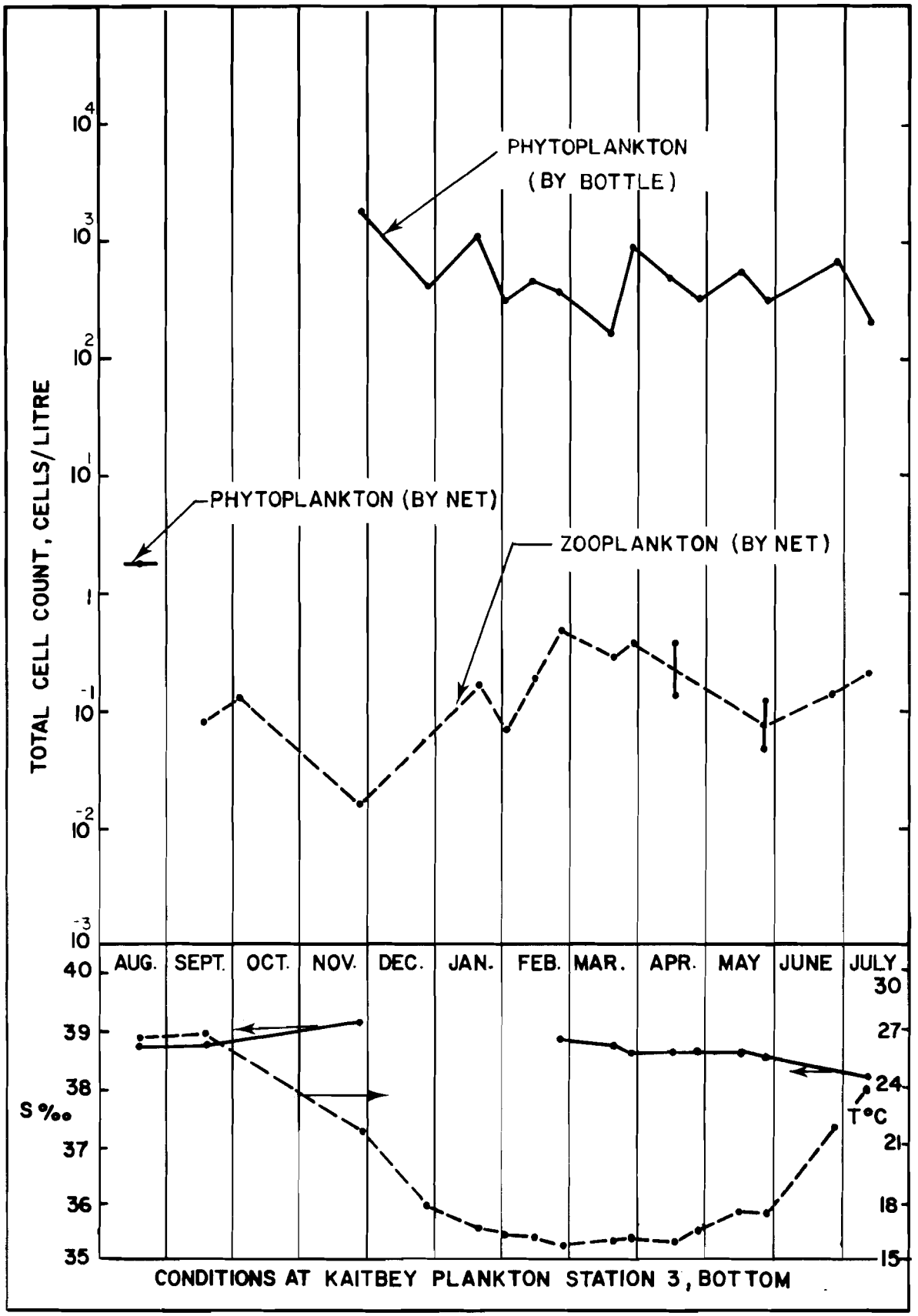


FIGURE 3-29

236

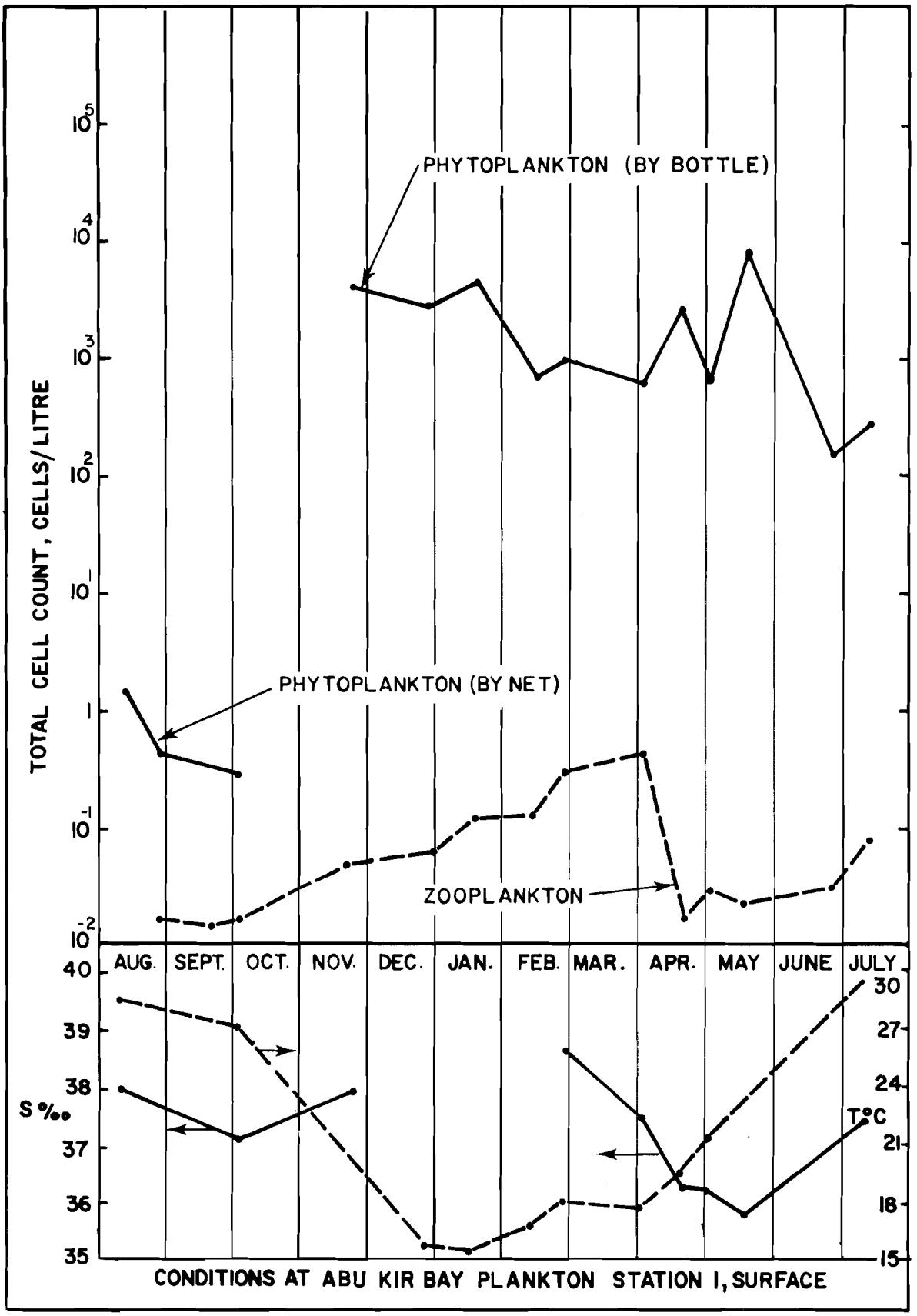

TOTAL CELL COUNT, CELLS/LITRE
10^5
10^4
10^3
10^2
10^1
1
10^{-1}
10^{-2}
PHYTOPLANKTON (BY BOTTLE)
PHYTOPLANKTON (BY NET)
ZOOPLANKTON
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
S ‰
40
39
38
37
36
35
T°C
30
27
24
21
18
15
CONDITIONS AT ABU KIR BAY PLANKTON STATION I, SURFACE

FIGURE 3-30

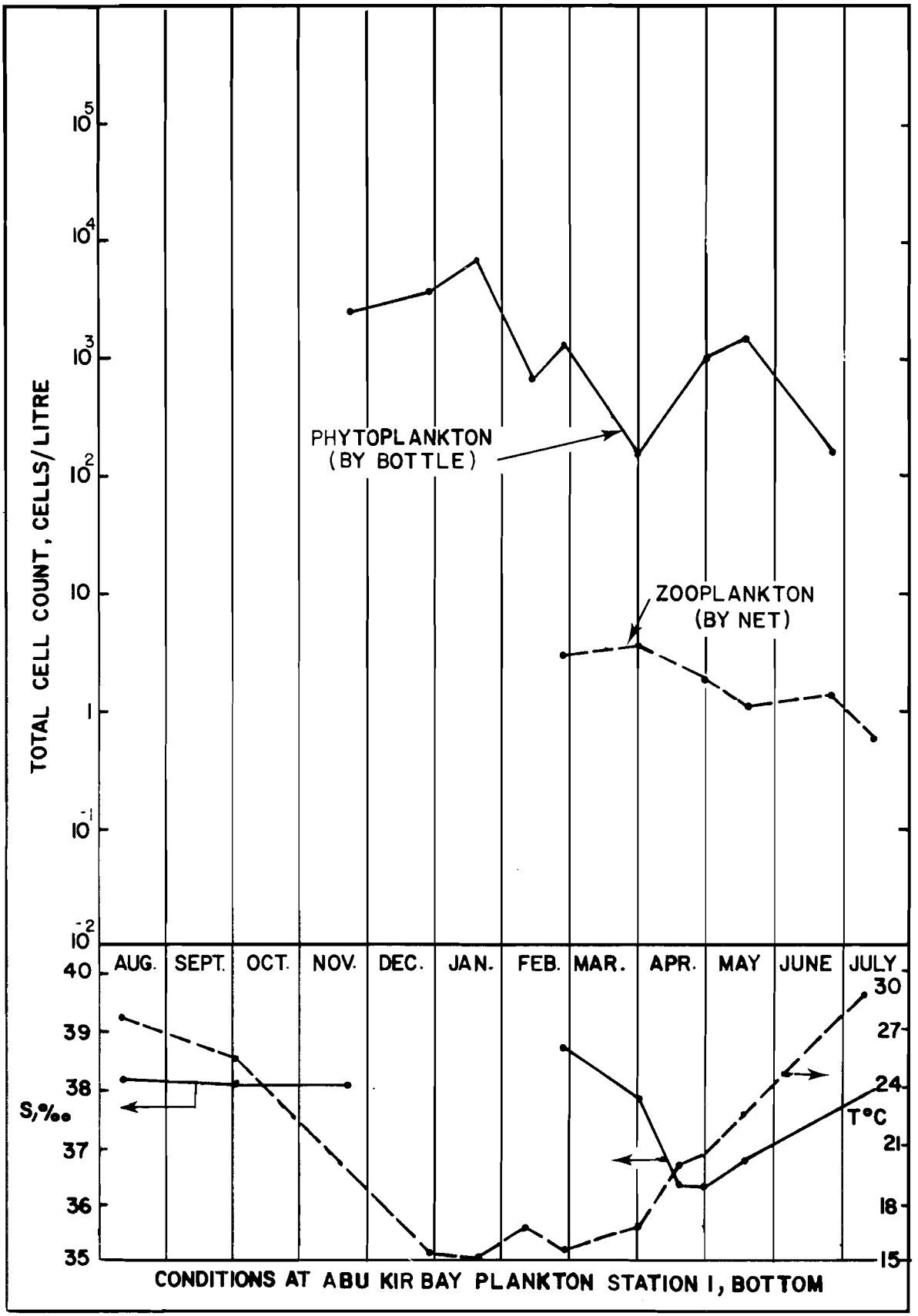

TOTAL CELL COUNT, CELLS/LITRE
10^5
10^4
10^3
10^2
10
1
10^{-1}
10^{-2}
PHYTOPLANKTON
(BY BOTTLE)
ZOOPLANKTON
(BY NET)
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
40
39
38
37
36
35
S,‰
30
27
24
21
18
15
T°C
CONDITIONS AT ABU KIR BAY PLANKTON STATION I, BOTTOM

FIGURE 3-31

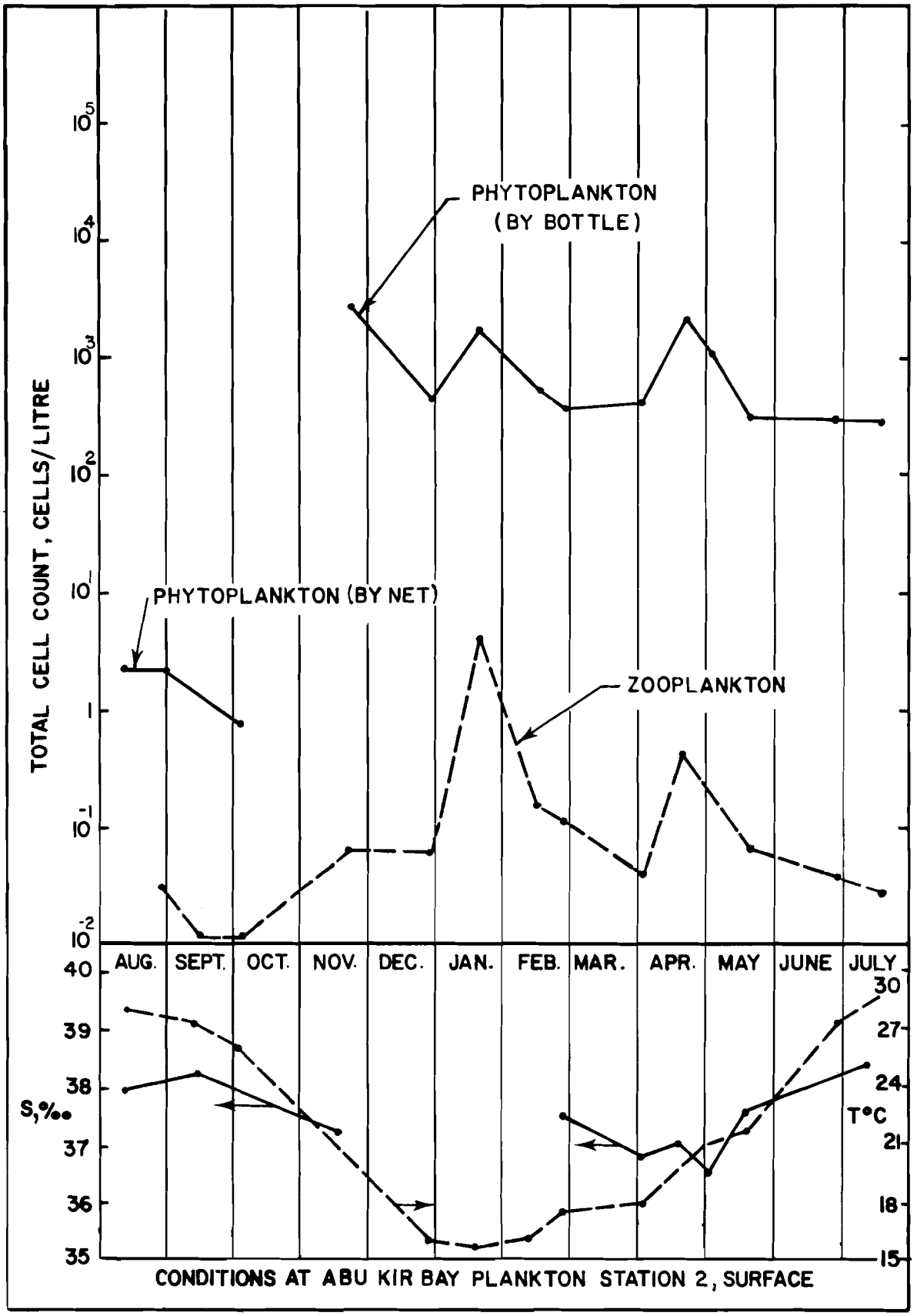
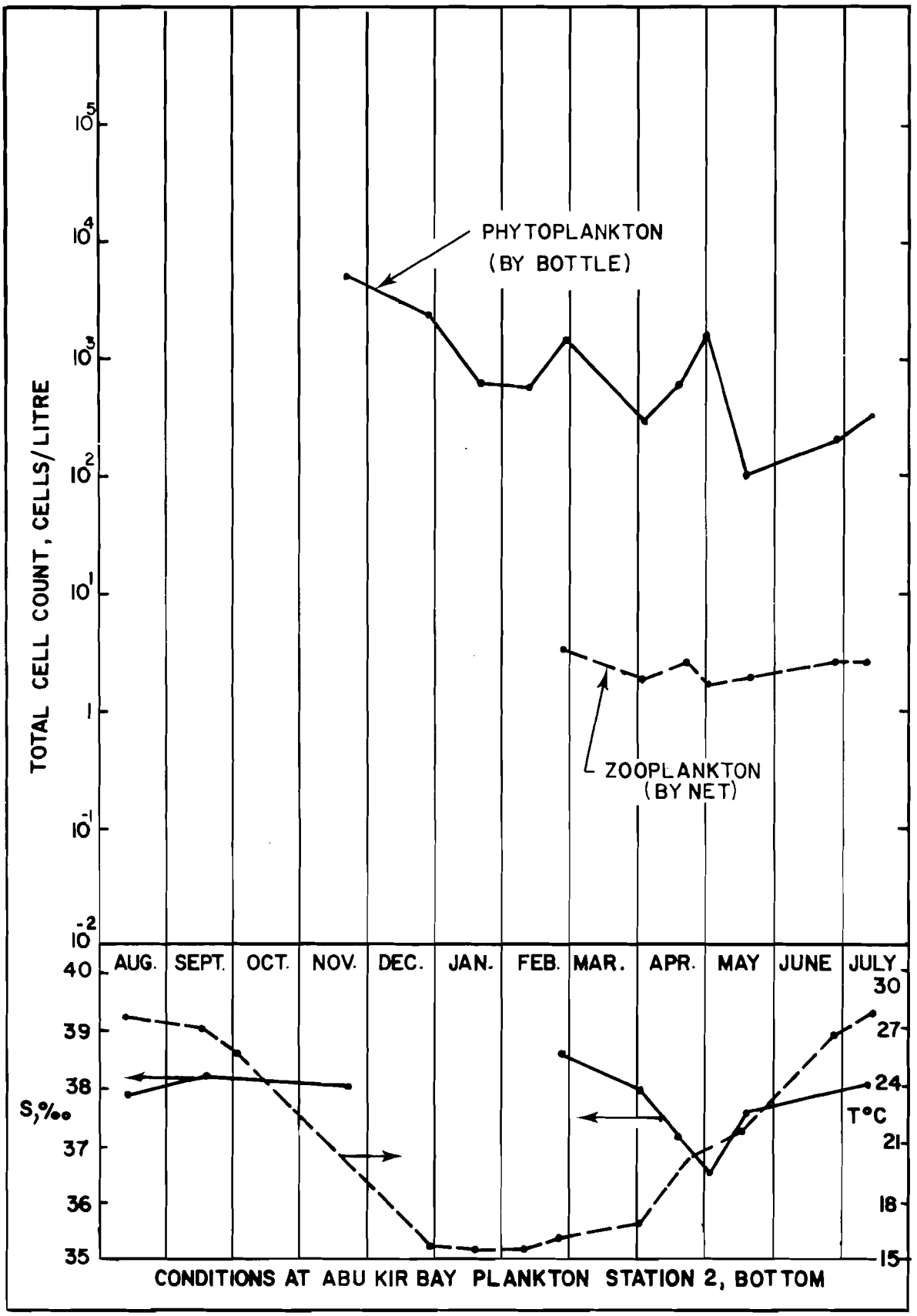


FIGURE 3-32

239


TOTAL CELL COUNT, CELLS/LITRE
10^5
10^4
10^3
10^2
10^1
1
10^{-1}
10^{-2}
PHYTOPLANKTON
(BY BOTTLE)
ZOOPLANKTON
(BY NET)
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
S,‰
40
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38
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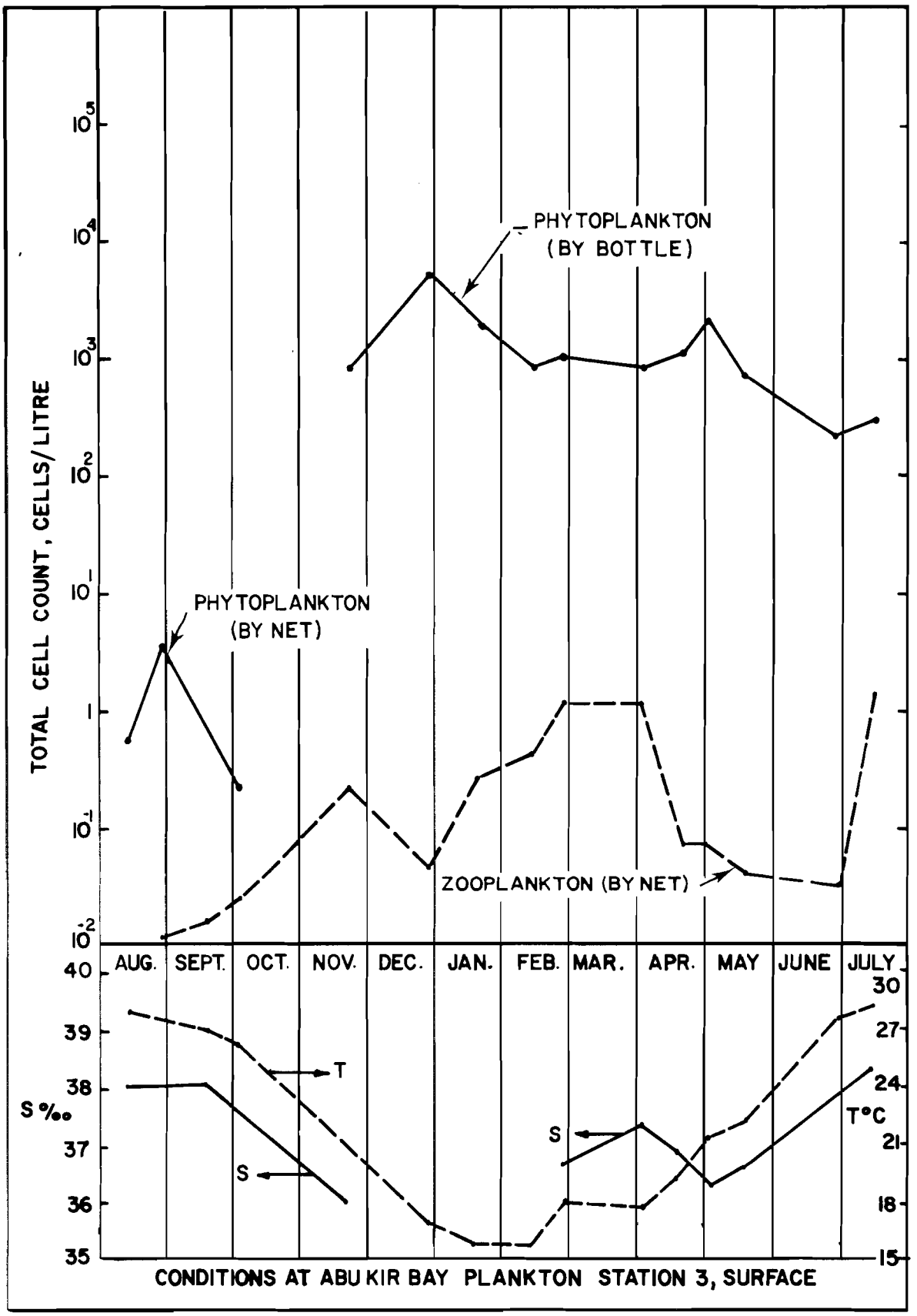
36
35
T°C
30
27
24
21
18
15
CONDITIONS AT ABU KIR BAY PLANKTON STATION 2, BOTTOM

FIGURE 3-33


TOTAL CELL COUNT, CELLS/LITRE
10^5
10^4
10^3
10^2
10^1
1
10^{-1}
10^{-2}
PHYTOPLANKTON (BY BOTTLE)
PHYTOPLANKTON (BY NET)
ZOOPLANKTON (BY NET)
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
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T°C
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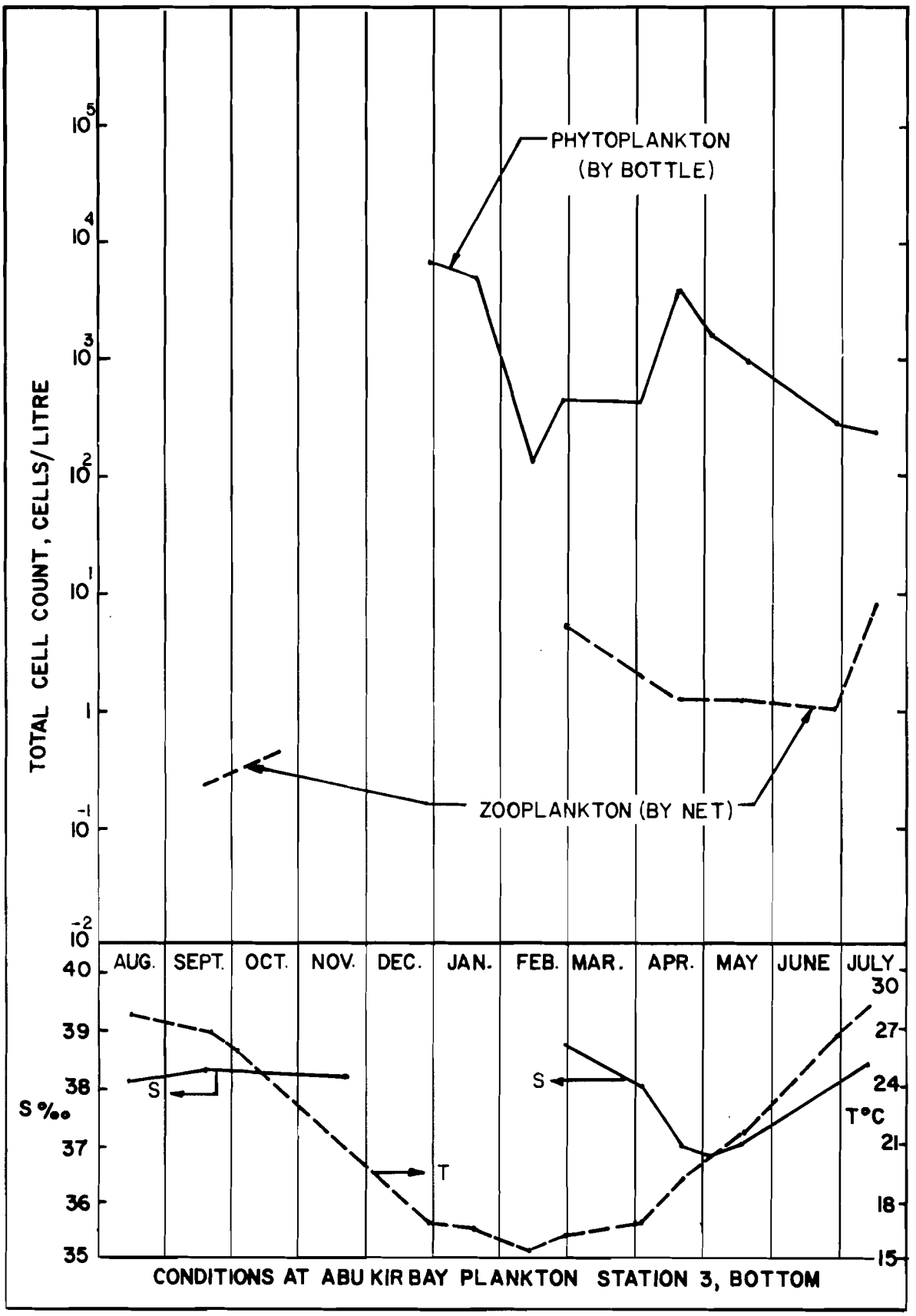
24
21
18
15
CONDITIONS AT ABU KIR BAY PLANKTON STATION 3, SURFACE

FIGURE 3-34



CONDITIONS AT ABU KIR BAY PLANKTON STATION 3, BOTTOM

FIGURE 3-35

242

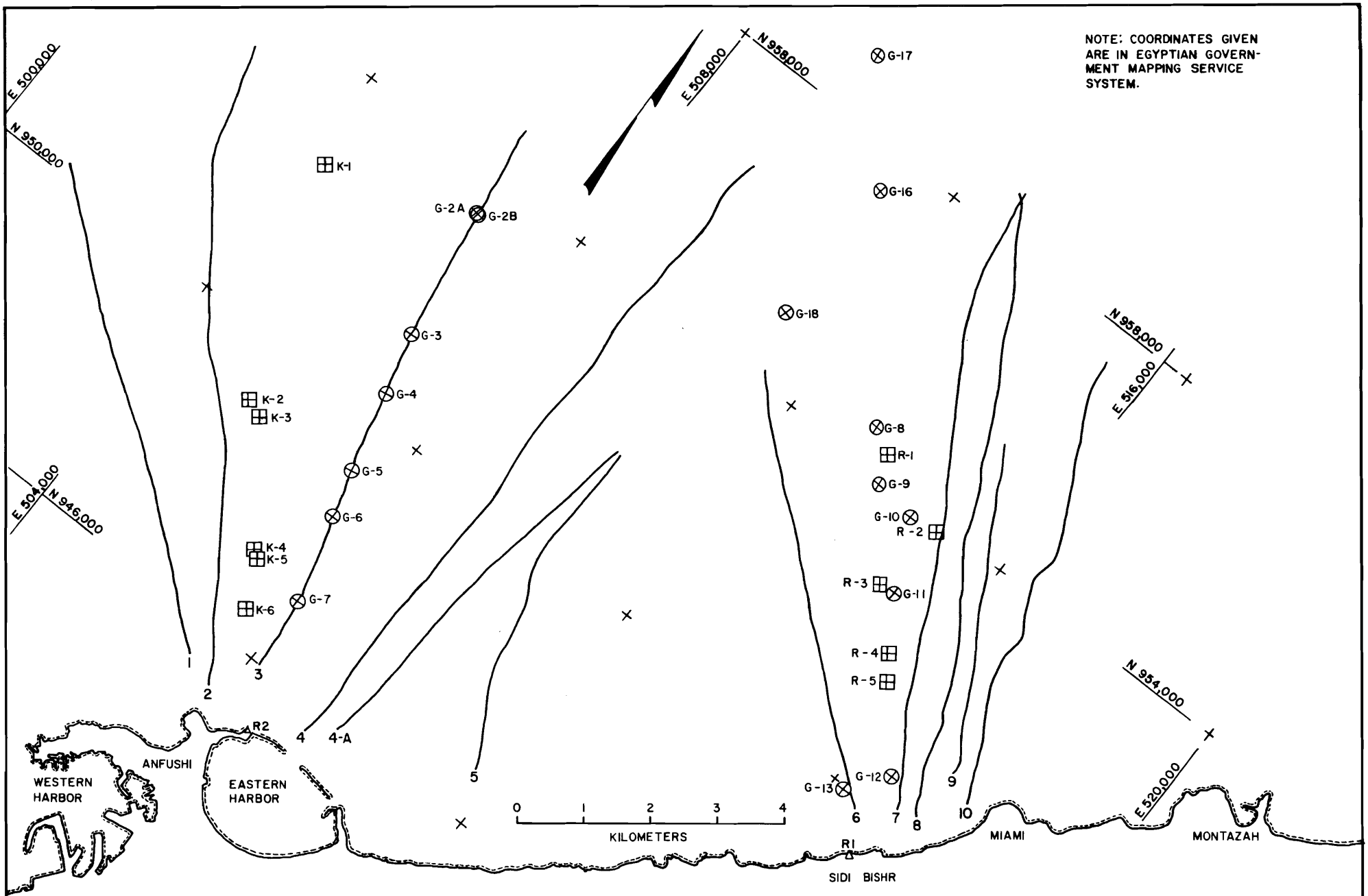
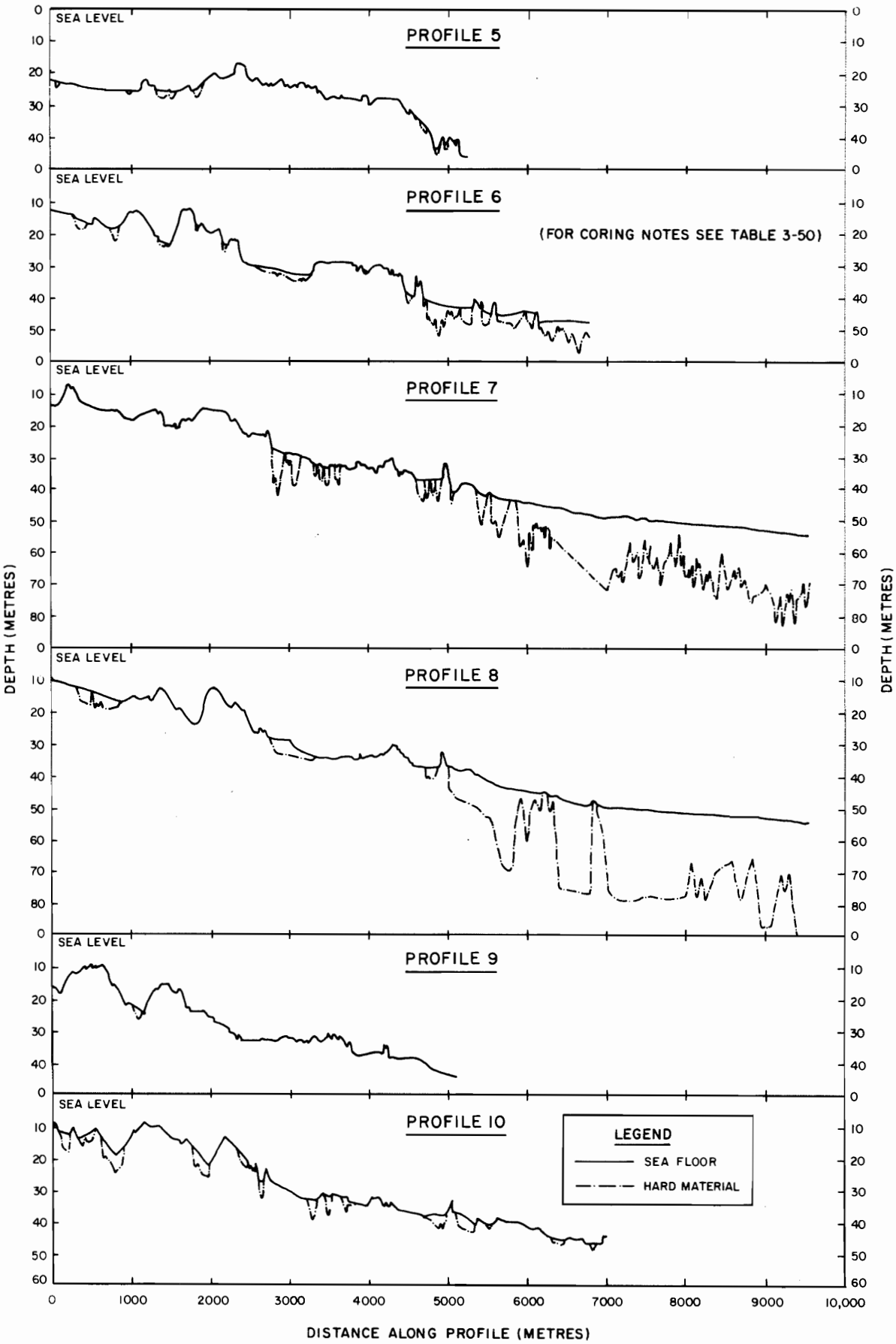


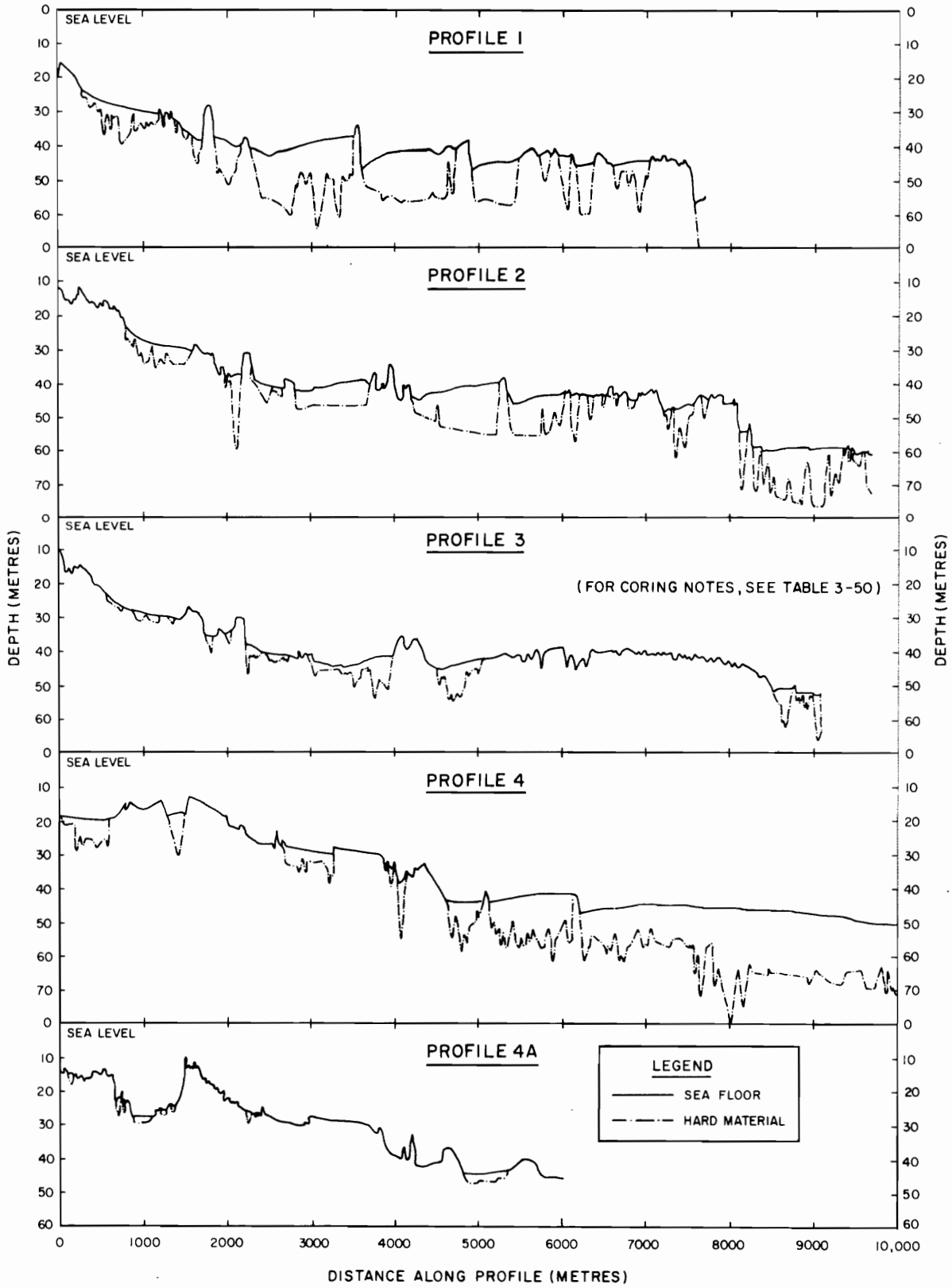
FIGURE 3-36

LOCATION CHART FOR BOTTOM SURVEY CROSS-SECTIONS (FIGURES 3-37, 3-38) AND CORING, SAMPLING AND OBSERVATION SITES (TABLE 3-50)



CROSS-SECTION PROFILES IN THE SIDI BISHR REGION

FIGURE 3-37

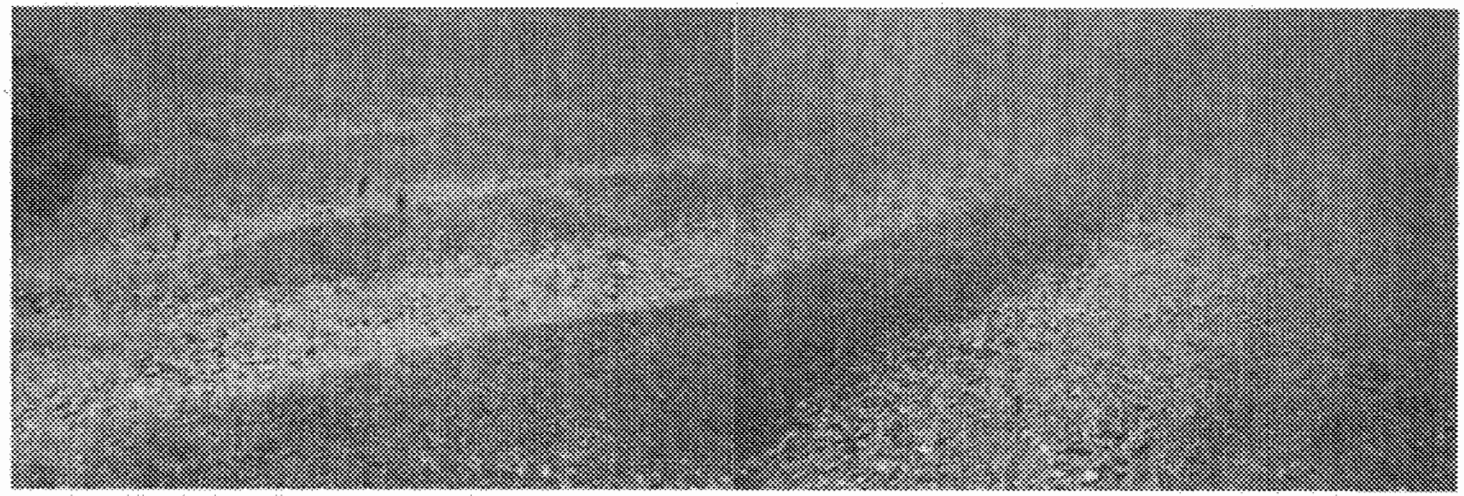


CROSS-SECTION PROFILES IN THE KAIT BEY REGION

FIGURE 3-38

245

CONDITIONS 5 KM OFF SIDI BISHR, WATER DEPTH 31 M, MAY, 1978



Above: Sand ripples 20 cm high, 1 m wavelength, ridges oriented north-south.

Left: Rock outcrop with neck cut in at grade elevation.

Figure 3-39

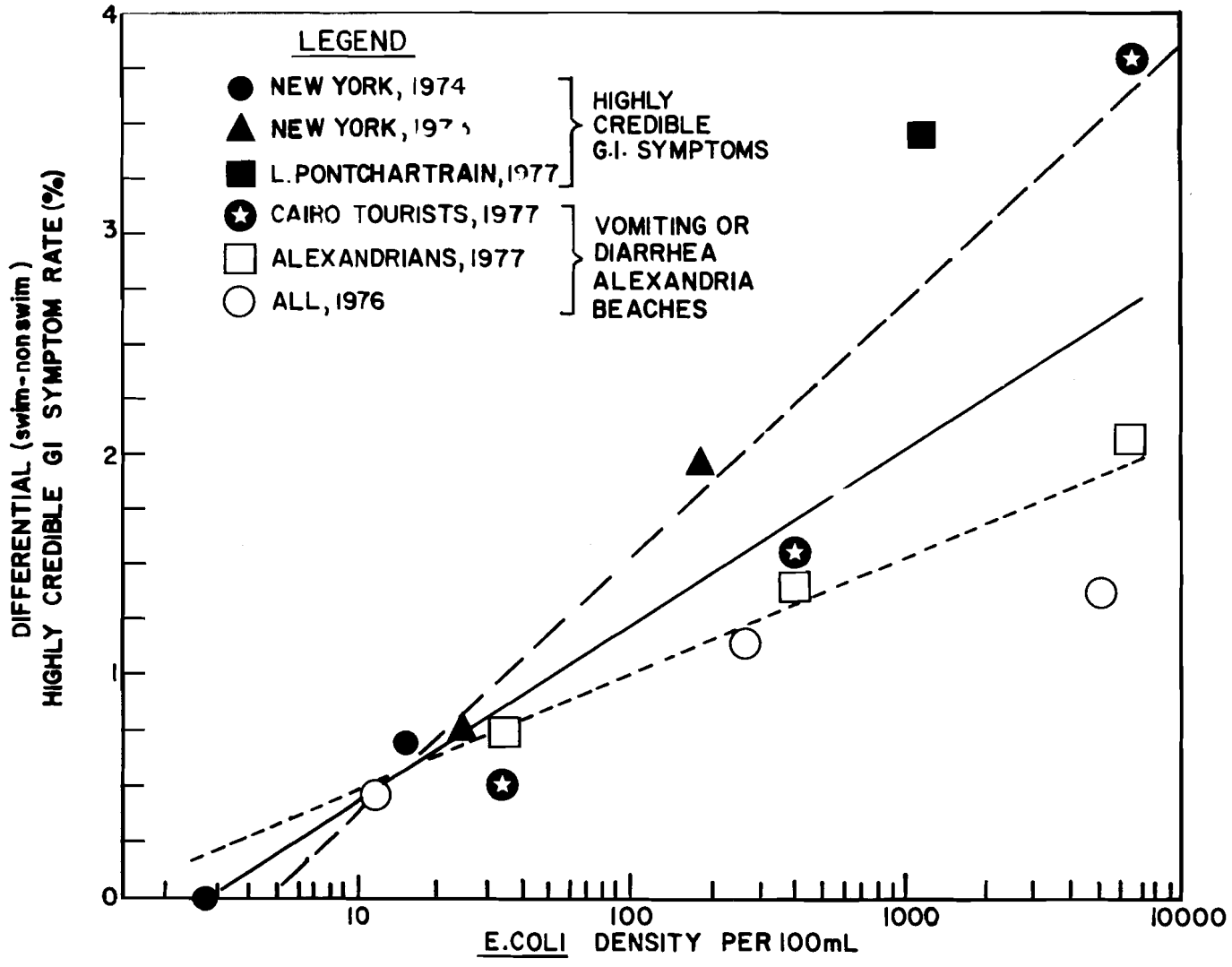


FIGURE 4-1

OBSERVED RELATIONSHIPS OF MICROBIAL INDICATORS TO HEALTH EFFECTS AT BATHING BEACHES (from Cabelli, 1978)

APPENDICES

APPENDIX A

MARINE BIOLOGICAL DATA

APPENDIX A

MARINE BIOLOGICAL DATA

The four sections of this Appendix contain tables of plankton data, benthos data, fish data and fouling organism data, respectively, in support of Section 3.4 of the report. Locations of the plankton and benthos sampling stations are shown on Figure 3-3 of the report.

Section A.1 contains tables of plankton data. For each of the three plankton stations in the Kait Bey region and each of the three plankton stations in Abu Kir Bay, there is one phytoplankton table and one zooplankton table. The tables report cell concentration by genera and sampling date. The procedure for determining cell concentration values is given in Section 3.4 of the report. For each sampling date at each station, salinity, temperature and dissolved oxygen data are provided at the bottom of the phytoplankton table.

Section A.2 contains a summary of the benthic sampling followed by tables of benthic biota found at 25 stations. The sampling procedure is described in Section 3.4.

Section A.3 contains the results of the fish market surveys at Eastern Harbor, Abu Kir and Maadiya. First there are comments on the fish species present in the commercial catch followed by a glossary in which the Latin names, common Egyptian names and common English names are given for all fishes landed in the Alexandria area. Then there are three tables indicating the relative abundance of species for each survey day, and on a monthly average basis. Low figures imply relatively high abundance; high figures or "0" imply relative scarcity. (Note that "0" means "other" and is usually applied to species represented by a few individuals only; it does not mean "zero.") Finally, there are tables of fish landing mass estimates, by species, date and station. The samples and reporting procedure is described in Section 3.4.

Section A.4 presents the results of the studies of fouling organisms which were carried out near Kait Bey.

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SECTION A.1

TABLE A.1-1

PHYTOPLANKTON KAIT BEY STATION 1

(CELLS/LITER)

SAMPLING DATE	16AU HOR	16AU VER	17SE HOR	2 OC HOR	15NO SUR	15NO BOT	30NO SUR	30NO BOT	29DE SUR	29DE BOT	17JA SUR	17JA BOT	1 FE SUR	1 FE BOT
A.DIATOMS														
ALITHRIX														
ASTERIONELLA														
AULACODISCUS														
BACTERIASTRUM														
BELLAROCHIA				.014			3500				100		400	
BIDDULPHIA														
CHAETOCEROS	.008				206K	25K		500	1800		2200		16200	
CLIMACOSPHENIA														
CORETHRON														
COSCINODISCUS	1.347			.014	125		250		100				200	
DACTYLIOSOLEN														
DINOPHYSIS														
DITYLUM														
GRAMMATOPHORA														
GUINARDIA														
GYROSIGMA														
HEMIAULUS													200	
LEPTOCYLINDRUS														
LICMOPHORA		.086												
LITHODESMIUM														
MELOSIRA							456K	1875	3300		4000	600		
METACYLIS														
NAVICULA										100				
NITZSCHIA														
PLEUROSIGMA														
RHABDONEMA	.097													
RHIZOSOLENIA			.036	.027						100				
SKELETONEMA														
STRIATELLA														
SURIRELLA		1.121												
THALASSIONEMA			.018											
THALASSIOSIRA														
THALASSIOTHRIX														
B.TINTINNIDS														
CODONELLA														
CODONELLOPSIS														
EUTINTINNUS														
FAVELLA	.129	.086	.018											
TINTINNOPSIS	.040													
UNDELLA														
C.DINOFLAGELLATES														
CERATIUM	.438	.172									1600			
PETALOTRICA					125									
PROPLECTELLA	.016													
PROROCENTRUM														
TRICERATIUM														
D.RADIOLARIA									100					
PERIDINIUM														
DICTYOCYSTA														
TTL CELL COUNT	2.08	1.47	.072	.055	206K	25K	460K	2375	5300	200	7900	600	17K	1000
NO.OF SPECIES	7	4	3	3	3	1	3	2	4	2	4	1	4	2
SURFACE SAL	35.1		35.3		37.2		35.8							
TEMP	28.5		26.8		21.3		20.6		17.0		16.0		17.0	
DO	6.1													
BOTTOM SAL		38.4	38.6			39.1		36.4						
TEMP		27.5	26.6			21.5		21.1		17.4		16.0		16.0
DO		6.1												7.3
BOTTOM DEPTH		17M	13M			22M		11M		25M		30M		30M
DEPTH MAX DO														5M
MAX DO VALUE														7.6

BEST AVAILABLE COPY

1FE SUR	11FE BOT	27FE SUR	27FE BOT	19MH SUR	19MH BOT	31MH SUR	31MH BOT	15AP SUR1	15AP BOT	15AP SUR2	30AP SUR	30AP 10M	30AP BOT	15MY SUR	15MY 10M	15MY BOT	29MY SUR	29MY BOT	28JN SUR	28JN 10M	28JN BOT	13JL SUR	13JL 10M	13JL BOT
						50																		
	400	2500	50			1100	200		300	1000				400	300	300		500	8500	1750	333	2555		18
00		50	50	150			50					50											250	12
							50																	
								50		50	50											167	62	6
																						444		
				100					100												111		62	
				100																				
					50																			
						100																		
																						167		
								50										50						
																50								
0	700	2600	150	500	150	12400	550	750	400	1050	350	1000	700	1000	1100	500	1550	1350	8750	2250	500	3944	1312	36
	3	3	3	6	3	5	4	4	2	2	2	3	2	2	2	3	3	4	3	3	3	7	6	3
		37.9		38.7		35.6		38.3			36.2			38.5			37.2					36.0		
5		16.7		16.4		17.3		17.9			21.6			20.5			23.8		27.0			28.4		
		7.8		8.6		7.2		7.3			7.6			7.1			7.0							
			38.6		39.4		38.2		38.4				38.2			38.7		38.6						38.6
	15.9		15.7		16.2		16.4		16.3				17.6			17.7		21.2			25.0			26.2
			7.7		8.4		7.2		7.6				7.7			7.5		7.2						
	30M		27M		35M		15M		27M				33M			34M		35M			20M			14M
			SURF		10M		SURF		25M				15M			20M		25M						
			7.8		9.3		7.2		7.8				8.5			7.5		7.2						

BEST AVAILABLE COPY

25278

TABLE A.1-2

PHYTOPLANKTON KAIT BEY STATION 2

(CELLS/LITER)

SAMPLING DATE	16AU HOR	17SE HOR	2 OC HOR	15NO SUR	15NO BOT	30NO SUR	30NO BOT	29DE SUR	29DE BOT	17JA SUR	17JA BOT	1 FE SUR	1 FE BOT	11FE SUR	11FE BOT	27FE SUR	27FE BOT	19MH SUR	19MH BOT	31MH SUR	31MH BOT	15AP SUR1	15AP 30M	15AP BOT	15AP SUR2	30AP SUR
A.DIATOMS																										
ALITHRIX																										
ASTERIONELLA		.032																								
AULACODISCUS	.073																									
BACTERIASTRUM																										
BELLAROCHIA											100															
BIDDULPHIA												300		111												
CHAETOCEROS					5625	2750	1375			400		2500		3667	333					3600		1400	300	300	111	5300
CLIMACOSPHENIA																										
CORETHRON																										
COSCINODISCUS	1.15															50		150	100							
DACTYLIOSOLEN																										
DINOPHYSIS																										
DITYLUM																										
GRAMMATOPHORA																				100	50					
GUINARDIA														111												
GYROSIGMA																50										
HEMIAULUS																										
LEPTOCYLINDRUS						500										400	350									
LICMOPHORA																									222	
LITHODESMIUM																						200				
MELOSIRA						51K	2250			1200	1600					2400	300	300		400						800
METACYLIS																										
NAVICULA																							50	100		
NITZSCHIA																					50					
PLEUROSIGMA																										
RHABDONEMA																										
RHIZOSOLENIA	.024	.032	.047		62.5			125				50								50	50					
SKELETONEMA																										
STRIATELLA																										
SURIRELLA																										
THALASSIONEMA																										
THALASSIOSIRA																										
THALASSIOTHRIX			.028		125								571								100					
B.TINTINNIDS																										
CODONELLA																										
CODONELLOPSIS					63																					
EUTINTINNUS									125																	
FAVELLA	.032																									
TINTINNOPSIS	.040																									
UNDELLA																										
C.DINOFLAGEL-LATES																										
CERATIUM	.693	.016	.019	2500				125					143									50				150
PETALOTRICA																										
PROPLECTELLA																										
PRORODENTRUM																50				50	50	150				
TRICERATIUM																										
D.RADIOLARIA																										
PERIDINIUM				125												50			50			200		50	56	
DICTYOCYSTA																										
TTL CELL COUNT	2.02	.080	.094	2625	5875	54K	3625	125	250	1600	1700	2850	857	3889	333	3000	650	450	150	4200	300	2000	350	450	399	6250
NO.OF SPECIES	6	3	3	2	4	3	2	1	2	2	2	3	2	3	1	6	2	2	2	5	5	5	2	3	3	3
SURFACE SAL	38.6	38.7		38.8		38.9										37.3		38.6		38.6		38.3				37.0
TEMP	27.4	26.7		22.5		21.4		17.8			16.5		16.9	16.4		17.2		16.4		16.7		18.2				19.9
DO	6.1											8.0				7.9		9.0		7.1		7.3				7.3
BOTTOM SAL	38.7	38.8		39.1			39.2										38.8		39.1		38.7			38.6		
TEMP	26.4	26.5		22.2			21.4		17.2		16.0		15.9		15.9		15.7		15.9		16.0			16.0		
DO	6.1												7.4				7.6		7.7		7.2			7.9		
BOTTOM DEPTH	37M	40M		40M			40M		40M		40M		45M		40M		45M		60M		60M			46M		
DEPTH MAX DO													10M				SURF		SURF		35M			BOT		
MAX DO VALUE													8.1				7.9		8.9		8.8			7.9		

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6AP 2R2	30AP SUR	30AP 30M	30AP BOT	15MY SUR	15MY 30M	15MY BOT	29MY SUR	29MY 30M	29MY BOT	28JN SUR	28JN BOT	13JL 25M	13JL BOT
							100		5000				
11	5300		1800		150	400						50	
						50							
									250	56			62
22							4450						62
	800	150	500	1700	800	800	900		6125 2063	20K	1000	50	
				100	50	100	150 4000		1250 250			100 50	500
						200			125				
									875		56		125
													62
	150	50		150					1000	167			188
		50											
6													
0	6250 3 37.0 19.8 7.3	250 3	2300 2 38.4 17.2 7.3 43M 15M 8.2	1950 3 38.1 20.7 7.6	1000 3	1550 5 38.7 17.2 7.8 47M 20M 8.6	9600 5 38.3 23.7 6.6		17K 9 38.6 17.8 7.7 45M BOT 7.7	21K 3 27.2	1056 2 24.0 40M	250 4 35.3 28.5	999 6 38.2 25.5 35M

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TABLE A.1-3

PHYTOPLANKTON KAIT BEY STATION 3 1977-1978

(CELLS/LITER)

SAMPLING DATE	16AU HOR	16AU VER	17SE HOR	2 OC HOR	30NO SUR	30ND BOT	29DE SUR	29DE BOT	17JA SUR	17JA BOT	1 FE SUR	1 FE BOT	11FE SUR	11FE BOT	27FE SUR	27FE BOT	19MH SUR	19MH BOT	31MH SUR	31MH BOT	15AP SUR1	15AP 30M	15AP BOT	15AP SUR2	15AP SUR3	30AP SUR
A.DIATOMS																										
ALITHRIX																										
ASTERIONELLA																										
AULACODISCUS		.065																								
BACTERIASTRUM	.113																									
BELLAROCHIA		.162																								
BIDDULPHIA											500	200														
CHAETOCEROS									1800	300	3125			333					200		2200				1400	
CLIMACOSPHENIA																										
CORETHRON																										
COSCINODISCUS	.831	.974									125					50	100		100	200					100	
DACTYLIOSOLEN																					200					
DINOPHYSIS	.081	.065																								
DITYLUM																										
GRAMMATOPHORA																100										50
GUINARDIA																										
GYROSIGMA								125																		
HEMIAULUS																										
LEPTOCYLINDRUS																										
LICMOPHORA																										
LITHODESMIUM																										
MELOSIRA					375	375			1100	600					300						600		300			
METACYLIS																										
NAVICULA																	50	100					100			
NITZSCHIA																					100		50			
PLEUROSIGMA							250	125																		
RHABDONEMA	.008	.032																								
RHIZOSOLENIA				.046			125			100	125	100	111												400	
SKELETONEMA																										
STRIATELLA																100										
SURIRELLA																										
THALASSIONEMA																										
THALASSIOSIRA																										
THALASSIOTHRIX																										
B.TINTINNIDS																										
CODONELLA								125							50											
CODONELLOPSIS																										
EUTINTINNUS																									50	
FAVELLA	.395	.129																								
TINTINNOPSIS	.153	.097																								
UNDELLA	.032																									
C.DINOFLAGEL-LATES																										
CERATIUM	.935	.227	.017	.011		1250					125		222	111							100					
PETALOTRICA																										
PROPLECTELLA																										
PROROCENTRUM																					200					150
TRICERATIUM																50										
D.RADIOLARIA																										
PERIDINIUM																50		50							100	
DICTYOCYSTA																										
TTL CELL COUNT	2.55	1.75	.017	.057	375	1625	375	375	2900	1000	4000	300	333	444	500	350	150	150	300	850	400		450		2050	200
NO. OF SPECIES	8	8	1	2	2	2	2	3	2	3	5	2	2	2	3	5	2	2	2	2	6		3		5	2
SURFACE SAL	38.4		38.6		39.2										38.7		38.5		38.2		38.5					
TEMP	26.5		26.5		21.4		18.0		16.5		16.6		16.4		16.7		16.3		16.7		17.9					
DO	6.4		6.5												7.8		7.8		7.4		7.1					
BOTTOM SAL		38.7		38.7		39.1										38.8		38.7		38.6			38.6			37.8
TEMP		26.2		26.4		21.2		17.6		16.3		16.1		15.9		15.4		15.8		15.9			15.8			19.1
DO		6.3		6.5								7.2				7.5		7.2		7.3			8.0			7.7
BOTTOM DEPTH		55		50		55		52		55		55				55		60		60			58			
DEPTH MAX DO											SURF				SURF		20M		25M		45M					15M
MAX DO VALUE											8.1				7.8		8.4		8.8		8.1					8.0

5AP UR3	30AP SUR	30AP 30M	30AP BOT	15MY SUR	15MY 30M	15MY BOT	29MY SUR	29MY 30M	29MY BOT	28JN BOT	13JL SUR	13JL 30M	13JL BOT
													62
400												18	
00						100							
	50							50					
				100						100	111		
						50							125
				300		300				300			
						250	100			100	56		
											56		
												6	
00		50	100	150	111							6	
										100			
		50								50			
				100									
0													
			200	100	56								
	150												
00				50		800							
050	200	100	300	500	167	550	400	50	300	650	223	30	187
5	2	2	2	5	2	4	2	1	1	5	3	3	2
											38.5		
										25.9	27.0		
	37.8												38.2
	19.1									21.6			23.8
	7.7												
										50			40
	15M												
	8.0												

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TABLE A.1-4

PHYTOPLANKTON ABU KIR BAY STATION 1

(CELLS/LITER)

SAMPLING DATE	10AU HOR	31AU HOR	30C HOR	24NO SUR	24NO BOT	31DE SUR	31DE BOT	18JA SUR	18JA BOT	12FE SUR	12FE BOT	28FE SUR	28FE BOT	1 AP SUR	1 AP BOT	21AP SUR
A.DIATOMS																
ALITHPIX																
ASTERIONELLA																
AULACODISCUS	.209	.010														
BACTERIASTRUM																
BELLAROCHIA			.038													
BIDDULPHIA					100			1000	3300	200	400	235		100		
CHAETOCEROS		.151		2500	1900		600						294			
CLIMACOSPHENIA																
CORETHRON																
COSCINODISCUS	.084			100	200	200	200								100	
DACTYLIOSOLEN												235	50			
DINOPHYSIS																
DITYLUM										68	133					
GRAMMATOPHORA	.007					100							59	200		100
GUINARDIA																
GYROSIGMA						100										
HEMIAULUS																100
LEPTOCYLINDRUS																
LICMOPHORA																
LITHODESMIUM																
MELOSIRA						2500	3000	2000	4000	333		353	588			
METACYLIS																
NAVICULA					200									50		100
NITZSCHIA					100					68	133			100		
PLEUROSIGMA																
RHABDONEMA	.119															
RHIZOSOLENIA		.090	.100					300								300
SKELETONEMA																
STRIATELLA																
SURIRELLA	.014				100											
THALASSIONEMA		.080	.125					1000								
THALASSIOSIRA																
THALASSIOTHRIX																
B.TINTINNIDS																
CODONELLA				100									59			
CODONELLOPSIS	.007															
EUTINTINNUS																
FAVELLA	.530															
TINTINNOPSIS	.265													50	50	
UNDELLA	.035															150
C.DINOFLAGEL-LATES																
CERATIUM	.028			1500	100			400					176			150
PETALOTRICA																
PROPLECTELLA													59			
PROROCENTRUM				100								118				1750
TRICERATIUM	.021															
D.RADIOLARIA																
PERIDINIUM																50
DICTYOCYSTA																
TTL CELL COUNT	1.32	.331	.263	4300	2700	2900	3800	4700	7300	669	666	941	1285	500	150	2700
NO.OF SPECIES	11	4	3	5	7	4	3	5	2	4	3	4	7	5	2	8
SURFACE SAL	37.9		37.1	37.9								38&		37.5		36.3
TEMP	28.0		26.3			15.5		15.3		16.5		17.7		17.4		20.2
DO	5.2							7.9		7.1		6.3		8.2		7.3
BOTTOM SAL	38.2		38.1		38.1								38.8		37.9	36.4
TEMP	27.5		25.4				15.6		15.1		16.7		15.8		16.7	20.3
DO	6.7								7.6		6.2		7.6		8.0	7.3
BOTTOM DEPTH	5M		6M		5M		5M		3M		4.5M		6M		6M	4M
DEPTH MAX DO									SURF		SURF		BOT		SURF	SURF
MAX DO VALUE									7.9		7.1		7.6		8.2	7.3

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	1 AP SUR	1 AP BOT	21AP SUR	1 MY SUR	1 MY BOT	16MY SUR	16MY BOT	29JN SUR	29JN BOT	14JL SUR
	100									
				300						
		100				50				56
	200		100		200	150				
						50	200			
			100			150				
8							300			
	50		100			750	250			
	100					100				
						50				
			300		50		450	100	56	
							50			
									111	
9										
					100					
						50				
	50	50		50	100					
			150							
5			150	300	450	200				223
9										
			1750	50	100	6550	250			
			50		50	50		50		
					50					
5	500	150	2700	700	1100	8150	1500	150	167	279
	5	2	8	4	8	11	6	2	2	2
	37.5		36.3	36.2		35.8				37.5
	17.4		29.2	21.1		23.0		27.8		29.6
	8.2		7.3	6.6		7.6				
8		37.9	36.4		36.4		36.8			38.0
9		16.7	20.0		20.5		22.5		27.5	28.0
5		8.0	7.0		7.0		8.0			
M		6M	4M		6M		4M		6M	6M
T		SURF	SURF		BOT		BOT			
6		9.2	7.3		7.0		8.0			

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TABLE A.1-5

PHYTOPLANKTON ABU KIR BAY STATION 2

(CELLS/LITER)

SAMPLING DATE	10AU HOR	31AU HOR	3 OC HOR	24NO SUR	24NO BOT	31DE SUR	31DE BOT	18JA SUR	18JA BOT	12FE SUR	12FE BOT	28FE SUR	28FE BOT	1 AP SUR	1 AP BOT	21AP SUR	21AP BOT	1 MY SUR
A.DIATOMS																		
ALITHRIX																		
ASTERIONELLA		1.15																
AULACODISCUS																		
BACTERIASTRUM	.015																	
BELLAROCHIA	.030																	
BIDDULPHIA			.037							214	214				50			
CHAETOCEROS		.699	.029	2250	4600													500
CLIMACOSPHENIA					100													
CORETHRON																		
COSCINODISCUS			.037	375			100			71	71	50				150		
DACTYLIOSOLEN																		
DINOPHYSIS																		
DITYLUM											71							
GRAMMATOPHORA	.015												63	50				
GUINARDIA																		
GYROSIGMA																		50
HEMIAULUS																		
LEPTOCYLINDRUS																		
LICMOPHORA																		
LITHODESMIUM											143							
MELOSIRA						300	2200	1600	600			300	1375					
METACYLIS																		
NAVICULA														200	50			
NITZSCHIA					400			100									50	
PLEUROSIGMA																		
RHABDONEMA			.037															
RHIZOSOLENIA	.223	.268	.529													50		150
SKELETONEMA										143								
STRIATELLA																		
SURIRELLA																		
THALASSIONEMA		.045	.191															100
THALASSIOSIRA																		
THALASSIOTHRIX															100			
B.TINTINNIDS																		
CODONELLA						100												
CODONELLOPSIS																50	50	
EUTINTINNUS																50		
FAVELLA	1.085																	
TINTINNOPSIS		.227												100				
UNDELLA	.015															50		
C.DINOFLAGEL-LATES																		
CERATIUM	.438												63			300	100	150
PETALOTRICA																		
PROPLECTELLA																		
PRORODENTRUM														50	100	1400	400	
TRICERATIUM											71							
D.RADIOLARIA																		
PERIDINIUM										71						50		100
DICTYOCYSTA																50		
TTL CELL COUNT	2.10	2.16	0.77	2625	5100	400	2300	1700	600	499	570	350	1501	400	300	2150	600	950
NO.OF SPECIES	8	4	6	2	3	2	2	2	1	4	5	2	3	4	4	9	4	6
SURFACE SAL	37.9			37.2								37.5		36.8		37.0		36.6
TEMP	27.7		25.9			15.9		15.5		16.0		17.6		18.0		19.4		20.8
DO	6.9							8.4		6.7		7.5		8.2		7.3		6.8
BOTTOM SAL	37.9				38.0								38.6		38.0		37.2	
TEMP	27.4		25.6				15.8		15.5		15.5		16.0		16.7		19.2	
DO	7.0								8.5		7.7		7.6		8.6		7.2	
BOTTOM DEPTH	10M		6M		5M		6M		9M		6M		5M		6M		5M	
DEPTH MAX DO									5M		BOT		3M		BOT		SURF	
MAX DO VALUE									8.6		7.7		7.6		8.6		7.3	

1AP BOT	1 MY SUR	1 MY BOT	16MY SUR	16MY BOT	29JN SUR	29JN BOT	14JL SUR	14JL BOT
	500	400						150
			150					
								50
							50	
		50						
	50							
		100	100	50				
							150	
							50	100
50								
	150	800			150	100		50
	100							
50			50	50				
						50	50	
100	150				100	50		
400		100			50			
	100							
600	950	1450	300	100	300	200	300	350
4	6	5	3	2	3	3	4	4
	36.6		37.6				38.4	
	20.8		21.4		27.1		28.5	
	6.8							
7.2		36.5		37.6				38.1
9.2		20.6		21.4		26.4		28.0
7.2		6.9						
5M		4M		6M		7M		6M
ORF		BOT						
7.3		6.9						

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TABLE A.1-6

PHYTOPLANKTON ARU KIR BAY STATION 3

(CELLS/LITER)

SAMPLING DATE	10AU HOR	31AU HOR	3 OC HOR	24NO SUR	31DE SUR	31DE BOT	18JA SUR	18JA BOT	12FE SUR	12FE BOT	28FE SUR	28FE BOT	1 AP SUR	1 AP BOT	21AP SUR	21A BO
A.DIATOMS																
ALITHRIX																
ASTERIONELLA																
AULACODISCUS		.150														
BACTERIASTRUM																
BELLAROCHIA	.021	.312			300											
BIDDULPHIA	.011						100	200	231	188				200		10
CHAETOCEROS			.013		3600	4200	600	1500								
CLIMACOSPHENIA																
CORETHRON																
COSCINODISCUS		1.85	.013	400					154				100			
DACTYLIOSOLEN																
DINOPHYSIS																
DITYLUM																
GRAMMATOPHORA	.021										125				50	10
GUINARDIA									77							
GYROSIGMA																
HEMIAULUS															100	
LEPTOCYLINDRUS																
LICMOPHORA	.032															
LITHODESMIUM										188						
MELOSIRA	.021				1500	1600	1200	2800			750	353				500
METACYLIS											63					
NAVICULA									77		63	59	100		100	5
NITZSCHIA																
PLEUROSIGMA																
RHABDONEMA	.161	.288	.090											100		
RHIZOSOLENIA															300	
SKELETONEMA								300								
STRIATELLA									154							
SURIRELLA																
THALASSIONEMA			.096			500										
THALASSIOSIRA																
THALASSIOTHRIX														100		10
B.TINTINNIDS																
CODONELLA				100												5
CODONELLOPSIS																
EUTINTINNUS																
FAVELLA	.064	.612														
TINTINNOPSIS	.032															
UNDELLA	.032			300											150	
C.DINOFLAGEL-LATES																
CERATIUM	.118	.075								125					100	20
PETALOTRICA																
PROPLECTELLA																
PROROCENTRUM													600		250	250
TRICERATIUM									154							5
D.RADIOLARIA																
PERIDINIUM															50	
DICTYOCYSTA																
TTL CELL COUNT	.513	3.29	.212	800	5400	6400	1900	4800	847	501	1031	412	800	400	1100	3650
NO.OF SPECIES	10	6	4	3	3	3	3	4	6	3	4	2	3	3	8	9
SURFACE SAL	38.0			36.0							36.7		37.4		36.9	
TEMP	27.6		25.9		16.6		15.8		15.7		18.1		17.7		19.1	
DO	6.1						8.4		7.2		6.6		8.2		7.7	
BOTTOM SAL	38.1			38.2								38.7		38.0		37.0
TEMP	27.5		25.6			16.7		16.4		15.4		16.1		16.7		19.1
DO	6.2							8.5		7.1		7.6		8.4		7.6
BOTTOM DEPTH	5M		6M	15M		7M		6M		5M		7M		6M		10M
DEPTH MAX DO								BOT		SURF		3M		BOT		SURF
MAX DO VALUE								8.5		7.2		7.8		8.4		7.7

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AP SUR	21AP BOT	1 MY SUR	1 MY BOT	16MY SUR	16MY BOT	29JN SUR	29JN BOT	14JL SUR	14JL BOT
			50						
	100								
		2000	1000						
		50				56			
							56		
50	100								111
00									
			50						
	500			389					
00	50							50	56
								50	
0					625	111	111	50	
					62				
								100	
	100								
	50			56				50	
		150							
					62	56			
0									
0	200		300	167					
0	2500	200	100	111	188				
	50								
		50							56
	3650 9	2450 5	1500 5	723 4	937 4	223 3	278 3	300 5	223 3
		36.3		36.6				38.4	
		21.1		22.0		27.4		28.2	
		7.0							
	37.0		36.8		37.0				38.4
	19.1		20.2		21.4		26.5		28.0
	7.6		7.4						
	10M SUPF		7M BOT		8M		6M		6M
	7.7		7.4						

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TABLE A.1-7

ZOOPLANKTON KAIT BEV STATION 1
(CELLS/LITRE X 1000)

SAMPLING DATE	16AV HOR	17SE HOR	2 OC HOR	2 OC VER	15NO HOR	30NO HOR	29DE HOR	17JA HOR	1 FE HOR	1 FE OBL	11FE HOR	27FE HOR	27FE VER	19MH HOR	19MH VER	31MH HOR	31MH VER	15AP HOR	15AP VER	30AP HOR	30A VE
A.COELENTERATES																					
MEDUSA STAGE			1		5	248								16	106		163				
SIPHONOPHORES														8							
B.ROTIFERS																					
C.ECHINODERM -LARVAE																					
D.ANNELIDS																					
POLYCHAETE LAR				120									63								
E.MOLLUSCS																					
GASTROPODS															106						
PTEROPODS						6					18										
HETEROPODA													63								
F.CRUSTACEANS -COPEPODS																					
ACARTIA SP.		4			29							13	63	20	319	31	245	196	265	1628	74
CANDACIA				120							36										
CALANUS SP								40	36	4	10	27	126	8	213	61		13	88		
CENTROPAGES		4	1	359			2	8						4		9		17	88		59
CLAUSOCALANUS						6										126	245				
EUAETIDEUS																					
EUCHAETA																					
HALOPTILUS																					
ISIAS CLAVIPES											18	27	189		106					1754	89
PARACALANUS						23		16		3	9										
TEMORA SP.											9										
PLEUROMAMMA																					
AETIDEUS																					
COPILIA																					
CORYCAEUS						6	4		18	3	18	18	126			4					
CORYCELLA																					
EUTERPINA	2		1																		
SAPPHIRINA											18										
LUBBOKIA																					
OITHONA NANA			1													4					
LAPIDOCERA																					
NAUPLIUS LARVAE OF COPEPODS	4																				
G.CRUSTACEANS																					
CRUSTACEAN OVA			1								36					4					
CLADOCERA																					
OSTRACODA																					
CONCHOECIA																					
NAUPLIUS OF CIRRIPEDIA	4								18			18				9					
AMPHIPODA																					
DECAPOD LARVAE	2		2	120	22				9			44				13				112	11
MYSIS LARVA OF DECAPODA																					
H.CHAETOGNATHS																					
SAGITTA		4	2	598	36	51	2				9			4	106	4	7			112	3
I.CHORDATES																					
ASCIDIANS																				28	
TADPOLE OF ASCIDIAN	6																				
FISH EGGS		15		120		6	4	16													
J.RADIOLARIA																	326				
TTL CELL COUNT	18	27	9	1437	92	346	19	80	81	10	190	147	630	60	956	255	979	233	441	3634	37
NO. OF SPECIES	5	4	7	6	4	7	5	4	4	3	11	6	6	6	6	10	4	4	3	5	

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AP HOR	15AP VER	30AP HOR	30AP VER	15MY HOR	15MY VER	29MY HOR	29MY VER	28JN HOR	28JN VER	13JL HOR	13JL VER
				65	317	80	253				
96	265	1628	74		238		42				
3	88				79	40	84		35		2069
7	88		59	32		53	84	44	69	139	1862
							84				
		1754	89	615	634	53	169			63	3103
											621
						13					
						13					
						13					
								7			
								22		32	
		112	119	65	158	27	84	22	35	504	414
		112	30	162	238	13	84	15	35	113	414
		28									
									35		
233	441	3634	371	939	1664	305	884	110	209	851	9518
4	3	5	5	5	6	9	8	5	5	[illegible]	6

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2584

TABLE A.1-8

ZOOPLANKTON KAIT BEY STATION 2

(CELLS/LITER X 1000)

SAMPLING DATE	16AU HOR	17SE HOR	17SE VER	2 OC HOR	15NO HOR	15NO OBL	30NO HOR	30NO OBL	29DE HOR	17JA HOR	17JA OBL	1 FE HOR	1 FE OBL	11FE HOR	11FE VER	27FE HOR	27FE VER	19MH HOR	19MH VER	31MH HOR	31MH VER	15AP HOR	1KAP VER
A.COELENTERATES																							
MEDUSA STAGE			48			21	7	19			13											23	64
SIPHONOPHORES									2		13	7		7							41		
B.ROTIFERS	8	2				3																	
C.ECHINODERM -LARVAE						3		8								4							
D.ANNELIDS																							
POLYCHAETE LAR					2																		
E.MOLLUSCS																							
GASTROPOD LAR																		5		7			
PTEROPODS						14													42				
HETEROPODA																							
F.CRUSTACEANS -COPEPODS																							
ACARTIA				2												18	248	15	83			538	96
CANDACIA							2	8															
CALANUS SP.					2		2	4	2	17	13	41	17	41	321	4	41	5		18	61		
CENTROPAGES		4	95	1		14								7				5		7	20	31	
CLAUSOCALANUS							2													14	41		
EUATIDEUS																							
EUCHAETA																							
HALOPTILUS																							
ISIAS CLAVIPES	2								2			34		7		27		10	125			177	129
PARACALANUS								4		8	13		8	7		18					20		
TEMORA SP.				3	11	7																	
PLEUROMAMMA																							
AETIDEUS																							
COPILIA																							
CORYCAEUS				1					2	8	26		17		107		83		83	7			
CORYCELLA													8										
EUTERPINA				1																			
SAPPHIRINA																							
LUBBOKIA																							
OITHONA NANA					2																		
LAPIDOCERA																							
NAUPLIUS LARVA OF COPEPODS	4																						
G.CRUSTACEANS																							
CRUSTACEAN OVA						3	11		4					7									
CLADOCERA										8	13	7											
OSTRACODA																							
CONCHOECIA																			42				
NAUPLIUS OF CIRRIPED												11	25			9							
AMPHIPODA																							
DECAPODS LARVA			48		4	7					13					9	41						
MYSIS LARVA OF DECAPODA																							
H.CHAETOGNATHS																							
SAGITTA				2	11	28	9	15	2		26		8		107	4	83	5	42		41		32
I.CHORDATES																							
ASCIDIAN																							
TADPOLE OF ASCIDIANS																							
FISH EGGS	6	6	71				2	11		8		7	8			9							
J.RADIOLARIA												7	17							252	306		
TTL CELL COUNT	20	12	262	9	32	100	35	69	14	49	130	114	108	76	535	102	496	45	417	305	530	769	321
NO. OF SPECIES	4	3	4	6	6	9	7	7	6	5	9	7	8	6	3	9	5	6	6	6	7	4	4

A-

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AP VER	30AP HOR	30AP VER	15MY HOR	15MY VER	29MY HOR	29MY VER	28JN HOR	28JN VER	13JL HOR	13JL VER
64		144		141						
					7	92		22		
					36					
		72						67	6	37
96	75	72		28						
	9									
	33	289		56	14			22		37
					14		23	93		
	14			28		46				
									6	
129	131			56	28	46				
	5									
		144			7					
						46				
	14							44		
	38	72					31	67	13	37
32				85		137	8		6	
	47	72								
							62	45	130	71
					14				6	
321	366	865		394	120	357	124	357	157	185
4	9	7		6	7	5	1	7	6	1

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TABLE A.1-9

ZOOPLANKTON KAIT 9EV STATION 3

(CELLS/LITER X 1000)

SAMPLING DATE	16AU HOR	17SE HOR	17SE VER	2 OC HOR	2 OC VER	30NO HOR	30NO OBL	29DE HOR	17JA HOR	17JA OBL	1 FE HOR	1 FE OBL	11FE HOR	11FE OBL	27FE HOR	27FE VER	19MH HOR	19MH VER	31MH HOR	31MH VER	15AP HOR	15AP OBL	15AP VER	30AP HOR	30AP OBL	30AP VER
A.COELENTERATES																					8					
MEDUSA STAGE									7					23		135		32		23						
SIPHONOPHORES									45	18																
B.ROTIFERS		2																								
C.ECHINODERM -LARVAE																										
D.ANNELIDS																										
POLYCHAETE LAR																										
E.MULLUSCS																										
GASTROPOD LAR																										
PTEROPODS															4	45										
HETEROPODA																										
F.CRUSTACEANS -COPEPODS															7				3	70	116	6				
ACARTIA														8						47						
CANDACIA					28									23	11	90			9	70	40	16	61			
CALANUS SP.									15	24			16								20	11				
CENTROPAGES	3		24																							
CLAUSOCALANUS										18										23						
EUATIDEUS						3																				
EUCHAETA										6																
HALOPTILUS							4			6				4			10	65			232	28	123			
ISIAS CLAVIPES			24														3	65	3							
PARACALANUS							2	2			9	13	9													
TEMORA SP.						6																				
PLEUROMAMMA																										
AETIDEUS																										
COPILIA							2							16	7			65				11	61			
CORYCAEUS									15					8												
CORYCELLA							2	2				7														
EUTERPINA														8												
SAPPHIRINA																										
LUBBOKIA						3														47						
OITHONA NANA																										
LAPIDOCERA																										
NAUPLIUS LARVA OF COPEPODS																										
G.CRUSTACEANS														23							20	11				
CRUSTACEAN OVA							4	4	15	6																
CLADOCERA																										
OSTRACODA										12																
CONCHOECIA																		32								
NAUPLIUS OF CIRRIPED											8															
AMPHIPODA														16		45						28	92			
DECAPODS LARVA			24		56	6				6																
MYSIS LARVA OF DECAPODA												7														
H.CHAETOGNATHS														16	4	45	7	7				11				
SAGITTA	3				28	3		2	15	30	8	7	8													
I.CHORDATES																										
ASCIDIAN																										
TADPOLE OF ASCIDIANS																	3		6							
FISH EGGS		.2		3							9	27	9													
J.RADIOLARIA									30	18			25	16			3		108	47						
TTL CELL COUNT	6	2	73	3	112	21	14	10	142	144	32	61	65	161	33	450	26	266	129	327	436	122	337			
NO. OF SPECIES	2	2	4	1	3	5	5	4	7	10	4	5	5	11	5	5	5	6	5	7	6	9	4			

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30AP HOR	30AP OBL	30AP VER	15MY HOR	15MY OBL	29MY HOR	29MY OBL	29MY VER	28JN HOR	28JN OBL	13JL HOR	13JL OBL
					7	12			27	15	32
											16
						17		5	22		32
						23	6				
					36		13				
								20			
						29			11	15	
											8
					58		6				
									5		
						6					
											8
						6	13				
					14						
									5		
					29			15			
								15	27		16
						12		10	16		41
					7	6			15	44	24
										15	8
					14	6	6	5	5	15	8
					165	117	44	70	134	104	193
					7	9	5	6	9	5	1[illegible]

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TABLE A.1-10

ZOOPLANKTON ABU KIR BAY STATION 1

(CELLS/LITER X 1000)

SAMPLING DATE	31AU HOR	18SE HOR	3 OC HOR	24NO HOR	31DE HOR	18JA HOR	12FE HOR	28FE HOR	28FE VER	1 AP HOR	1 AP VER	21AP HOR	21AP VER	1 MY HOR	1 MY VER	16MY HOR	16MY VER	29JN HOR	29JN VER	14JL HOR	14JL VER
A.COELENTERATES																					
MEDUSA STAGE				26		26	10	7			206										
SIPHONOPHORES																					
B.ROTIFERS																					
C.ECHINODERM -LARVAE																					
D.ANNELIDS																					
POLYCHAETE LAR																					
E.MOLLUSCS																					
GASTROPOD LAR					3																
PTEROPODS																					
HETEROPODA																					
F.CRUSTACEANS -COPEPODS																					
ACARTIA							105	42	2308	437	5	10	337		928	7	200				
CANDACIA																					
CALANUS SP.											618										
CENTROPAGES																			462	9	
CLAUSOCALANUS																					
EUATIDEUS																					
EUCHAETA																					
HALOPTILUS																					
ISIAS CLAVIPES														9		14	600				
PARACALANUS																					
TEMORA SP.			9																		
PLEUROMANMA																					
AETIDEUS																					
COPILIA																					
CORYCAEUS					3																
CORYCELLA																					
EUTERPINA								14													
SAPPHIRINA																					
LUBBOKIA																					
OITHONA NANA																					
LAPIDOCERA																					
NAUPLIUS LARVA OF COPEPODS		3			9	26		14	769												
G.CRUSTACEANS																					
CRUSTACEAN OVA																					
CLADOCERA	3																				
OSTRACODA																					
CONCHOECIA																					
NAUPLIUS OF CIRRIPED					44	52	22	70													
AMPHIPODA												2									
DECAPODS LARVA	6	8	4				10					5	168					6	231	26	
MYSIS LARVA OF DECAPODA																					
H.CHAETOGNATHS																					
SAGITTA	3	5	7	20										14	619		400	6	231	9	309
I.CHORDATES																					
ASCIDIAN																					
TADPOLE OF ASCIDIANS																					
FISH EGGS	9		2				10			2					309			17	462	35	309
J.RADIOLARIA														5							
TTL CELL COUNT	21	16	22	46	59	104	157	304	3077	439	3906	17	505	28	1856	21	1200	29	1386	79	618
NO. OF SPECIES	4	3	4	2	4	3	4	5	2	2	3	3	2	3	3	2	3	3	4	4	2

TABLE A.1-11

ZOOPLANKTON ABU KIR BAY STATION 2

(CELLS/LITER X 1000)

SAMPLING DATE	31AU HOR	18SE HOR	3 OC HOR	24NO HOR	31DE HOR	19JA HOR	12FE HOR	28FE HOR	28FE VER	1 AP HOR	1 AP VER	21AP HOR	21AP VER	1 MA HOR	1 MA VER	16MA HOR	16MA VER	29JN HOR	29JN VER	14JL HOR	14JL VER
A.COELENTERATES																					
MEDUSA STAGE				9	2	9	37	10	694			102	720		235	35	368				
SIPHONOPHORES																					
B.ROTIFERS																					
C.ECHINODERM			2																		
-LARVAE																					
D.ANNELIDS																					
POLYCHAETE LAR													180								
E.MOLLUSCS																					
GASTROPOD LAR					2																
PTEROPODS																					
HETEROPODA																					
F.CRUSTACEANS																					
-COPEPODS																					
ACARTIA							37	52	2083	21	1200	219	1080		470	10	737				
CANDACIA																					
CALANUS SP.										9											
CENTROPAGES		1								6					235	5					
CLAUSOCALANUS																					
EUATIDEUS																					
EUCHAETA																					
HALOPTILUS																					
ISIAS CLAVIPES											400	34			706						
PARACALANUS				9	2																
TEMORA SP.			2																		
PLEUROMAMMA																					
AETIDEUS																					
COPILIA																					
CORYCAEUS																					
CORYCELLA																					
EUTERPINA																					
SAPPHIRINA																					
LUBBOKIA																					
OITHONA NANA													180								
LAPIDOCERA																					
NAUPLIUS LARVA				9		9		26			200										
OF COPEPODS																					
G.CRUSTACEANS																					
CRUSTACEAN OVA													180								
CLADOCERA	11																				
OSTRACODA																					
CONCHOECIA																					
NAUPLIUS OF				9	50	4110	56														
CIRRIPED																					
AMPHIPODA																	737				
DECAPODS LARVA	4		5		2		19	10				20	180			20	368				
MYSIS LARVA OF																					
DECAPODA																					
H.CHAETOGNATHS																					
SAGITTA	4	2		28	3			5	694			34	180							5	638
I.CHORDATES																					
ASCIDIAN																					
TADPOLE OF																					
ASCIDIANS																					
FISH EGGS	7									3		20									
J.RADIOLARIA																					
TTL CELL COUNT	26	3	9	64	61	4128	149	103	347	39	1800	429	2700		1646	70	2210	37	2666	26	2553
NO. OF SPECIES	4	2	3	5	6	3	4	4	3	4	3	6	7		4	4	4				

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TABLE A.1-12

ZOOPLANKTON ABU KIR BAY STATION 3

(CELLS/LITER X 1000)

SAMPLING DATE	31AU HOR	18SE HOR	3 OC HOR	3 OC VER	24NO HOR	31DE HOR	18JA HOR	12FE HOR	28FE HOR	28FE VER	1 AP HOR	1 AP VER	21AP HOR	21AP VER	1 MY HOR	1 MY VER	16MY HOR	16MY VER	29JN HOR	29JN VER	14JL HOR	14JL VER
A.COELENTERATES																						
MEDUSA STAGE					108		20	66					21		7		9	152	6		1172	3448
SIPHONOPHORES																						
B.ROTIFERS																						
C.ECHINODERM -LARVAE																						
D.ANNELIDS																						
POLYCHAETE LAR																						
E.MOLLUSCS																						
GASTROPOD LAR							13											152				
PTEROPODS																						
HETEROPODA																					7	
F.CRUSTACEANS -COPEPODS																						
ACARTIA								265	277	3600	1014	1111		592	14							
CANDACIA		2																				
CALANUS SP.							13				10	444										
CENTROPAGES	2	2	2	100									7	296			9			188	34	690
CLAUSOCALANUS													14									345
EUATIDEUS			2																			
EUCHAETA																						
HALOPTILUS																						
ISIAS CLAVIPES											10	222			14		4	304			21	690
PARACALANUS						4	7				5											
TEMORA SP.			6		8																	
PLEUROMAMMA																						
AETIDEUS																						
COPILIA																						
CORYCAEUS							20															
CORYCELLA							13															
EUTERPINA																						
SAPPHIRINA																						
LUBBOKIA																						
OITHONA NANA																	9					
LAPIDOCERA																					7	
NAUPLIUS LARVA						4				1200	5											
OF COPEPODS																						
G.CRUSTACEANS																						
CRUSTACEAN OVA																						
CLADOCERA	6																					
OSTRACODA																						
CONCHOECIA																						
NAUPLIUS OF CIRRIPED					16	25	132	95	910					148				304				
AMPHIPODA																						
DECAPODS LARVA	2	4	6		16	4	7	19			29		7	148	14			152	24	562		345
MYSIS LARVA OF DECAPODA																						
H.CHAETOGNATHS																						
SAGITTA		7	4	100	50	8	33	9			14				7		4				69	1724
I.CHORDATES																						
ASCIDIAN																						
TADPOLE OF ASCIDIANS																						
FISH EGGS			2	100									7		14					188		
J.RADIOLARIA																						
TTL CELL COUNT	10	15	22	300	198	45	258	454	1187	4800	1073	1777	70	1184	70		39	1064	30	938	1310	7242
NO. OF SPECIES	3	4	6	3	5	5	9	5	2	2	6	3	6	4	6		6	5	2	3	6	6

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SECTION A.2

SECTION A.2

SUMMARY OF BENTHIC SAMPLING

Eastern Harbor

The bottom of the eastern harbor is mostly of loose putrified mud covered with plants. In the middle of the harbor the bottom is sandy and covered with plants. Farther to the west, the bottom changes to sand mixed with rocks, covered with plants, while at the harbor mouth, the bottom is again observed to be putrified mud covered with plants.

The flora in the harbor is mainly *Caulerpa prolifera*. Among the flora gathered, a few specimens of *Codium clongatum*, together with *Ulva lachica* were found.

Sample 1. This sample was taken inside the eastern harbor on its west side. It contained Hydroides and 5 Arenicola worms growing on Caulerpa leaves. The Crustacea present were all dead as were the Molluscs. Some Ascidiano (Ascidia mentula) and few Bryozoa (Buzula meritine) were also present.

Sample 2. This sample was taken in the middle of the harbor at a depth of 6 m. A few Anthozoans were found as well as some Crustacea. *Hydroides* elegans were common and a few Ascidians and Bryozoans were noted. The Molluscs found alive included *Murex trunculus* and *Tapes*; the others were only empty shells.

Sample 3. The third sampling was gathered further on the west out into the harbor. The fauna obtained belong to the Anthozoa, Polychaeta, Crustacea, Mollusca, Bryozoa and Ascidians. Among the Polychaeta, *Hydroides elegans* were dominant. Most of the Molluscs found were dead.

Sample 4. This sample was taken at the entrance of Eastern Harbor. At this point, Polychaets are most frequent and are represented by *Hydroides elegans*, *Spirorbis* sp., *Arenicola* sp., *Lepidonotus clava*, *Heteronereis* sp., and *Hyalinoecia* sp. The Crustaceans found included, *Balanus amphetrite*, numerous dead shells, *Balanus Perfaratus* in a small quantity, and one shrimp *Palaemon serratus*.

Outside the Eastern Harbor

Near the sewage outfall, 3 samples were taken.

Sample 1 was taken near the sewage outfall, 2 km from the Anfushi district. The depth there was 28 m and the bottom was mainly full of pebbles. There were no flora present and very few benthic animals were noted.

Sample 2 was taken 40 km of Anfushi at a depth of 55 m. In this area the bottom was muddy and full of rocks. There was flora, mainly consisting of Caulerpa sp., although a few specimens of Udotea Petiolata and Halimeda Tuna were also present. A few brown and red algae were also found. Benthic fauna found belonged to the following classes: Porifera, Coelentrata, Polychaeta, Crustacea, Mollusca, Bryozoa, Echinodermata and Ascidia. Among the Molluscs, the following genera and species were found alive: Bullaria striata, Mactra sp., Modiolus barbatus, and Tellina sp.

Sample 3 was taken outside the western entrance to the Eastern Harbor. There the bottom was rocky. Flora was rarely present, consisting mostly of green and red algae. The fauna present belonged to the following classes: Porifera, Coelentrates, Polychaeta, Crustacea and Mollusca. Of the molluscs, only one Gastrochaena dubia and 2 Lithophaga lithophaga were found alive.

Mex Bight

In Mex Bight samples were taken from 6 stations.

Sample 1 was taken in the middle of the bay at a depth of 27 m. The bottom was coarse sane mixed with calcarious fragments. The flora present consisted mainly of red algae, especially Pseudo lithophyllum expansum, but some green algae were also present.

Fauna from these classes was found: Porifera, Polychaeta, Crustacea, Mollusca, Bryozoa and Echinodermata. Of the Porifera, different species of sponges were found growing on calcarious fragments. The Polychaeta present, though few in number, belonged to foud different genera. Of the Crustacea, the

most frequently found were hermit crabs and the cirripedes Balanus amphetrite. Living Mollusca included Cardium echinatum, Lithophaga lithophaga, Pseudochama ferriguinea and Modiolus sp., Bryozoa were rare, but Echimodermata, especially Holothurian sp were frequent.

Sample 2. The second sample was taken towards the shore in the bight, on the eastern side at a depth of 10 m. The bottom was sandy and rocky. There was no flora except the dead roots of Posidonia sp. Fauna included: Porifera, Polychaeta, Crustacea, Mollusca and Bryozoa. Molloscas found living included Hydrobia sp., Natica millepunctata, Glycymeris glycymeris, Venus verrucosa and Donax sp. This station was, in general, poorer in benthic fauna and flora than the former.

Sample 3. The station for this sample was nearer shore at a depth of 10 m. The bottom was sandy and muddy and full of corals. The flora were rare, consisting mainly of dead leaves and roots of posidonia. The fauna belong to the following classes: Coelentrate, Polychaeta, Crustacea and Mollusca. All 18 of the cirripedes (Balanus amphetrite) present. were dead. Most Molluscas also were dead.

Sample 4. This sample was taken 100 m directly offshore from a chemical company outfall at a depth of 5 m. The bottom was pebbles mixed with coral. There was no flora. Of the fauna, Porifera were very rare, corals were frequent. The cirripedia (Crustacea) present were all dead. Almost all Molluscs were dead.

Sample 5. The next sample was taken west of the station near the shore. The bottom was sandy and mixed with pebbles and shell fragments. Of the flora, there were rare specimens of Godium dichotomum and dead roots of Posidonia ocaenica. Of the Polychaeta, Lepidonotus clava, Eunice sp., and Tube worms were found. Hermit crabs were abundant. The generae of Mollusca found alive included: Dentalium sp., Arcularia gibbosula, Venus gallina and Mactra sp.

Sample 6. The last sampling was taken farther offshore at a depth of 10 m., west of Station 4. There was no flora found. The fauna consisted of some coral, dead cirripedes (Balanus sp.) and hermit crabs. Some Molluscs were found alive: Hydrobia ulvae, Columbella rustica, Pseudomurex craticulatus, Glycymeric glycymeris, Venus striatula, Donax variegatus varcalverti. Bryozoa was rare at this station.

Abu Kir Bay

Sample 1 was taken just off the outfall of Tabia Pump Station. Here the bottom is sandy mud mixed with plants. The sample was taken at a depth of 6 metres. Flora present was dominated by Caulerpa prolifera. The benthic fauna belonged to Polychaeta, Crustacea and Mollusca. Of the Polychaeta there were a few hydroids present and one individual belonging to the genus Eunice. Of the Crustacea, three individuals of Charybdis hellerii and one individual of Eucrate crenata were found. The only living molluscs in the sample were 24 Loripes sp. and eight Nucula sp.

Sample 2 was taken further to the east in front of Maadiya Inlet at a depth of 6 m. The bottom was sandy, covered with plants, as at Station 1. The flora present was mainly Caulerpa prolifera. The benthic fauna were Porifera, Coelentrata, Polychaeta, Crustacea and Mollusca. Coelentrata dominated the bottom community in this area, mainly Obelia geniculata attached to caulerpa leaves. Of the polychaetes, a few hydroids were present. Of the crustacea, only one individual of Balanus eburneus was found. Except for empty shells, the only mollusc present was one Nassarius mutabilis. On Caulerpa leaves, colonies of bryozoa (Bugula neritina and Membranipora membranacea) were found, as well as some ascidians (Distomus sp.).

Sample 3 is still further east of the Tabia discharge, but more inside the bay at a depth of 10 m. Here the bottom was mainly sandy. Also here Caulerpa prolifera constituted the main flora on the bottom. The fauna

belonged to the following classes: Coelentrata, Polychaeta, Crustacea, Mollusca, and Echinodermata. The Coelentrata were mainly Obelia geniculata attached to caulerpa leaves. Of the crustacea, one hermit crab of unidentified species was found. Of the molluscs the following genera were found alive: Nassa, Venus and Donax. The molluscan fauna was dominated by Glycimeris glycimeris. Of the Echinoderms, two individuals of Astrospecten sp. were found.

Sample 4 was in front of Tabia outfalls but inside the bay. The depth was 6 m. The bottom here is mainly sandy. It is also covered with Caulerpa prolifera. The fauna belong to the classes Coelentrata, Polychaeta, Crustacea and Mollusca. Except for five Donax, all molluscs were dead. There were only a few coelentrates and polychaetes. Of the crustaceans, there was one Balanus amphetrite and one Crangon sp.

Sample 5 was close to Station 1 but slightly to the west. Here, the bottom was sand mixed with pebbles. Small amounts of flora, consisting mainly of red algae, Lithothamnion sp., were found. From the coelentrata, only a few Caryophyllia sp. were found. One Polychaeta and 2 hermit crabs were also present. All molluscs, with the exception of 2 Venus gallina, were found dead.

Sample 6 was situated further to the west, inside the bay. The sample was taken at a depth of 6 m. The sea floor was mud mixed with rocks and plants. The flora gathered consisted predominantly of Caulerpa profilera. A few sponges were found together with one crustacean, Macropipus depurator. The molluscs found were all empty shells with the exception of 25 living Loripes sp. and 8 Tellina sp.

TABLE A.2-1

ANALYSES OF BENTHIC TRAWLS

Sample 1, Eastern Harbor — Date: 3 December 1977

Duration of dredging: 5 minutes — Depth: 5 metres

Type of bottom: Loose putrified mud covered with plants

Flora:

Green Algae:		Dominant
	Caulerpa prolifera	Dominant
	Codium elongatum	Rare

Fauna:

Polychaeta:

Hydroides elegans	Frequent

(These are tube worms settling on *Caulerpa*)

Arenicola	5 individuals

Crustacea:

Balanus amphetrite	10 dead individuals
Mya fugax	1 carapace
Charybdis sp.	1 arm

Mollusca:

Nassarius reticulata	1 shell
Murex trunculus	1 shell
Venus gallina	3 valves
Tapes spp.	36 valves
Tellina spp.	8 valves
Loripes spp.	2 valves
Other bivalves	

(All are empty shells and valves).

Bryozoa:

Bugula neritina	Very rare

Ascidians:

Ascidia mentula	25 individuals

TABLE A.2-2

ANALYSES OF BENTHIC TRAWLS

Sample 2, Eastern Harbor — Date: 3 December 1977

Duration of dredging: 5 minutes — Depth: 6 metres

Type of bottom: Sandy covered with plants

Flora:

Green Algae:

Caulerpa prolifera	Dominant

Fauna:

Coelenterata:

Cerianthus sp.	1

Polychaeta:

Hydroides elegans	Common
Marphysa sanguinea	6 individuals

Crustacea:

Macropipus sp.	2 individuals
Charybdis sp.	1 individual

Mollusca:

Murex trunculus	2 alive and 1 shell
Pseudomurex sp.	3 shells
Arcularia sp.	1 shell
Nassarius mutabilis	1 shell
Tapes sp.	1 alive and 164 valves
Venus verrucosa	2 valves
Venus casina	1 valve
Venus gallina	2 valves
Cardium glaucum	2 valves
Loripes sp.	11 valves
Tellina sp.	3 valves

Bryozoa:

Bugula turbinata	Rare

Ascidians:

Ascidia mentula	4 individuals
Phallusia mamellata	2 individuals
Ascidia sp.	1 individual

TABLE A.2-3

ANALYSES OF BENTHIC TRAWLS

Sample 3, Eastern Harbor — Date: 3 December 1977

Duration of dredging: 8 minutes — Depth: 6 metres

Type of bottom: Sandy and rocky, covered with plants

Flora:

Green Algae:

Caulerpa prolifera	Dominant

Fauna:

Coelenterata:

Sea anemone	2 individuals

Polychaeta:

Hydroides elegans	Dominant
Spirorbis sp.	Frequent
Eunice sp.	2 individuals
Lepidonotus sp.	2 individuals
Marphysa sanguinea	8 individuals
Other Errantia sp.	1 individual

Crustacea:

Pirimela sp.	4 individuals
Corophium sp.	1 individual

Mollusca:

Murex trunculus	6 shells
Pseudomurex sp.	4 shells
Natica josephine	3 shells
Nassarius variabilis	1 shell
Zizyphinus granulatus	1 shell
Venus verrucosa	125 valves
Venus gallina	6 valves
Cardium glaucum	36 valves
Irus irus	2 valves
Tapes sp.	450 valves and 2 alive
Ostria edulis	3 valves
Modiolus sp.	6 valves

(Most are dead; only 2 found alive).

Bryozoa:

Bugula neritina	Rare
Bowerbankia imbricata	Rare
Walkeria uva	Rare

Ascidians:

Ascidia mentula	4 individuals

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TABLE A.2-4

ANALYSES OF BENTHIC TRAWLS

Sample 4, Eastern Harbor — Date: 3 December 1977

Duration of dredging: 5 minutes — Depth: Not Available

Type of bottom: Loose putrified mud covered with plants

Flora:

Caulerpa prolifera	Dominant
Codium tomentosum	Rare
Ulva lactuca	Rare

Fauna:

Porifera:		
	Suberites domuncula	Rare
Coelenterata:		
	Astroides sp.	Rare
Polychaeta:		
	Hydroides elegans	Frequent
	Spirorbis sp.	Rare
	Arenicola sp.	21 individuals
	Lepidonotus clava	1 individual
	Heteronereis sp.	1 individual
	Hyalinoecia sp.	5 individuals
Echiura:		
	Echiura sp.	1 individual
Crustacea:		
	Balanus amphitrite	30 dead individuals and 5 alive
	Balanus perfaratus	Rare
	Palaemon serratus	1 individual
Mollusca:		
	Nassarius sp.	1 shell
	Tapes sp.	40 valves and 3 alive
	Venus gallina	1 valve
	Cardium glaucum	2 valves
	Cardium sp.	1 valve
	Modiolus sp.	2 valves and 1 alive
	Tellina sp.	11 valves and 1 alive
	Ostrea sp.	2 valves
Bryozoa:		
	encrusting Bryozoa	Few colonies
Ascidians:		
	Ascidia sp.	1 individual

TABLE A.2-5

ANALYSES OF BENTHIC TRAWLS

Sample 1, 2km off Anfushi
Latitude: 31° 13' 43"
Longitude: 29° 52' 11"

Date: 6 January 1978

Duration of dredging: 10 minutes

Depth: 28 metres

Type of bottom: pebble

Flora:

Benthic flora are absent from this sample.

Fauna: (Very rare in this sample)

Porifera (sponge)	Rare
Nemertinea	1 individual
Polychaeta:	
Audouinia tentaculata	1 individual
Tube worms	Rare
Other polychaeta species	1 individual

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TABLE A.2-6

ANALYSES OF BENTHIC TRAWLS

Sample 2, ten km off Anfushi

Latitude: 31° 18' 15" Date: 6 January 1978

Longitude:29° 50' 53"

Duration of dredging: 15 minutes Depth: 55 metres

Type of bottom : Rocky muddy.

N.B. Only 2/3 of the sample was examined.

Flora:

Green Algae:

Caulerpa prolifera	Rare
Caulerpa sp.	Frequent
Udotea petiolata	Rare
Halimeda tuna	Rare

Brown Algae

Sargassum spp.	Rare
Fucus sp.	Rare

Red Algae

Lithophyllum sp.	Dominant
Expansum sp.	
Cristatum sp.	
Vidalia Volubilis	Rare
Nemalion sp.	Rare
Helminthoides	

Fauna:

Porifera (Sponge)

Hippospongia	Rare
Communis	
Other sponge spp.	Common

Coelenterata:

Gerardia sp.	Rare

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TABLE A.2-6 (cont'd)

Polychaeta:		
	Glycera sp..	One individual
	Hermione sp.	One individual
	Polychaeta Spp.	2 individuals
Crustacea:		
	Dromia persenata	One individual
	Actaea rufopunctata	One carapace
Mollusca:		
	Chiton olivaceus	One individual
	Stambiformis subulata	One shell
	Turitella sp.	One shell
	Siliquaria anguina	One shell
	Bittium sp.	One shell
	Rissoa costata	One shell
	Aptyxis sp.	One shell
	Stellaria sp.	One shell
	Bullaria striata	5 shells+ 2 alive
	Persicula sp.	One shell
	Aporrhais pes-pelicani	One shell
	Vermetus gigas	2 shells
	Natica sp.	One shell
	Other Gastropod spp.	3 shells
	Dentalium sp.	5 shells
	Chlamys spp.	21 valves
	Arca barbata	One valve
	Dosinia sp.	11 valves
	Venus verrucosa	3 valves
	Cardium sp.	5 valves
	Glycymeris sp.	One valve
	Spisula sp.	2 valves + One alive
	Modiolus barbatus	One valve + One alive
	Lima sulcata	One valve
	Tellina sp.	20 valves + One alive
	Nucula sp.	One valve
	Other lamellibranchia spp.	20 valves.

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TABLE A.2-6 (cont'd)

Bryozoa:		
	Retipora cellulosa	Frequent
	Other Encrusting Bryozoa	Common
Echinodermata:		
	Echnaster sp.	One
	Echinoid sp.	One
	Amphiura chiajei	2
	Ophiuroid sp.	2
Ascidia:		
	Botryllus schlosseri	Rare

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TABLE A.2-7

ANALYSES OF BENTHIC TRAWLS

Sample 3, Outside Western Entrance to Eastern Harbor — Date: 6 January 1978

Latitude: 31° 12' 58"

Longitude: 29° 53' 31"

Duration of dredging: The dredge was taken off after entangling.

Type of bottom: Rocky bottom — Depth: 10 metres

Flora:

Green algae	Rare
Red algae	Rare

Fauna:

Porifera (sponge)			
	Suberites sp.		Rare
Coelentrata (corals)			
	Astroides sp		Frequent
Polychaeta:			
	Paraonis sp.	8	individuals
	Lagisca sp.	3	individuals
	Tube worms	8	Tubes
	Other polychaeta	2	individuals
Crustacea:			
	Balanus amphitrite	15	individuals
	Amphipoda	One	individual
Mollusca:			
	Lithophaga lithophaga	2	individuals (alive)
	Gastrochaena sp.	One	individual (alive)

TABLE A.2-8

ANALYSES OF BENTHIC TRAWLS

Sample 1, Mex Bight — Date: 13 January 1978

Latitude: 31° 10' 46"

Longitude: 29° 48' 45"

Time: 10 hr. 45m.

Duration of dredging: 14 minutes — Depth: 27 metres

Type of bottom: Coarse sand mixed with calcarious fragments.

Flora:

Green Algae:

Udotea despontaini	Frequent
Posidonia oceanica	Few leaves

Red Algae:

Psuedolithophyllum expansum	Dominant
Other red algae(not Calcarious)	Rare

Fauna:

Porifera (sponges):

Different species of sponge growing on calcarious fragments Common.

Polychaeta:

Serpula torquata	1 Individual
Eunice sp.	2 Individuals
Lumbrinereis sp.	2 Individuals
Aphrodite sp.	2 Individuals
Other polychaeta spp.	6 Individuals

Crustacea:

Actaea sp.	1 Individual
Hermit crab	5 Individuals
Balanus amphitrite	3 Individuals

Mollusca:

Murex tranculus	1 shell
Murex cristata	2 shells

TABLE A.2-8 (cont'd)

	Cerithium sp.	1 shell
	Anachis sp.	7 shells
	Bittium sp.	1 shell
	Vermetus sp.	1 shell
	Arca barbata	1 valve
	Chlamys varia	1 valve
	Lima lima	1 valve
	Cardium echinatum	4 live individuals
	Lithophaga lithophaga	6 live individuals
	Pseudochama ferruginea	2 live individuals (Burrowing in rocks)
	Modiolus sp.	1 live individual (Burrowing in rocks)
Bryozoa:		
	Retipora cellulosa	Rare
	Other encrusting Bryozoa	Frequent
Echinodermata:		
	Holothuria sp.	10 juvenile individuals + 30 post larval individuals (Burrowing under rocks)

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TABLE A:2-9

ANALYSES OF BENTHIC TRAWLS

Sample 2, Mex Bight — Date: 13 January 1978

Latitude: 31° 10' 14"

Longitude: 29° 49' 56"

Time: 11 hr. 45m.

Duration of dredging: 4 minutes — Depth: 10 metres

Type of bottom: Sandy rocky bottom

Flora:

Dead roots of *Posidonia* sp.	Very rare

Fauna:

Porifera (sponges)	Very rare
Polychaeta:	
Tubes of tube worms; old tubes on stones and shells:	
Errantia polychaeta sp.	Frequent
Crustacea:	3 Individuals
Pagurus sp.	2 Individuals
Balanus amphitrite	Dead individuals encrusted on stones common
Mollusca:	
Hydrobia sp.	2 live individuals
Natica millepunctata	1 live gastropod
Epidromus reticulata	1 shell
Cerithium sp.	3 shells
Anachis rustica	5 shells (old)
Conus mediterraneus	2 shells (old)
Triphora sp.	1 shell
Glycymeris glycymeris	1 live + 16 valves
Arca noa	1 old valve
Venus verrucosa	1 live + 8 valves

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TABLE A.2-9 (cont'd)

Astarte fusca	3 valves
Cardium tuberculatum	3 valves
Avicula hirundo	2 valves
Ostrea edulis	1 valve
Lucina sp.	10 valves
Donax variegatus	3 valves
Donax sp.	1 live
Tapes castrensis	1 valve
Other lamellibranchs	Frequent

Bryozoa:

Encrusting Bryozoans on shells and stones.

TABLE A.2-10

ANALYSES OF BENTHIC TRAWLS

Sample 3, Mex Bight — Date: 13 January 1978

Latitude: 31° 09' 10"

Longitude: 29° 49' 19"

Duration of dredging: 15 minutes — Depth: 10 metres

Type of bottom: Corals on sandy muddy bottom

Flora:

Dead leaves and roots of posidonia	Rare

Fauna:

Coelenterata:

	Caryophyllia caespitosa	Dominant
Polychaeta:		
	Lepidonotus sp.	3 Individuals
	Cirratulus sp.	1 Individual
	Platynereis sp.	2 Individuals
	Tube worms	Frequent encrusting on the corals
Crustacea:		
	Charybdis longicollis	1 Individual
	Hermit crab	1 Individual
	Balanus amphitrite	18 dead individuals
Mollusca:		
	Vermetus spp .	3 shells
	Cerithium vulgatum	1 shell
	Murex trunculus	1 shell
	Gibbula adansoni	16 shells
	Rossoa spp.	24 shells
	Bullaria striata	1 shell
	Fusus sp.	1 shell
	Calliostoma sp.	10 shells

TABLE A.2-10 (cont'd)

Anachis rustica	2 shells
Conus mediterraneus	1 shell
Ostrea spp.	Common valves attached to the corals
Venus gallina	1 valve
Venus verrucosa	1 valve
Arca noa	2 valves
Arca barbata	1 valve
Cardium edule	1 live + 3 valves
Cardium tuberculatum	2 valves
Loripes lacteus	2 valves
Dosinia sp.	5 valves
Glycymeris sp.	1 valve
Tapes sp.	4 live + 12 valves
Petricola lithophaga	2 valves
Chlamys varia	1 valve

TABLE A.2-11

ANALYSES OF BENTHIC TRAWLS

Sample 4, Mex Bight Date: 13 January 1978

Position: 100 metres directly offshore of chemical company outfall, Mex Bight

Duration of dredging : Not calculated due to the rough bottom

Type of bottom: Pebbles mixed with corals Depth: 5 metres

Flora: No flora at all

Fauna:

Porifera (sponge):		
	Encrusting on stones	Rare
Coelenterata (corals)		
	Cladocryne cespitosa	Common
Polychaeta:		1 Individual
Crustacea:		
	Hermit crab	1 Individual
	Balanus amphitrite	12 dead individuals
Mollusca:		
	Nassarius mutabilis	1 shell
	Anachis rustica	6 shell
	Conus mediterranaeus	1 shell
	Rissoa parva	1 live + 6 shells
	Vermetus spp.	2 shells
	Gibbula nobulosa	2 shells
	Crepidula fornicata	2 shells
	Murex trunculus	1 live + 1 shell
	Cerithium vulgatum	2 shells
	Arca noa	1 valve
	Tapes sp.	1 valve
	Glycymeris sp.	1 valve
	Loripes fragilis	1 valve
	Venus orata	2 valves
	Cardium edule	3 valves

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TABLE A.2-11(cont'd)

	Ostrea cochlea	2 valves
	Ostrea sp.	1 valve
	Irus irus	1 live
Bryozoa:		
	Encrusting :	
	Schizoporella sp.	Rare

TABLE A.2-12

ANALYSES OF BENTHIC TRAWLS

Sample 5, Mex Bight — Date: 13 January 1978

Latitude: 31° 08' 19"

Longitude: 29° 47' 53"

Duration of dredging: 3 minutes

Type of bottom: Sandy mixed with pebbles and shell fragments.

Flora:

Dead roots of	*Posidonia oceanica*	Frequent
	Codium dichotomum	Rare

Fauna:

Polychaeta:		
	Lepidonotus sp.	1 Individual
	Eunice sp.	1 Individual
	Tube worms	Rare
	Other Polychaeta sp.	1 Individual
Crustacea:		
	Hermit crab	35 Individuals
Mollusca:		
	Conus mediterraneus	5 shells
	Nassarius sp.	2 shells
	Euthria sp.	1 shell
	Cerithium rupestre	2 shells
	Anachis rustica	3 shells
	Rissoa sp.	2 shells
	Gibbula sp.	5 shells
	Pseudomurex craticulatus	2 shells
	Dentalium sp.	2 live + 3 shells
	Arcularia gibbosula	24 live + 42 shells
	Venus verrucosa	27 valves
	Venus gallina	2 live + 1 valve
	Cardium edule	4 valves

TABLE A.2-12(cont'd)

Cardium sp.	5 valves
Glycymeris sp.	4 valves
Nucula sp.	1 valve
Loripes lacteus	77 valves
Arca barbata	4 valves
Mytilus sp.	4 valves
Tapes sp.	38 valves
Spisula sp.	2 live
Ostrea spp.	7 valves
Bryozoa:	
Encrusting Bryozoa species	Rare
Echinodermata:	
Fragments of echinoidae.	

TABLE A.2-13

ANALYSES OF BENTHIC TRAWLS

Sample 6, Mex Bight — Date: 13 January 1978

Latitude: 31° 89' 13" — Depth: 10 metres

Longitude: 29° 48' 28"

Duration of dredging : 5 minutes

Type of bottom: Sandy with corals.

Flora: No flora

Fauna:

Coelenterata (corals)		Frequent
Crustacea:		
	Balanus amphitrite	30 dead individuals
	Hermit crab	2 Individuals
Mollusca:		
	Hydrobia ulvae	1 live gastropod
	Aricularia sp.	1 shell
	Natica josephine	3 shells
	Anachis rustica	10 shells + 1 live
	Conus mediterraneus	4 shells
	Capulus sp.	1 shell
	Calliostoma striatum	7 shells
	Monodonta sp.	18 shells
	Rissoa sp.	1 shell
	Cantharidus sp.	3 shells
	Tirivia europaea	1 shell
	Bullaria striata	1 shell
	Roxania blainvillei	1 shell
	Pseudomurex craticulatus	1 live
	Aporrhais pes-pelicani	1 shell
	Nassarius alexandrina	2 shells
	Vermetus gigas	1 shell
	Dentalium sp.	1 shell
	Glycymeris glycymeris	2 live + 4 valves
	Venus striatula	1 live

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TABLE A.2-13(cont'd)

Calverti donax variegatus var.	7 live + 2 valves
Loripes lacteus	71 valves
Gari depressa	2 valves
Dosinia exoleta	1 valve
Nucula hanleyi	5 valves
Venus ovata	1 valve
Arca barbata	6 valves
Arca noa	3 valves
Mytilus edulis	2 valves
Modiolus barbatus	1 vale
Chlamys varia	3 valves
Lima lima	2 valves
Cardium edule	1 valve
Cardium sp.	1 valve

Broyozoa:

Retepora cellulosa	Rare
Membranipora sp.	Rare
Other encrusting Bryzoa	Frequent

TABLE A.2-14

ANALYSES OF BENTHIC TRAWLS

Sample 1, Abu Kir Bay — Date: 31 January 1978

Latitude: 31° 16' 52"

Longitude: 30° 7' 13"

Duration of dredging: 8 minutes — Depth: 6 metres

Type of bottom: Sandy mud mixed with plants.

N.B. Only 1/2 of the sample was examined.

Flora:

Green algae:		
	Caulerpa prolifera	Dominant

Fauna:

Polychaeta:		
	Hydroides sp.	Rare
	Eunice sp.	One Individual
Crustacea:		
	Charybdis hellerii	3 Individuals
	Eucrate crenata	One Individual
Mollusca:		
	Rossoa sp.	40 Shells
	Nassarius sp.	40 Shells
	Cerithium sp.	8 Shells
	Dentalium sp.	8 Shells
	Tellina sp.	1800 Valves
	Glycymeris glycymeris	16 Valves
	Venus gallina	16 Valves
	Modiolus barbata	44 Valves
	Tapes spp.	74 Valves
	Loripes sp.	1150 Valves + 24 alive
	Cardium edule	48 Valves
	Nucula sp.	40 Valves + 8 alive
	Corbula sp.	24 Valves
	Donax sp.	24 Valves

TABLE A.2-15

ANALYSES OF BENTHIC TRAWLS

Sample 2, Abu Kir Bay — Date: 18 February 1978

Latitude: 31° 17' 43"

Longitude: 30° 9' 45"

Duration of dredging: 25 minutes — Depth: 6 metres

Type of bottom: Sandy covered with plants.

Flora:	Green algae:	
	Caulerpa prolifera	Dominant
Fauna:		
	Porifera (Sponge):	Rare
	Coelenterata:	
	Obelia geniculata	Dominant (Attached to Caulerpa leaves)
	Polychaeta:	
	Hydroides sp.	Rare
	Crustacea:	
	Balanus eburneus	One Individual
	Mollusca:	
	Nassarius reticulata	One shell
	Nassarius mutabilis	One shell + 1 alive
	Glycymeris glycymeris	12 Valves
	Modiolus sp.	34 Valves
	Ensis sp.	2 Valves
	Spisula glauca	14 Valves
	Venus gallina	One Valve
	Arca antiqua	One valve
	Cardium edule	8 Valves
	Aricula hirundo	One Valve
	Tellina tenuis	450 Valves
	Anomia sp.	2 Valves

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TABLE A.2-15 (cont'd)

Bryozoa:	
Bugula neritina	2 Colonies
Membranipora membranacea	Few Colonies (Encrusting on Caulerpa)
Ascidians:	
Distomus sp.	Rare (On Caulerpa leaves)

TABLE A.2-16

ANALYSES OF BENTHIC TRAWLS

Sample 3, Abu Kir Bay — Date: 18 February 1978

Latitude: 31° 19' 00"

Longitude: 30° 10' 29"

Duration of dredging: 10 minutes — Depth: 10 metres

Type of bottom: Sandy

Flora:

Green algae:		
	Caulerpa prolifera	Few
Fauna: Coelenterata:		
	Obelia geniculata	Frequent (Attached to caulerpa leaves)
Polychaeta:		One Individual
Crustacea:		
	Hermit crab	One Individual
Mollusca:		
	Nassarius sp.	One shell + 4 alive
	Glycymeris glycymeris	80 Individuals
	Tellina sp.	225 Valves
	Arca antiqua	19 Valves
	Modiolus sp.	8 Valves
	Spisula corpallina	5 Valves
	Loripes sp.	One Valve
	Tapes sp.	9 Valves
	Venus striatula	12 Valves + one alive
	Ensis sp.	3 Valves
	Donax spp.	26 Valves + 3 alive
	Ostrea sp.	2 Valves
Echinodermata:		
	Astropecten sp.	2 Individuals

TABLE A.2-17

ANALYSES OF BENTHIC TRAWLS

Sample 4, Abu Kir Bay — Date: 18 February 1978

Latitude: 31° 19' 19"

Longitude: 30° 7' 46"

Duration of dredging: 2 minutes — Depth: 6 metres

Type of bottom: Sandy

Flora:

Green algae:		
	Caulerpa prolifera	Rare

Fauna:

Coelentrata:		
	Obelia geniculata	Few
	Caryophyllia caespitosa	Rare
Polychaeta:		
	Hyroides sp.	Rare
	Other Polychaeta	One Individual
Crustacea:		
	Balanus amph trite	One Individual
	Crangon sp.	One Individual
Mollusca:		
	Arcularia gibbosula	3 Shells
	Anachis rustica	2 Shells
	Conus mediterraneus	4 Shells
	Triphora sp.	2 Shells
	Dentalium sp.	One Shell
	Tellina sp.	2 Valves
	Chlamys varia	2 Valves
	Tapes sp.	One Valve
	Glycymeris glycymeris	227 Valves
	Dosinia sp.	11 Valves
	Venus gallina	20 Valves

TABLE A.2-17(cont'd)

Lucinoma sp.	10 Valves
Corpula sp.	4 Valves
Donax spp.	145 Valves + 5 alive
Ensis sp.	One Valve
Modiolus sp.	5 Valves
Arca sp.	One Valve
Cardium edule	10 Valves
Tellina nitida	4 Valves
Avicula sp.	One Valve
Ostrea sp.	4 Valves
Spisula stultorum	One Valve
Eggs of *Sepia* sp.	5 Eggs

TABLE A.2-18

ANALYSES OF BENTHIC TRAWLS

Sample 5, Abu Kir Bay — Date: 18 February 1978

Latitude: 31° 16' 48"

Longitude: 30° 6' 32"

Duration of dredging: 3 minutes — Depth: 5 metres

Type of bottom: Sandy mixed with pebble

Flora:

Red Algae:		
	Lithothamnion sp.	Rare

Fauna:

Coelentrata:		
	Caryophyllia sp.	Rare
Polychaeta:		One Individual
Crustacea:		
	Hermit crab	2 Individuals
Mollusca:		
	Conus mediterraneus	50 Shells
	Nassarius sp.	2 Shells
	Anachis rustica	3 Shells
	Rissoa sp.	200 Shells
	Cerithium sp.	3 Shells
	Hydrobia sp.	2 Shells
	Bulla striata	One Shell
	Glycymeris glycymeris	147 Valves
	Venus gallina	33 Valves + 2 alive
	Cardium edule	29 Valves
	Cardium nodosum	One alive
	Venus verrucosa	4 Valves
	Venus cassina	One Valve
	Loripes sp.	3 Valves
	Dosinia sp.	3 Valves
	Nucula sulcata	29 Valves

TABLE A.2-18(cont'd)

Corbula sp.	4 Valves
Arca barbata	9 Valves
Donax spp.	54 Valves
Ostrea sp.	16 Valves
Spisula sp.	2 Valves
Chlamys varia	One Valve
Tellina nitida	7 Valves
Modiolus sp.	5 Valves

TABLE A.2-19

ANALYSES OF BENTHIC TRAWLS

Sample 6, Abu Kir Bay. Date: 18 February 1978

Latitude: 31° 18' 17"

Longitude: 30° 6' 48"

Duration of deredging: 2 minutes Depth: 5 metres

Type of bottom: Muddy mixed with rocks and plants

Flora:

Green algae:

Caulerpa prolifera	Dominant

Fauna:

Porifera (Sponge):	Rare
Crustacea:	
Macropipus depurator	One Individual
Mollusca:	
Rossoa sp.	4 Shells
Nassarius nitida	One Shell
Hydrobia sp.	One Shell
Bullaria sp.	8 Shells
Glycymeris glycymeris	One Valve
Loripes sp.	700 Valves + 25 alive
Cardium edule	16 Valves
Modiolus sp.	52 Valves
Tellina sp.	190 Valves + 8 alive
Venus ovata	4 alive
Venus sp.	16 Valves

TABLE A.2-20

ANALYSES OF BENTHIC GRAB SAMPLES

Mex Bight
Sample 1

Date: 13 January 1978

Latitude: 31° 10' 46"

Longitude: 29° 48' 45"

Area of Grab: 200 cm^2

Depth: 27 Metres

Type of bottom: Coarse Sand

Flora : Nil

Fauna:

Polychaeta:		1	Individual
Mollusca:			
	Nucula sp.	1	valve
	Cardium edule	1	valve
	Lima Lima	1	valve
	Modiolus sp.	1	valve
	Other bivalvia	10	valves
	Cerithium spp.	9	Shells
Echinodermata:			
	Echinoidae	A piece of an individual	

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TABLE A.2-21

ANALYSES OF BENTHIC GRAB SAMPLES

Mex Bight
Sample 2

Date: 13 January 1978

Latitude: 31° 10' 14"

Longitude: 29° 49' 46"

Area of Grab: 924 cm^2

Depth: 10 Metres

Type of bottom: Sandy, rocky.

Flora: Nil

Fauna:

Polychaeta:			
	Tube worms	32	Individuals
Crustacea:			
	Balanus amphitrite		Fragment
	Hermit Crab	3	Crabs
Mollusca:			
	Cerithium sp.	3	shells
	Triphora sp.	11	shells
	Gibbula sp.	2	shells
	Crepidula sp.	1	shell
	Conus sp	2	shells
	Tricolia sp.	6	shells
	Other shells	4	shells
	Glycymeris sp.	9	valves
	Corculum sp.	4	valves
	Donax spp.	5	valves+1 alive
	Modiolus sp.	1	valve
	Ostrea sp.	2	valves
	Venus gallina	6	valves
	Loripes sp.	2	valves
	Lucina sp.	2	valves
	Astarte sp.	1	valve
	Nucula sp.	2	valves
Bryozoa:			
	Retepora sp.		Rare
	Cryptosula sp.		Rare
Echinodermata:			
	Echinoid sp.		Fragment

TABLE A.2-22

ANALYSES OF BENTHIC GRAB SAMPLES

Mex Bight
Sample, 3 — Date: 13 January 1978

Latitude: 31° 09' 10"

Longitude: 29° 49' 19"

Area of Grab: 924 cm^2 — Depth: 10 Metres

Type of bottom: Sandy muddy

Flora: Nil

Fauna:

Crustacea:			
	Amphipoda sp.	1	Individual
	Brachyura sp.	1	chaela
Mollusca:			
	Tricolia sp.	9	shells
	Crepidula sp.	5	shells
	Strombiformis sp.	3	shells
	Melanella sp.	1	shell
	Turbonilla sp.	7	shells
	Conus sp.	2	shells
	Philippia Mediterranea	2	shells
	Other shells	50	shells
	Corculum sp.	4	valves
	Cardium sp.	1	valve
	Venerupis sp.	2	valves
	Nucula sp.	1	valve
	Corbula sp.	2	valves
	Other lamellibranchs	10	valves

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TABLE A.2-23

ANALYSES OF BENTHIC GRAB SAMPLES

Mex Bight
Sample 4 Date: 13 January 1978

Position: 100 metres directly offshore of chemical company outfall, Mex Bight

Area of Grab: 200 cm^2 Depth: 5 metres

Type of bottom: Pebbles mixed with corals.

Flora: Nil

Fauna: Coelenterata (corals)

TABLE A.2-24

ANALYSES OF BENTHIC GRAB SAMPLES

Hex Bight
Sample 5

Date: 13 January 1978

Latitude: 31° 08' 19"

Longitude: 29° 47' 53"

Area of Grab: 200 cm^2

Depth: 5 metres

Type of bottom: Sandy mixed with pebbles and shell fragments

Flora: Nil

Fauna:

Polychaeta:

Tube worms	4	Tubes

Mollusca:

Rossoa spp.	7	shells
Raphitoma sp.	1	shell
Bittium sp.	26	shells
Loripes sp.	14	valves
Laevicardium sp.	2	valves
Nucula sp.	1	valve
Leda sp.	1	valve
Corculum sp.	1	valve
Chlamys varia	1	valve
Lutraria sp.	1	valve

TABLE A.2-25

ANALYSES OF BENTHIC GRAB SAMPLES

Mex Bight
Sample 6

Date: 13 January 1978

Latitude: 31° 89' 13"

Longitude: 29° 48' 28"

Area of Grab: 200 cm^2

Depth: 10 metres

Type of bottom: Sandy

Flora: Nil

Fauna:

Mollusca

Cerithium sp.	2	shells
Raphitoma sp.	1	shell
Rossoa sp.	1	shell

SECTION A.3

COMMENTS ON FISH SPECIES PRESENT IN THE COMMERCIAL CATCH

A. Bony Fish

Sparidae. In Alexandria waters, there are 17 species of Sparidae. Pagrus, Pagellus, Diplodus and Sparus were the most dominant genera in the catch. Other sparid fish appeared in smaller quantities and were sold together with other fish species of minor abundance appearing in the catch. Sparid fish landed in Eastern Harbor represented 21.0 percent of the total fish landed, while in Abu Kir, they represented 5.70 percent of the total fish landed. In the Maadiya area, they represented 10.26 percent of the landed fish. Although sparid fish represent a small percentage of the catch, they represent the greatest variety of fish species, and they are highly esteemed as fish food. The Sparid fish species netted were the following:

Boops boops was highly abundant in the Eastern Harbor fish market as well as in Abu Kir, while in Maadiya fish market, they were rare. They are most frequent in April and May.

Boops salpa are more frequent in the Eastern Harbor and in Abu Kir Bay than in the Maadiya area. They are most abundant in January, February and March.

Charax puntazzo were observed in Eastern Harbor only. They were poorly represented in the catch.

Dentex dentex were observed in Eastern Harbor and Maadiya areas, most frequently in March. In Abu Kir, they were noted only in March.

Dentex macrophthalmes were represented by few individuals in Abu Kir fish market and Maadiya fish market. They were most apparent in February, March and September.

Diplodus annularis were more abundant in Eastern Harbor than in the other areas. They were most frequent in February, March and April.

Diplodus sargus were more abundant in the catch of Eastern Harbor. In Abu Kir, they were most frequent in March and April. The genus Diplodus constituted 1.83 percent of the fish landed in the Eastern Harbor while in Abu Kir they were 2.23 percent of the landed fish. 28782 kg of Diplodus spp. were landed in a year in Abu Kir Bay, while in Eastern Harbor, the weight of Diplodus landed was 41738 kg in a year.

Oblada melanura were not observed in Eastern Harbor, while in Abu Kir, only a few individuals were noted in the catch in different months. They were most frequent in February. In Maadiya this species was also frequent.

Pagellus acarne were not recorded in Alexandria waters in the present survey, although they have been observed in the past (S. Clofnam, UNESCO 1973).

Pagellus erythrinus were present in small nunbers in the catch, in Abu Kir Bay and Eastern Harbor. None were seen in Maadiyu.

Pagellus mormyrus were frequently seen among the fish landed in Eastern Harbor, most frequently in January. In Abu Kir Bay they were most abundant in June, while in Maadiya area they appeared in late autumn and winter.

Pagrus ehrenbergi were observed in small quantities in Eastern Harbor especially in the months of January and February. In Abu Kir Bay they were observed only in January in appreciable quantities. In the Maadiya area, this species was not observed.

Pagrus spinifer were noted in Eastern Harbor in October and November. In Abu Kir, few individuals were observed in September and November. In Maadiya, few individuals were noted in the month of March.

Pagrus vulgaris is the most abundant species of Sparidae in Alexandria waters. In Eastern Harbor, the genus Pagrus represented 7.73 percent of the fish landed (176405 kg per year), while in Abu Kir Bay they represented, 1.12 percent of the fish landed (14 412 kg). This species was abundant in Eastern Harbor fish market throughout the year. In Abu Kir Bay they were also highly abundant. In Maadiya area, they were less frequent.

Sparus auratus is one of the dominant species of sparid fish in the Alexandria waters. They constituted 2.355 percent (30 350 kg) of the catch in Abu Kir Bay, while in Eastern Harbor they constitute about 0.886 percent of the catch (20 217 kg per year).

Mugilidae. From the Mugilidae, two species were observed. They were Mugil cephalus and Mugil capito. The first species was more dominant than the second. Mugil cephalus was most abundant in the catch during winter time.

Atherinidae. Of this family, the species present was Atherina boyeri. It was most abundant in Eastern Harbor in the winter while in Abu Kir Bay and Maadiya, they were most abundant during early summer. They represented about 2 percent of the commercial catch in Maadiya.

Angullidae. The family Anguillidae was represented by Anguilla vulgaris. It was present in the three fish markets and was most abundant in April.

Scombridae. There were four species of this family that appeared in the fish landed. They were: Auxis bisus, Sarda sarda, Scomber scombrus, and Euthynnus pelamis. Sarda sarda was noted in Eastern Harbor in the month of January, while Scomber scombrus was most frequent in May and

June. The other two species were most abundant in winter. Auxis bisus was not noted in Abu Kir Bay. Sarda sarda was noted in Maadiya, except in August. Scomber scombrus was not found in Maadiya, nor was Auxis bisus.

Clupeidae. From this family two species were abundant, Clupea aurita (Sardinella aurita) and Sardinella pilchardus. Clupeidae were the most abundant fish in the three markets. In Eastern Harbor they represented 34 percent of the fish landed and in Abu Kir Kay, they represented 44.49 percent of the catch. They were most abundant in winter and spring. In Maadiya they represented 9 percent of the commercial catch.

Mullidae. From this family two species were present: Mullus barbatus and Mullus surmuletus. They were nearly equally abundant. Mullus spp. represented 10.5 percent of the total fish landed in Eastern Harbor (238 599 kg), while in Abu Kir they represented 3.86 percent (49 711 kg). They were more abundant in Eastern Harbor than in the other two markets. They were most abundant in late summer and early winter. In Maadiya they represented 5.54 percent of the landed fish.

Serranidae. Seven species belonging to this family were present in the commercial catch for Alexandria waters. They were Ephinephelus alexandrinus, Epinephelus guaza, Epinephelus aenus, Serranus cabrilla, Serranus scriba, Morone labrax, and Morone punctata. Serranidae represented about 3.14 percent (72 587 kg) of the total fish catch in Eastern Harbor, while in Abu Kir Bay they represent 4.16 percent (53 750 kg). They were most abundant in Eastern Harbor. Epinephelus were most abundant in summer, whereas, Morone were most abundant in winter. In Maadiya Morone represented 2.15 percent of the catch.

Synodontidae. There were two species netted from this family. These were Saurus atlanticus and Saurida undosquamis. They represented 0.886 percent (20,217 kg) of the fish landed in Eastern Harbor.

In Abu Kir Kay, they represented 1.78 percent of the catch (22 944 kg), and thus more are abundant in Abu Kir Bay. Saurida was not observed in the Abu Kir Bay catch nor in the Maadiya catch. Saurus was poorly represented in Maadiya, while it constituted the whole catch of Synodontidae in Abu Kir Bay.

In Eastern Harbor, Saurida was more abundant than Saurus.

Sciaenidae. Three species belonging to this family were found in the fish landings: Corvina nigra, Umbrina cirrosa and Sciaena acquilla. The last species formed the major part of the catch of Sciaenidae. Sciaena represetned 2.42 percent (55 221 kg) percent of the total catch in Eastern Harbor while in Abur Kir Bay they represented 0.75 percent (9686 kg), and in Maadiya 3.04 percent of the catch. Corvina nigra was more abundant in Eastern Harbor in March but in Abu Kir Bay it was present in fewer numbers. In Maadiya, Corvina was not observed. Umbrina cirrosa was not observed in Maadiya nor in Abu Kir Bay, while in Eastern Harbor Umbrina was observed to most frequent in January, February and March.

Solidae. The family Solidae was represented in the catch by Solea vulgaris aegyptiaca. Solea represented 4.25 percent (96,976 kg) of the fish catch in EAstern Harbor and in Abu Kir Bay 1.11 percent (29 147 kg) of the total catch. In Maadiya they were most abundant in winter: November, December and January. They represented 6.11 percent of the catch.

Pomatidae. The only species found belonging to this family was Temnodon saltator. It represnted 2.18 percent (49,846 kg) of the fish landed, while in Abu Kir Bay, it represented 0.63 percent (8127 kg). This species was found to be most frequent in November, December, April and May. In Maadiya, this species represented 5.4 percent of the catch.

Carangidae. Of this family 4 species were present in Alexandria waters, including: Caranx crysos, Lichia glauca, Trachurus trachurus and Trachurus picturatus. Trachurus and Lichia represented 0.61 percent of the total catch in Eastern Harbor. Caranx was mostly caught in December, Lichia appeared most frequently in June, while Trachurus was most abundant in February. This was true for all three areas studied. Lichia, however, was observed only in November, in the Maadiya fish market.

The above families were the most abundant bony fish in the commercial catch in Alexandria. Other fish species were noted but they were less abundant

than the above species. These are represented in Table 1.

B. Cartilagenous Fish

These represented 0.55 percent (12,586 kg) of the fish landed in Eastern Harbor, while in Abu Kir Bay and Maadiya Cartilagenous fish were less abundant. Cartilagenous fish present in the catches belonged to the following genera: Acanthias, Mustelus, Myliobatus, Raja, Rhinobatus, Scyllium, Squatina, Torpedo and Trygon.

Acanthias was abundant in good quantities in Eastern Harbor, present in November and December in Abu Kir Bay but was not present in Maadiya.

Mustelus was present in all months of investigation in good amounts. It was absent from Abu Kir Bay and Maadiya.

Myliobatus can reach very large sizes especially in Abu Kir Bay. This species was most abundant during November, December, April and May.

Raja was the most abundant cartilagenous fish throughout the year in all three areas.

Rhinobarus was also one of the most abundant cartilagenous fish throughout the whole period of investigation. In Maadiya this species was observed for a few months only and in very small numbers.

Scyllium was of very low abundance and was observed in February, March and April in Eastern Harbor, while in Abu Kir, it was noted in May and July only. In Maadiya this genus was not observed in the commercial catch.

Squatina was observed in Eastern Harbor, and was most abundant in January and February. Neither in Abu Kir nor in Maadiya was it observed.

Torpedo was most abundant in winter in Eastern Harbor and Abu Kir Bay. In Maadiya it was abundant during most months investigated, representing 3.31 percent of the catch.

Trygon was most abundant in winter in Eastern Harbor and Abu Kir Bay. In Maadiya it was observed in late autumn and early winter.

C. Cephalopoda.

To this family belonged one species Sepia officinalis found in the fish landed. This represented 3.09 percent (39 861 kg) of the catch in Abu Kir, while in Eastern Harbor it represented 4.6 percent (104,346 kg) of the catch. This species was most abundant in January and February. Sepia was abundant in late autumn, winter and early spring.

D. Crustacea.

Crustacea: Crabs. Crabs present in the fish market belonged to about 3 species. They were present throughout the period of investigation. They were most frequently observed from September to November. They were more abundant in Maadiya fish market and constituted about 6 percent of the landed fish catch. In Abu Kir Bay, crabs represent 0.87 percent and in Eastern Harbor they represent 0.06 percent of the fish landed. The most abundant crab species in Alexandria waters was Portunus pelagicus and to a lesser extent Carcinas mediterraneus and Callinectes sapidus. It should be noted that Portunus pelagicus is an indo-pacific immigrant, and Callinectes sapidus is of Atlantic origin.

Penaeidae. Several species of shrimp were present in Egyptian Mediterranean waters. They were: Penaeus japonicus, Penaeus semisulcatus, Penaeus trisulcatus, Penaeus kerathurus, Metapenaeus monoceros, Metapenaeus stebbingi, Para-penaeus longirostris, Trachypenaeus curvirostris, Solenocera indica, Solenocera membranacia and Sicyonia corinata. Of these species, P. kerathurus, P. semisulcata, and P. japonicus were most abundant in the commercial catch. Shrimp were present in good quantities throughout the whole period of inves-

tigation. Pennaeidae were more abundant in Maadiya than in the other two fish markets. In Maadiya, shrimp constituted 30.8 percent of the landed fish, in Eastern Harbor 3.5 percent, and in Abu Kir Bay 5.74 percent of the catch.

Palinurus. A few individuals of this family were often present in Abu Kir fish market. They were most abundant in the month of May.

It should be noted that in the years since the construction of the Aswan High Dam in 1966, the catch of shrimp and crabs has decreased drastically. This is attributed to the decreased discharge of Nile water directly into the Mediterranean Sea, a condition which has greatly affected organic production in the southeastern Mediterranean. It should also be mentioned that crabs and shrimp have been in high demand, and have been intensively fished.

E. Chelonia.

Chelonia represented 0.149 percent (3408 kg) of the commercial catch in Eastern Harbor. This family was not observed in Abu Kir Bay. In Maadiya it was of minor importance and was observed only in February.

TABLE A.3-1

GLOSSARY OF FISH LANDED IN THE ALEXANDRIA FISH MARKETS

Latin Name	Commom Egyptian Name	Common English Name
Sparidae		
Boops boops	Moza	Bogue
Boops salpa	Sarb	Salema
Charax puntazzo	Teis	Puntazzo
Dentex dentex	Addad	Common dentex
Dentex gibbosus	Addad Abu Koura	Pink dentex
Dentex macrophthalmes	Addad Abu Ein	Large eye dentex
Diplodus annularis (Sargus annularis)	Sabaris	Sea bream
Diplodus sargus (sargus sargus)	Sharghoush	White sea bream
Oblada melanura	Botet	Saddled bream
Pagellus acarne	Ghozailla bronzia	Axillary bream
Pagellus erythrinus	Ghozailla	Pandora
Pagellus mormyrus	Mormar	Pandora
Pagrus ehrenbergi	Gorgar	Common sea bream
Pagrus spinefer	Maleka	Sea bream
Pagrus pagrus	Morgan horr	Common sea bream
Sparus auratus (Chrysophrys auratus)	Denis	Gilt-head sea bream
Mugilidae		
Mugil capito	Tobar	Mullet
Mugil cephalus	Bouri	Common mullet

TABLE A.3-1
(continued)

GLOSSARY OF FISH LANDED IN THE ALEXANDRIA FISH MARKETS

Latin Name	Common Egyptian Name	Common English Name
Atherinidae		
Atherina boyeri	Bessaria	Boyer's sand smelt (silversideo)
Anguillidae		
Anguilla vilgaris	Teeban el Bahr	Eel
Scombridae		
Auxi thazard	Balamita souda	Frigate mackerel
Euthynnus pelamis	Balamita beida	Skipjack tuna
Sarda sarda	Balamita	Atlantic bonito
Scomber scombrus	Kaskomri	Atlantic mackerel
Clupeidae		
Sardinella aurita	Sardine mabroum	Spanish sardine
Sardina pilchardus	Sardine	Pilchard
Balistidae		
Balistes spp.	Khanzir	Trigger fish
Monacanthidae		
Monacanthus spp.	Khanzir beshouka	File fish
Sciaenidae		
Corvina nigra	Khenena	Brown maegre
Sciaena aquila	Loot	Maegre
Umbrina cirrosa	Shifsh	Corb
Dactylopteridae		
Dactylopterus pirapeda	Tayyara	Flying gurnard

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TABLE A.3-1
(continued)

GLOSSARY OF FISH LANDED IN THE ALEXANDRIA FISH MARKETS

Latin Name	Common Egyptian Name	Common English Name
Triglidae		
Trigla lucerna	Farkha	Yellow gurnard
Trigla lyra	Farkha	Piper
Aspitrigla cuculus	Farkha	Red gurnard
Echeneididae		
Echeneis naucrates	Amlet el darfeel	Shark sucker
Serranidae		
Epinephelus aenus	Wakar	White grouper
Epinephelus alexandrinus	Wakar	Golden grouper
Epinephelus guaza	Wakar	Dusky grouper
Dicentrarchus labrax	Karous	Sea bass
Dicentrarchus punctata	Nokt	Sea bass
Serranus cabrilla	Korfossa	Comber
Serranus scriba	Sheikh	Painted comber
Exocoetidae		
Exocoetus volitans	Tayyara	Flying fish
Gobiidae		
Gobius spp.	Abu-Kirsh	Goby
Holocentridae		
Plectrypops retrospinis	Sandook	Cardinal soldierfish
Labridae		
Coris julis	Aroussa	Rainbow wrasse
Labrus viridis (Labrus turdus)	Khoddair	Brown wrasse
Xrichtys novacula	Aroussa	Cleaver wrasse

TABLE A.3-1
(continued)

GLOSSARY OF FISH LANDED IN THE ALEXANDRIA FISH MARKETS

Latin Name	Common Egyptian Name	Common English Name
Bramidae		
Legidotus catalonicus	-	Ray's sea bream
Merluccidae		
Merluccius merluccius	Nazelli	Hake
Carangidae		
Caranx crysos	Bagha	Yellow jack
Trachynotus ovatus	Ghalanfish	Derbio
Trachurus picturatus	Shakhoura	Blue scad
Trachurus trachurus	Shakhoura	Atlantic horse mackerel
Mullidae		
Mullus barbatus	Barbouni el hagar	Striped mullet
Mullus surmuletus	Barbouni	Red mullet
Muraenidae		
Muraena helena	Taeban el bahr el sam	Moray
Platycephalidae		
Platycephalus indicus	Rakkad	-
Synodontidae		
Saurida undosquamis	Hareth	Lizard fish
Saurus atlanticus	Mokarouna	Lizard fish
Soleidae		
Solea impar	Samak moussa	Sole
Solea ocellata	Samak moussa	Eyed sole
Solea solea aegyptiaca	Samak moussa	Sole

TABLE A.3-1
(continued)

GLOSSARY OF FISH LANDED IN THE ALEXANDRIA FISH MARKETS

Latin Name	Common Egyptian Name	Common English Name
Siganidae		
Teuthis sigana	Sigan batata	Morbid spine foot
Pomatomidae		
Pomatomus saltatrix	Miass	Blue fish
Trachinidae		
Trachinus draco	Ballama	Greater weever
Trichiuridae		
Lepidopus caudatus	Seif	Scabbard fish
Trichiurus lepturus	Seif	Hairtail
Sphyraenidae		
Sphyraena sphyraena	Abu-Meghzal	Barracuda
Uranoscopidae		
Uranoscopus scaber	Kott	Stargazer
Lophiidae		
Lophius piscatorius		
Zeidae		
Seus faber	Afreet	John dory
Bleniidae		
Blennius spp.	Blenny	Blenny
Lutjanidae		
Lutjanus spp.	-	Snapper
Scorpaenidae		
Scorpaena spp.	Akrab	Large-scaled scorpion fish

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TABLE A.3-1
(continued)

GLOSSARY OF FISH LANDED IN THE ALEXANDRIA FISH MARKETS

Latin Name	Common Egyptian Name	Common English Name
Scomberesocidae		
Scomberesox sppl	Scombri (Zengari)	Skipper
Belonidae		
Belone bellone	Khirm	Garfish
Stromateidae		
Stromateus flatola	-	-
Cartilagenous Fishes		
Squaulus acanthias	Ersh be-shoka	Spiny dog fish
Mustelus spp.	Mastoula	Smooth dog fish
Myliobatus spp.	Wetwat	Ray
Raja spp.	Raja	Ray
Rhinobatus spp.	Mehrat	Ray
Scyllium canicula	Kalb el-samak	Dog fish
Squatina spp.	Meshkatelli	Angel ray
Torpedo spp.	Raad	Electric ray
Trygon spp.	Bakar	Stingrays
Chelonia spp.	Tersa	Marine turtle
Crustacea		
Carcinus mediterraneus	Kabouria	Mediterranean mud crab
Portunus pelagicus	Kabouria hamra	Mud crabs
Callinectes sapidus	Kabouria zarka	Blue crab
Panulirus vulgaris	Estakoza	Common spiny lobster
Peneaus spp.	Gambari	Prawns
Portunus pelagicus	Kabouria hamra	Crabs

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TABLE A.3-1
(continued)

GLOSSARY OF FISH LANDED IN THE ALEXANDRIA FISH MARKETS

Latin Name	Common Egyptian Name	Common English Name
Cephalopoda		
Sepia officinalis	Sobait	Cuttle fish

SUMMARY OF FISH LANDED IN ORDER OF ABUNDANCE –

LATIN NAMES OF FISH

DATE	SPARIDAE	Boops boops	Boops salpa	Charax puntazzo	Dentex dentex	Dentex gibbosus	Dentex macrophthalmes	Diplodus annularis	Diplodus sargus	Oblada melanura	Pagellus acarne	Pagellus erythrinus	Pagellus mormyrus	Pagrus ehrenbergi	Pagrus spinifer	Pagrus vulgaris	Sparus auratus	MUGILIDAE	Mugil spp	ATHERINIDAE	Atherina [illegible]	ANGUILLIDAE	[illegible] vulgaris	SCOMBRIDAE	Auxis bisus	Euthynnus pelamis	Sarda sarda	Scomber scombrus	CLUPEIDAE	Sardinella spp	BALISTIDAE
AUGUST 1977																															
Summary	3	6					5	4			7					21		8								20			13		
SEPTEMBER 1977																															
Summary																											1				
OCTOBER 1977																															
Summary														1																	
NOVEMBER 1977																															
3 Nov. 77								8						0	2	3		5						12	12				4		
5 Nov. 77	16	13		0			14	8							3	10		9				20		12					1		22
8 Nov. 77		13		0			15	4			14		0		2	5		12							17				7		
15 Nov. 77	15	16	0					6				7	0		3	8		12		0				21	21		22		1		0
20 Nov. 77	12	10	8				11	7							2	6		5				27			14						
23 Nov. 77	11	3		0			13	5			2				2	6				22		0		9	9						
29 Nov. 77	15							11			3	24			3	4		6		17		29					21		1		
Summary	2	2		0			3	3			6			0	4	5		8		0		0		13	14		0		7		0
DECEMBER 1977																															
1 Dec. 77	6	8		2				7			2		0		2	5						19									
5 Dec. 77	11							7			3				2	4				14									1		0
8 Dec. 77			8								2				3	7				0				15	16				5		
15 Dec. 77	9						11	7			5		25		4	6		2									19		1		
18 Dec. 77			8				7	10					14		3	9		5							0				1		0
22 Dec. 77	11	18	13					5			4		10		3	17		12				29		22	23				1		
25 Dec. 77				5			14	6			4	13			3	11						16							1		0
29 Dec. 77			7					8			3	9	0		2	6		4											1		0
Summary	25	27	16	22				6			11		20		1	5		15		37		34		30	31		36		3		0
JANUARY 1978																															
2 Jan. 78		7	20					9			2	21	8		3	6		5				11		17	16	0					0
6 Jan. 78								11			2	10			3	12				0											
11 Jan. 78		11						5			6	4	13					17				0		20	21						0
15 Jan. 78	7	4	29					8					5		6	9		20						23		14					
18 Jan. 78	7	5		0			14	10			9	6		0	8									22		17			15		
21 Jan. 78		8	7					6			5	14			4			15						24		20					
25 Jan. 78	7	5		11							8	6	9		10	13		19		0		0		23							
29 Jan. 78	2	11	0	0							4	17	5		6	12		14													28
Summary	13	7	0	1				10			4	15	5		6	12		18		0		24		0	0	0					0
FEBRUARY 1978																															
1 Feb. 78	8			5				9			4	15	6		3	10								21					1		
6 Feb. 78	8			5			18	7			3				4	17		19		0		27		21	22						0
12 Feb. 78	7		0	0			11	4			6				5	10		17								0			12		
16 Feb. 78	7			5				8			6	10	4		3			11						0							
19 Feb. 78	2							4			6					7						22		23	24		19				0
22 Feb. 78	7						19	6				20	5		4	18		14				26									28
25 Feb. 78	7						6	5			2		3		4	17								19	20						
29 Feb. 78	6							5			3	7				15				0				19							
Summary	4							3			9				16	10		15						19							

DATE	Balistes spp	MONACANTHIDAE	Monacanthus spp	SCIAENIDAE	Corvina nigra	Sciaena aquila	Umbrina cirrosa	CEPHALACANTHIDAE	Dactylopterus propedo	TRIGLIDAE	Trigla spp	ECHENEIDIDAE	Echeneis naucrates	SERRANIDAE	Epinephelus spp	Morone spp	Serranus spp	EXOCOETIDAE	Exocoetus volitans	GOBIIDAE	Gobius spp	HOLOCENTRIDAE	Holocentrus ruber	LABRIDAE	Julis vulgaris	Labrus viridis	Xrichthys novacula	BRAMIDAE	Lepidopus caudatus	GADIDAE	Me[illegible]	CA[illegible]
AUGUST 1977																																
Summary		0		0	0					14		0		11	18	10						0		0								
SEPTEMBER 1977																																
Summary								7				6										4		3	2	9						
OCTOBER 1977																																
Summary						5																										
NOVEMBER 1977																																
3 Nov. 77				0		0				16					7					0		0			0					9		
5 Nov. 77		22								19				5	7	6						0		0		0						
8 Nov. 77					16	0				19				11	23	24				0				0						8		
15 Nov. 77						0		0		11		27		14	9							0		0						18		
20 Nov. 77					9	0		29		21		0			4					0				0		26				17		
23 Nov. 77					7	0				18					4	14								0	17					10		
29 Nov. 77		0			14	0				22		0		9	7	10				0				0	0					12		
Summary		0		0	15	0				0		0		11	10	0				0		0		0	0	0				12		
DECEMBER 1977																																
1 Dec. 77					16	0				14				9	4	0														12		
5 Dec. 77														9	8	12						0		0		0				6		
8 Dec. 77						0				4		0		10										0	0					14		
15 Dec. 77		0			16					23				13	10			0				0			0	0				4		
18 Dec. 77					6					12												0			0	17				18		
22 Dec. 77		25		19						24				20	6	21														7		
25 Dec. 77				23						21				25	10	24						0			0					12		
29 Dec. 77										13				5								0		0	0	0						
Summary		0		26	18					10		0		7	24	28						0		0	0	21				8		
JANUARY 1978																																
2 Jan. 78				0	10			0																						18		
6 Jan. 78										7												0			17	0				5		
11 Jan. 78					15									19		18		0						0						9		
15 Jan. 78				17	16	25				18					27	21						28		0	0					10		
18 Jan. 78					19	18		0				0								0										11		
21 Jan. 78					13	21									19	12		0				0		0	0					9		
25 Jan. 78					20	16				15				21		22						0		0		0				3		
29 Jan. 78				20	19	18								21		22									0					10		
Summary					19	0		0		16				0		17						0			0	0				3		
FEBRUARY 1978																																
1 Feb. 78					20	0				18						14									0	0				12		
6 Feb. 78					16					13		0		14		15						0			0					11		
12 Feb. 78					16	0				19				13		14				0					0					8		
16 Feb. 78				0						16				0																12		
19 Feb. 78				16		0				12				15	25	17						27				0				8		
22 Feb. 78				11	10	27				17		0		9				0				0		0	0					12		
25 Feb. 78				15	16	21								13		14		0				0		0	0					10		
29 Feb. 78					14									11	13	8		0				0		0	22					17		
Summary					12					18		0		13	19	14		0				0		0		0				6		

1,2,3,... Order of Abundance   O- Other Fish

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TABLE A.3-2

NCE – EASTERN HARBOR

Labrus viridis	Xyrichthys novacula	BRAMIDAE	Lepidolus catalonicus	GADIDAE	Merluccius merluccius	CARANGIDAE	Caranx crysos	Lichia glauca	Trachurus spp	MULLIDAE	Mullus spp	MURAENIDAE	Muraena helena	PLATYCEPHALIDAE	Platycephalus indicus	SYNODENTIDAE	Saurida undosquamis	Saurus atlanticus	SOLEIDAE	Solea spp	SIGANIDAE	Teuthis sigana	POMATIDAE	Temnodon saltator	TRACHINIDAE	Trachinus draco	TRICHIURIDAE	Lepidopus caudatus	Trichiurus lepturus	SPHYRAENIDAE	Sphyraena sphyraena	URANOSCOPIDAE	Uranoscopus scaber
								12	22		2							15		16		9		11		0					17		
	9												11																				8
															3																		
					9			15	14		1						17			13				11							10		0
	0										2						17			18		15		11		0							21
					8				18		1		0				9	0		20		10		25					21		6		0
					18				19		2						13			23		10		20					25		17		
	26				17			19	13		1						18			22		16		24		28					15		0
					10			21			1				0					19				8					20		12		
					12			25	5		2		0							23		16		20					19		13		
0					12			0	0		1		0				0	0		0		16		17		0		0	0		0		0
					12			10			1						13			11		15				18					21		0
	0				6						5		0				10					13											
					14		9		18		1		0				17	17		13		12		11				0					
	0				14		17		18		3						15			21		20				0					24		0
	17				18		0				2		16							15		11		4				0					0
					7			0	28		2		30				14			26		15		8		27		0			16		0
					12				17		2						19	19		20		18		15							22		0
0	0								14								12	12		0		11									15		0
	21				8		38	32	14		4		0				9	15		13		2		17		29							
					18		22		23		1		12					19		15		13		14							0		0
7	0				5		8		9		1		19				6			13		14				20			18				0
					9		7		8		3						14			10				16		23					12		0
0					10		1		15		3						11			19		22				0			0		24		0
					11		1		16		4		21				12			20													0
0					9		1		11		3		23				10			16		18		25							17		0
	0				3		2		12		1		18				4			14		7											
0					10		18		16		1						15			13		23				24					25		
0	0				3		6		14		2		23				0	9		21		22		0		0					20		0
0	0				12		19		11		2						13			16		17											
0					11				9		6		26				12			23		10		20		24					25		0
0					8		0		1		3						9			15		18							20				
					12			0	2		9						13			15		14				0							
	0				8		13		3		5		21				9			11		10				18			0		20		0
0					12			21	8		3		25				13			15		16		22							23		0
0					10				12		1						11			9		8		18							0		0
22					17				12		2						18			10		9		16							20		
	0				6		17	0	7		1		23				5			8		7		11									

LOPHIIDAE	Lophius piscatorius	ZEIDAE	Zeus faber	BLENNIIDAE	Blennius spp	SCORPAENIDAE	Scorpaena spp	SCOMBERESOCIDAE	Scomberesox	BELONIDAE	Belone belone	STROMATEIDAE	Stromateus fiatola	CRUSTACEA	Crabs	Palinurus vulgaris	Penaeus spp	CEPHALOPODS	Sepia officinalis	CARTILAGENOUS FISH	Acanthias spp	Mustelus spp	Myliobatus spp	Raja spp	Rhinobatus spp	Scyllium canicula	Squatina spp	Torpedo spp	Trygon spp		Chelonia*	Scarus cretensis**	Lutianus spp.***	
	0		0				0										19						0	0	0	0	0	0	0					
			5						10																									
					4		2						6																					
																	6					3		2				4	1			0		
			23				0		0		0						4				3			1			4	2				0		
							22		0								3				2	4	5	1	3									
							0				24				5		4				5		3	2	4				1			26		
	0						23		20		25						3				6			2	3		5	4	1					
					0		16		15				0								1	2		3				4				0		
			28				27				0				18		8				1	4			3				2			26		
			0				0		0		0		0		11		9				5	3	8	2	7		6	4	1			0		
			0										0				3		20			4		1			5	3	2			17		
																								2					1			0		
													0				6		19		3		4	1	5				2					
															22		12							1	3				2			0	8	
															13									1	4			3	2					
							0										9					4		1	3				2					
			0				0								9		7		8						1		4	3	2			0		
																	10							1					2			0		
															19		12		35													33	23	
			0														4				4	1	3	2										
															0		15		4					2					1			16		
							22										2		1					1	3				2					
			0										26				2		12					1					2				13	
															13		3		2					2	3		4	1				23		
													22						2			3		2					1			0		
			0				0																	1	3		5	2	4			0		
													27		26		7		9					1	2							0	3	
			0										0				11		8		0	6	0	1	2		5	3	4			0		
			0										0				7				3			1	4	5	6		2			0		
													0				1		2		1			2	3		4		5			0		
																	2				1	4		2	5	8	6	7	3			21		
							0										1				2	3		1	4		5	6						
													14			26	1				4			1	5			3	2					
																	1		2		3			1	4		5	2	1			24		
			0																		5	6		1	2		3	4						
			0														1		4		2			1	3		6	5	4			21		
																	2		20													17		

* Turtle ** SCARIDAE *** Lutianus spp. – Red Sea immigrant fish

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SUMMARY OF FISH LANDED IN ORDER OF ABUNDANCE

DATE \ LATIN NAMES OF FISH	SPARIDAE	Boops boops	Boops salpa	Charax puntazzo	Dentex dentex	Dentex gibbosus	Dentex macrophthalmus	Diplodus annularis	Diplodus sargus	Oblada melanura	Pagellus acarne	Pagellus erythrinus	Pagrus auriga	Pagrus pagrus	Pagrus spinelli	Sparus aurata	MUGILIDAE	Mugil spp	ATHERINIDAE	Atherina boyeri	ANGUILLIDAE	Anguilla vulgaris	SCOMBRIDAE	Auxis bisus	Euthynnus pelamis	Sarda sarda	Scomber scombrus	CLUPEIDAE	Sardinella spp	BALISTIDAE	Balistes spp	MONACANTHIDAE	Monacanthus spp	SCIAENIDAE	Corvina nigra	Sciaena aquila	Umbrina cirrosa	CEPHALACANTHIDAE	Dactylopterus pirapeda	TRIGLIDAE	Trigla spp	ECHENEIDAE	Echeneis naucrates	SERRANIDAE	Epinephelus spp	Morone spp	Serranus spp	EXOCOETIDAE	Exocoetus volitans	GOBIIDAE	Gobius spp	HOLOCENTRIDAE	Holocentrus rubra	LABRIDAE	Julis vulgaris	Labrus viridis	Xirichtys novacula	BRAMIDAE	Lampadius catalocci	MULLIDAE	Mullus surmuletus	ARANIDAE
MARCH 1978																																																																							
1 March 78	7			4			12	8			3	15			2	11				0	23			20						0					21			16		0				17							0														9	
5 March 78	3		22				17	8			4	13	6		5	7		16					18											23										15		21		0			0		0	0	0						11	
8 March 78	8			6			10	4							5	7		12					23		22		25	0				14	13	26		0		19					9	20					0													11	
12 March 78	6						10	5			2					4				0								0										8															0											
16 March 78	1		20				12				4	10			3	13					24			19		21	2								22								9	17	18							0										6	
20 March 78	7	21	0					4			6	3				14								20	0		2					9	8										12	19	13					0					0					11	0
25 March 78	2	15		5			6	7			4	8		0	3			13		18			0				10					14	14																18					0							
29 March 78				4			5	6				2			3			14		0	15						13					12	11					17				8							0			0										
Summary	3	0	0	15			7	4			10	12	0		18	6					0		0	0		0	19	0				20	16	0		0		22		0			14	0	0		0		0		0	0							11		0
APRIL 1978																																																																				
2 April 78	10		0	17			3	4				9									18		0				7								0			13		0					14																5	
6 April 78	1	13	20	0				6			9				8	12		19									2						18					15				21		22				14					0	0				10		
10 April 78	10	26					19	11			4	12	5		3	18		22			25		0	0		0	1	0					9					14		0			20	23	21				8										17		
15 April 78	9		0	0				3				7	0		6	8							11				1						14										13						5					0							
18 April 78	1	13					11	10			5	12	6		4								22				2					0						19				8	20	9				17					0							0
20 April 78	7			5			9	8				16			4					0			12	13			2	0				15		0						0		6								0			0							
25 April 78	10						9	8				11			5	12		14					18			19	6						13									7			0			0												
29 April 78	11							2				8			3	7		6			20						5					10	9							0				13	0						0							16		
Summary	4	25	38	29			12	3			23	5	28		1	13		15			27		21	36		37	7	0				30	14					20		0		9	33	22		0		18		0		0	0					19		0
MAY 1978																																																																			
5 May 78	8	15					6	5				7			3			10								19	1			0			18			0						4	11	17								0	0							
11 May 78	4							3							7	6		13					14				2						12	0									8							0		0										
16 May 78	6	14	19	5							3	9			4	11				18	16					7	1							0											15							0	0				13		0
20 May 78	2						7	6			4	9						13		0	17			18		5	1															12	15								0						14		
22 May 78	10						9	8				5			4					0			13			11	1	0								0		14				7									0						15		
23 May 78	20	22		5				11			3	13	4	0	2	12							24			15	1	0					26			0		27				6		7							0	0	0			18		
25 May 78	12	16						13				14			6								19			11	1															3		4					0		0	0							
29 May 78	3			7			18								6						24		26			4	1	0									16				8		9																
Summary	2	15		19			13	7			18	9			12	21		22			28		17			10	6	0	0			25			0		30				4		16					0		0					14		0
JUNE 1978																																																																			
1 June 78	8						14				6	22			5			4			19		0			10	1											23				13		12																0
6 June 78	16			6			9	10			5	17			4	11		7								15	2	0					22	0		0						8																		0
10 June 78	11		0	21			9	28				7	0			27		8			22		17				1											24		0		4		5					20			0	0						
15 June 78	5		0				13	12			4				3			10					19			6	1							0				0				8		9				0				0						
20 June 78	10						3	4			14	9				5		7			20		19			6	1	0											0					11				0				0						
24 June 78	5		0									9	0		4			6						18			1						17										15							0										
27 June 78	11						7				9	8						5			15			16		4	6						13	0				18		0		2		3		0			0		0	0		0				
29 June 78	9						14	13				8			4	15		7		0			22				2						17					19				3							0		0	0						
Summary	4			27			6	30			16	9			15	23					24		22	29		17	1						21									5		20					32										
JULY 1978																																																																			
1 July 78	8						10					12			11	15		4			23		17	18		9	1	0					6	0				22				5				0			0		0									
6 July 78	10	11	0	15							14	12			13			3								17	2	0					9									7		8								0	0	0						
12 July 78	4						12					9				11		7		0	18		17			14	1						8							0				10								19						
16 July 78	10	11					14					12			13			15			22		20			16	2	0			9	8					21				7				0			0			0						
20 July 78	12			6							5	13			4			11					18			14	1	0			10	9			0						15		16				0										0	
23 July 78	12						15					13			3	14		11			23		18				1						7					24				5		6							0						19		1

1, 2, 3, .. Order of Abundance O- Other Fish

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TABLE A.3-2 (CONT'D)

BUNDANCE - EASTERN HARBOR

HOLOCENTRIDAE	Holocentrus ruber	LABRIDAE	Julis vulgaris	Labrus viridis	Xrichthys novacula	BRAMIDAE	Lepidotus catalonicus	GADIDAE	Merluccius merluccius	CARANGIDAE	Caranx crysos	Lichia glauca	Trachurus spp.	MULLIDAE	Mullus spp.	MURAENIDAE	Muraena helena	PLATYCEPHALIDAE	Platycephalus indicus	SYNODENTIDAE	Saurida undosquamis	Saurus atlanticus	SOLEIDAE	Solea spp.	SIGANIDAE	Teuthis sigana	POMATIDAE	Temnodon saltator	TRACHINIDAE	Trachinus draco	TRICHIURIDAE	Lepidopus candatus	Trichiurus lepturus	SPHYRAENIDAE	Sphyraena sphyraena	URANOSCOPIDAE	Uranoscopus scaber	LOPHIIDAE	Lophius piscatorius	ZEIDAE	Zeus faber	BLENNIIDAE	Blennius spp.	SCORPAENIDAE	Scorpaena spp.	SCOMBERESOCIDAE	Scomberesox	BELONIDAE	Belone belone	STROMATEIDAE	Stromateus fiatola	CRUSTACEA	Crabs	Polimurus vulgaris	Penneaus spp.	CEFHALOPODS	Sepia officinalis	CARTILAGENOUS FISH	Acanthias spp.	Mustelus spp.	Myliobatus spp.	Raja spp.	Rhinobatus spp.	Scyllium canicula	Squatina spp.	Torpedo spp.	Trygon spp.		Chelonia *	Scarus cretensis **	Lutianus spp. ***	
			0						9				6		5		22					10		14		13							24		0		0				0												19		1		18		5	6		1	3		7	2	4					
	0		0	0	0				11				9								10	10		14		12		24		20					19		0																	2		1				1			2	4				3			25		
									11			0	16		1		27					15		18		17		24		21							0				0										0				2		3		2			1	3									
			0										9		1											7				11							0				0														3		12		1				2									
			0						6				8		5		23					7		14		15		26							25		0								0								16		11		16					1	2		3							
					0				11		0	16	15		5							10		17		18											0				0														1				2			1	3			4						
				0								11	12		1									16		17				0							0								0										9				1				2							0		
			0									9	10		1		15				7					16				0											0				0															2			1	3									
	0		0	0					11		0	0	8		1		25				5	10		13		9		24		23		0			0																			21		2		17															0		
									5				12		2						6			11		8		16		19					15						0				0										1				2			1	3				1					
				0	0				10				17		3						11			16				7																	0										4				2			1	3	5		4	4			0		
									17			27	15		6						16			24				7		0							0														0				2		13					1	2			3						
				0									16		2		17				12			15		10		4																	0														3			1	2	5		4						
				0							0		16		7		21				18					15		3									0								0								14	23					4	3		1	2						14	0		
	0			0									14		3									11		10		1												0										0									2	4	1	3				5					
	0											15			2									17		16		1					0				0																	4	21	3					2	3	1		4						20			
			0						16			19	14		1		20				17			15		12		4		18							0				0																				4	1			3	2			12	0		
	0		0	0					19		0	26	6		2		31				10			16		8		11		32					35																		24		17		34																
				0	0										2							16		12		14		9		0					0		0								0										13				4	3		1	2		5		1					
	0		0									0			5									11		10		9		0					0										0										1							1	2		3	4				0		
				0	0				13		0				2		17							12				10									0																		8				3			1	4	5			2			0		
			0						14						3		16							11		10		8		0					0		0								0														2	3		1			4					0		
			0						15				16		6											12		3									0																	2				3		5	1	2	4							
			0	0	0				18						10		0					19		17		16		14					21				0														0		9		8		23		3			1	2							0	25	
	0		0	0									0		5									10		9		2					15		0										0									8	18	7		17															20	
												5	25		13		23					21		20		15		2		19			22		14		0				0				0						17		11		10		12			5		2	4	1			3			27		
	0		0						14		0	0	27		3		26				24	18		11		5		11					29																				20		8		23																
											0	9	24		7		20				16			15		21		2		18			17				0								0										3		11		5			1	4	3			2					
											0	3	18		14						19			13		12		1							21		0				0																		2	4		1		3						20		
	20			0	0							3			10						16			13		14		2		12					15																		18	23	6		25			3		1						2		26	19		
				0								7	14		11						17			18				2		16					15		0								0														3	2		1		4							
				0								8	17		15		21				13			18		12		2							16		0						0																2		1	4				3			0		
	0											2	11		7						16			12		8		3					14		13										0						20		10		19					2	1				3			0		
	0		0		0							10	14		20											12		1		19							0																				17					2	1	3						21		
	0		0	0								6	11		10									18		12		1		21					16						0												23		5		20					1	2	3			4					
	32											3	12		7		31				13			8		10		2		28			11		14																		26		19		18													33	25		
	0		0									7	14		2						16			19		13		3		20					21		0																						2	3		1				4				0		
			0	0	0							5	16		6											18		4																0								19		1		20		2		3	4	5			6	1			0		
	0			19								13	5		3		0							16		15		6												0										0				2				2			1	3							20		
	0			0								3	6		4		23				17	17		19		18		5																										1				2	3	5					4	1			0		
											0		7		3						19	19		17				8												0										0				2				3			1					2				
			0						19			16	10								17	17		20		25		4		21			0		22		0																9		8				3	2		1				4						

* Turtle

** SCARIDAE

*** Lutianus spp.- Red Sea immigrant fish

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SUMMARY OF FISH LANDED IN ORDER OF ABUNDANCE –

DATE	SPARIDAE	Boops boops	Boops salpa	Charax puntazzo	Dentex dentex	Dentex gibbosus	Dentex macrophthalmus	Diplodus annularis	Diplodus sargus	Oblada melanura	Pagellus acarne	Pagellus erythrinus	Pagellus mormyrus	Pagrus ehrenbergi	Pagrus spinifer	Pagrus vulgaris	Sparus auratus	MUGILIDAE	Mugil spp	ATHERINIDAE	Atherina boyeri	ANGUILLIDAE	Anguilla vulgaris	SCOMBRIDAE	Auxis bisus	Euthynnus pelamis	Sarda sarda	Scomber scombrus	CLUPEIDAE	Sardinella spp	BALISTIDAE	Balistes spp	MONACANTHIDAE
AUGUST 1977																																	
Summary	6	7					9	8			10					14		3								13							
SEPTEMBER 1977																																	
3 Sept. 77	9							8				11		0		4		0											0		0		
6 Sept. 77	0						0	8	11							6																	
25 Sept. 77	11					19		13							15	10										5			9				17
Summary	10					24		5				16			21	3													15				23
OCTOBER 1977																																	
11 Oct. 77	6							11							12	7										14					0		
25 Oct. 77	6										12					7										11							
Summary	6							11			13				12	7									16								
NOVEMBER 1977																																	
7 Nov. 77	10						13	11							3			7							2						17		
13 Nov. 77																7						9			5				10				0
17 Nov. 77	12							5			0				0										9				7				
29 Nov. 77	11	3									0	0		0	2	8		4							0				0				
Summary	15	12									0	0		0	7	9		13							5				11				0
DECEMBER 1977																																	
8 Dec. 77	8	0													6	5									0								
17 Dec. 77	0	0						11			0	0			0	9						0									0		0
21 Dec. 77	0										0				8							0			0								
Summary	13							10							10	9		4							9						0		0
JANUARY 1978																																	
12 Jan. 78		0				9		10				6			3	8													0				
19 Jan. 78	12							2							13	9									4				6		0		
25 Jan. 78								1					4		2										7				5				
27 Jan. 78		8						3							2	5													0				
Summary	18	15				16		1					14		3	11									9				10		0		
FEBRUARY 1978																																	
6 Feb. 78	11															13													1				
15 Feb. 78								8	0			0			9	3						0			0				4				
21 Feb. 78								0	10						0	1						0			0								
24 Feb. 78							0	13	0			0			10	4		12							0				0				
Summary	14								19						18	7		21											1				
MARCH 1978																																	
2 March 78		9										7			10	3													8				
12 March 78	8								10			9			12	3				17													
21 March 78	5			12			11	2				12			13	8													6				19
30 March 78	16							1						19	6	12		17		7						4			10				
Summary	15	16					31	7	24			8		27	11	1		23		30						29			10				

DATE	Monacanthus spp	SCIAENIDAE	Corvina nigra	Sciaena acquila	Umbrina cirrosa	CEPHALACANTHIDAE	Dactylopterus propeda	TRIGLIDAE	Trigla spp	ECHENEIDIDAE	Echeneis naucrates	SERRANIDAE	Epinephelus spp	Morone spp	Serranus spp	EXOCOETIDAE	Exocoetus volitans	GOBIIDAE	Gobius spp	HOLOCENTRIDAE	Holocentrus ruber	LABRIDAE	Julis vulgaris	Labrus viridis	Xirichthys novacula	BRAMIDAE	Lepidotus catalonicus	GADIDAE	Merluccius merluccius	CARANGIDAE	Caranx cr…	Lich…
AUGUST 1977																																
Summary													5	4																		
SEPTEMBER 1977																																
3 Sept. 77		0										1		14														7				
6 Sept. 77			0					0				3																				
25 Sept. 77			16					12				7	6																			14
Summary			22					18				2	12	19														13				20
OCTOBER 1977																																
11 Oct. 77		0				0		0				5		15								0										
25 Oct. 77								15				5																				
Summary								19				5		17																		
NOVEMBER 1977																																
7 Nov. 77								16				1		9								12										
13 Nov. 77								0				1																				
17 Nov. 77								0				1																			0	0
29 Nov. 77		0										1	0							0											0	0
Summary		0						0				1	0	14						0										0	0	
DECEMBER 1977																																
8 Dec. 77												4																				
17 Dec. 77			0					4				6																1		0		
21 Dec. 77			0					3				6																1				
Summary			0					7				8																5		0		
JANUARY 1978																																
12 Jan. 78								4				0																5				
19 Jan. 78			5					14				1						0														
25 Jan. 78			6					12				8						0										0				
27 Jan. 78			9									1																		10		
Summary			2					5				2						0										3		0		
FEBRUARY 1978																																
6 Feb. 78								3				12																7				
15 Feb. 78								1				10	11					0										7				
21 Feb. 78			13					6				0	7					2										9				1
24 Feb. 78			0					6				8	0					9										5			0	
Summary		17	16					3				6	8					10										5				20
MARCH 1978																																
2 March 78								11				12																				
12 March 78								5				16						1														
21 March 78			15					10				14	4															17				
30 March 78								18				2	14					15													5	
Summary								3				5	17					12													21	2

1,2,3,... Order of Abundance   O- Other Fish

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TABLE A.3-3

…ABUNDANCE - ABU KIR BAY

… volitans	Gobius spp.	HOLOCENTRIDAE	Holocentrus ruber	LABRIDAE	Julis vulgaris	Labrus viridis	Xrichtys novacula	BRAMIDAE	Lepidotus catalonicus	GADIDAE	Merluccius merluccius	CARANGIDAE	Caranx crysos	Lichia glauca	Trachurus spp.	MULLIDAE	Mullus spp.	MURAENIDAE	Muraena helena	PLATYCEPHALIDAE	Platycephalus indicus	SYNODENTIDAE	Saurida undosquamis	Saurus atlanticus	SOLEIDAE	Solea spp.	SIGANIDAE	Teuthis sigana	POMATIDAE	Temnodon saltator	TRACHINIDAE	Trachinus draco	TRICHIURIDAE	Lepidopus candatus	Trichiurus lepturus	SPHYRAENIDAE	Sphyraena sphyraena	URANOSCOPIDAE	Uranoscopus scaber	LOPHIIDAE	Lophius piscatorius	ZEIDAE	Zeus faber	BLENNIIDAE	Blennius spp.	SCORPAENIDAE	Scorpaena spp.	SCOMBERESOCIDAE	Scomberesox	BELONIDAE	Belone belone	STROMATEIDAE	Stromateus fiatola	CRUSTACEA	Crabs	Palinurus vulgaris	Penneaus spp.	CEPHALOPODS	Sepia officinalis	CARTILAGENOUS FISH	Acanthias spp.	Mustelus spp.	Myliobatus spp.	Raja spp.	Rhinobatus spp.	Scyllium canicula	Squatina spp.	Torpedo spp.	Trygon spp.		Chelonia*	Scarus cretensis**	Lutianus spp.***
																									11																													2		1																	
										7						0							6		5		0		10									0																		13		2		5				0		0							12		
																1							4		5		9		10							0		0				0				0								7		2							0					0					
														14		2																		8				18								20								3		1		4				1		3				2					
										13				20		6							9		8				11					14								0				25								4		1		7				1		3				2			17		
				0												3									13				10							8						0				0				9				2		1		4			3		1				4	2					
																3											14		10					13		8														9				1		2		4				3	1				4	2					
																3									14		18		10					15		8						0				0				9				2		1		4				3	1				4	2					
				12												4							18		8		14		15																									5		6				4		6	2	5			3	1					
																6				0					8		0		4		0			0				0				0												3		2							0	0			0	0					
													0	0		4									6		8		11																	10								2		3																	
		0											0	0		7											6		5		0																							10		9		12															
		0										0	0			2				0					6		10		8		0			0				0				0				16								3		4		0		6		5	3	2			4	1					
																2											9		7							0						0				0								3		1				0			0					0					
										1		0				5							8		2				0							7						0				0								3		10		0															
										1						2							7		4				9																	0								5		10		0															
										5		0				1							12		6		15		11							4																		1		3				0			1										
										5						7							12		11		1		0									0																		2		0										0					
0																10									7		11		3																										8																	
0										0						9							0		10		11		0																									13		3												0					
												10				0									4		7									0		0																		6				1													
0										3		0				10							17		8		6		12							0		0																19		4		0									0	0					
										7						6							8		5											9																		2		4		10															
0										7						2		0					6		5		0							0																						0		0															
2										9				11		3		0					0		5				12		0					0		0																0		8		4					0	0				0					
9										5			0			1							0		7									11				0								0								0		2		3				0											
10										5				20		2							11		4				15		0					12																				9		13				0	0										
																									2		4		5		6					13		14																		1																	
1																7							16		6									13		14																		11		2		4															
										17				7											3											9						20												16		1																	
15													5												8		11		3							13																		9																			
12													21	22		20							28		2		14		13		19			26		4		25				30												9		6		18															

* Turtle ** SCARIDAE *** Lutianus spp.- Red Sea immigrant fish

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TABLE

SUMMARY OF FISH LANDED IN ORDER OF ABUNDANCE

DATE \ LATIN NAMES OF FISH	SPARIDAE	Boops boops	Boops salpa	Lithognathus mormyrus	Dentex dentex	Dentex gibbosus	Dentex macrophthalmus	Diplodus annularis	Diplodus sargus	Oblada melanura	Pagellus acarne	Pagellus erythrinus	Pagellus mormyrus	Pagrus ehrenbergi	Pagrus pagrus	Sparus aurata	Sparus vulgaris	MUGILIDAE	Mugil spp	ATHERINIDAE	Atherina boyeri	ANGUILLIDAE	Anguilla vulgaris	SCOMBRIDAE	Auxis thazard	Euthynnus pelamis	Sarda sarda	Scomber scombrus	CLUPEIDAE	Sardinella spp	BALISTIDAE	Balistes spp	MONACANTHIDAE	Monacanthus spp	SCIAENIDAE	Corvina nigra	Sciaena aquila	Umbrina cirrosa	CEPHALACANTHIDAE	Dactylopterus volitans	TRIGLIDAE	Trigla spp	ECHENEIDAE	Echeneis naucrates	SERRANIDAE	Epinephelus spp	Morone spp	Serranus spp	EXOCOETIDAE	Exocoetus volitans	GOBIIDAE	Gobius spp	HOLOCENTRIDAE	Holocentrus ruber	LABRIDAE	Julis vulgaris	Labrus viridis	Xenichthys novacula	BRAMIDAE	Lepidopus caudatus
APRIL 1978																																																																			
9 April 78	11						6						1	7					20					21					15														19			8	14																		
17 April 78	12					10	11						6	7					26		27								9		25				14			22							4		13				17													
24 April 78	6	13				11	10				16		1																														15			7		12				8											
30 April 78	15	23				20	16				18		2						26		21			24					1						25	7							11			17	8	10				12											
Summary	7	26				15	6				25		9	19					30		29			28					10		32				33	22			31				16			5	23	12				14											
MAY 1978																																																																	
3 May 78	18					19	7				15		6						20		17								3						10								8			1		14				9											
8 May 78	9					0		0			11		6	8										10					2						0								5			3						0											
17 May 78		8					2	0		3	10	7	1	0		0																											9			4		0							0							
25 May 78	12							9			5			0					3																10								4			0		11				0		7									
30 May 78	7				12			0			11		4	0					9															5								0			1	0																	
Summary	8	31			34	38	20	10		27	4		11	9					19		35			32					18						29	12							6			2		14				22		30									
JUNE 1978																																																																	
8 June 78	6			0			12				5		7	8		11								0									0												3	0	0																	
12 June 78	14					0	8	0			0		5						1							12									10			0		11				0											0									
21 June 78							3				6		12	0															2						0								5			10		0						0									
29 June 78	15	12				0	0	0					11	9		13			4					16					5														0			14																	
Summary	9	23				18	10				13		2			21			11					24		20			12							19							16			5																	
JULY 1978																																																																	
6 July 78		0					0	0			0		10	0					4					7		0			1							0								0			6																	
15 July 78		5					11	10			0		0	0					7					9					1														0			0																	
26 July 78	6	10					0	0			5		2			0			0					0					8																4								0										
Summary																																																																	

1, 2, 3, ... Order of Abundance O- Other Fish

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TABLE A.3-3 (CONT'D)

ABUNDANCE — ABU KIR BAY

	...NIDAE Gobius spp.	HOLOCENTRIDAE Holocentrus volitans	LABRIDAE Iniocentrus ruber	Julis vulgaris	Labrus viridis	BRAMIDAE Xenichthys xenicus	GADIDAE Lepidotus catalonicus	CARANGIDAE Melanogrammus aeglefinus	Caranx crysos	Lichia glauca	MULLIDAE Trachinotus spp.	MURAENIDAE Mullus spp.	PLATYCEPHALIDAE Muraena helena	SYNODONTIDAE Platycephalus indicus	Saurida undosquamis	SOLEIDAE Synodus saurus	Solea spp.	SIGANIDAE Siganus oligatricus	POMATIDAE Teuthis signata	TRACHINIDAE Temnocora spinosa	TRICHIURIDAE Trachinus draco	Lepidopus caudatus	SPHYRAENIDAE Trichiurus lepturus	URANOSCOPIDAE Sphyraena sphyraena	LOPHIIDAE Uranoscopus scaber	ZEIDAE Lophius piscatorius	BLENNIDAE Zeus faber	SCORPAENIDAE Blennius spp.	SCOMBERESOCIDAE Scorpaena spp.	BELONIDAE Scomberesox	STOMATEIDAE Belone belone	CRUSTACEA Stromateus fiatola	Crabs	CEPHALOPODS Palinurus vulgaris	CARTILAGENOUS FISH Penaeus spp.	Acanthias spp.	Mustelus spp.	Myliobatus spp.	Raja spp.	Rhinobatus spp.	Scyllium spp.	Squalina spp.	Torpedo spp.	Trygon spp.	Chelonia*	Scarus cretensis**	Lutianus spp.***
											10				22	3	9			13		17	12	18		16						5	2	4														
17							19				3				18	1	8			16		15	20	21		24		23					5	2													
8							9				2					5								18		17		19				14	3	4				1									
12							4			5	3				13	9				19						22							6	14				1									
14							11			13	2				17	4	20			24				18		8		27				21	1	3				1									
9							5				4				11	12				16													2	13				1	2		3						
0															7	4				0		0	0	0		0		0					1	0				1		2		0	0				
			0								0					0	11															0	0	5													6	
0	7										13				2	6	0			0		0	8	0				0				0	1	0		0		0	0									
										0	6				3	0		10				8						0				0	2						1	2								
22	30						28				7				5	3	36	33		15		13	24	25		41		26					1				1	2	3		4	6			23	
									0		4					0	9	2		0				0		0						10	1															
										15	3				13	9	6			0		4	0	0		0		0				7	2	0		0		0									0	
	0									0	4				9	0		7				0	11									8	1			0		0					0					
										0	0				7	8	3	6				10	1			0		0				17	2					0										
									0	22	3				17	15	6	4				14	7									8	1															
									0	0	0				3	11	9	12				0	5									8	2						0		0							
										3	0					6	0	2														4	8															
	0										9				7	0	0	3										0					1	0								0						

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* Turtle

** SCARIDAE

*** Lutianus spp. - Red Sea immigrant fish

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SUMMARY OF FISH LANDED IN ORDER OF ABUNDANCE

DATE \ LATIN NAMES OF FISH	SPARIDAE	Boops boops	Boops salpa	Chloro. puntazzo	Dentex dentex	Dentex gibbosus	Dentex macrophthalmus	Diplodus annularis	Oblada melanura	Pagellus acarne	Pagellus erythrinus	Pagrus auriga	Pagrus pagrus	Pagrus vulgaris	Sparus aurata	MUGILIDAE	Mugil spp.	ATHERINIDAE	Atherina boyeri	ANGUILLIDAE	Anguilla vulgaris	SCOMBRIDAE	Auxis thus	Euthynnus pelamis	Sarda sarda	Scomber scombrus	CLUPEIDAE	Sardinella spp.	BALISTIDAE	Balistes spp.	MONACANTHIDAE	Monacanthus spp.	SCIAENIDAE	Corvina nigra	Sciaena aquila	Umbrina cirrosa	CEPHALACANTHIDAE	Dactylopterus pirapeda	TRIGLIDAE	Trigla spp.	ECHENEIDAE	Echeneis naucrates	SERRANIDAE	Epinephalus spp.	Morone spp.	Serranus spp.	EXOCOETIDAE	Exocoetus volitans	GOBIIDAE	Gobius spp.	HOLOCENTRIDAE	Holocentrus ruber	LABRIDAE	Julis vulgaris	Labrus viridis	Xyrichys novacula	BRAMIDAE	Lepidopus caudatus
AUGUST 1977																																																																	
Summary	12	13				11	10							17		1				9				14																																										
SEPTEMBER 1977																																																																	
6 Sept. 77														10													1												6			0	0	0																					
16 Sept. 77					0					0			0	12				6		0							2				0								9				8						0				0											
20 Sept. 77	0					0		0					0	10				7																					0				5																					
Summary	0				0	0		0		0			0	7				8									1												9				10	0					0				0											
OCTOBER 1977																																																																	
9 Oct. 77	10			0			0							3																	0			2					0		0																							
16 Oct. 77	7			0									9	5													11		0										0				10		0				0															
Summary	11			0			0						12	4													14		0					2							0		13		0																			
NOVEMBER 1977																																																																	
3 Nov. 77	0						6							8		9							0				5												0												0													
7 Nov. 77										0				8													5				0			11					0					12					0					0									
10 Nov. 77																1				3							7															11	2	13			10															
17 Nov. 77										0				6													1		0					10					0				0					8															
29 Nov. 77	0						0			0			0														4		0					0					0					7				6					0									
Summary							15			0			0	7		9				12			0				3		18		0			16					0				0	11	19			14					0									
DECEMBER 1977																																																																	
4 Dec. 77	0													6													8				0												9																					
12 Dec. 77				0										8													5							0										7				6				0											
20 Dec. 77	10						0			0			0	7													5				0			6					9				0					8															
Summary	11			0			11			0			11	15													3				0			12					18		0		0	2	4								17									
JANUARY 1977																																																																	
15 Jan. 78										0				0																				0					6				0					5													
22 Jan. 78						0				0				4													0				0			8					0									5												0	
25 Jan. 78														5													12							4										13				3													
29 Jan. 78														3													0		0					6					0				0	0				2												0	
Summary						0				0				4													0		0		0			5					0				0	0				6												0	
FEBRUARY 1978																																																																	
9 Feb. 78		0												0																	0			6										0				5													
12 Feb. 78					0			0						4													11							6					0					8				2												0	
27 Feb. 78														4						0							0							8										9				2												0	
Summary	18	0			0		17	16					11	4													9							10					8					7				5												0	
MARCH 1978																																																																	
6 March 78						0		6				0		4													0				0			8														0													
8 March 78										0				5				8		0							0							9					0				0	6				4												0	
16 March 78	0						11			7				4						0									0					9										0				3													
26 March 78	0			0	9					4																	0										0		0				0				6												0	
30 March 78														0				4																0														0													
Summary	14			0	17	0	22	15		7		0		5				10									0		0		0			11			0		19			0	12				6												0	

1, 2, 3, ... Order of Abundance O - Other Fish

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TABLE A. 3-4

UNDANCE - MAADIYA

	HOLOCENTRIDAE spp	LABRIDAE Halichoeres ruber	Labrus viridis	Xyrichtys novacula	BRAMIDAE Lepidotus catalonicus	CARANGIDAE Mariscobrama marbacoba	Caranx crysos	Lichia glauca	MULLIDAE Trachinotus spp	Mullus spp	MURAENIDAE Muraena helena	PLATYCEPHALIDAE Platycephalus indicus	SYNODONTIDAE Saurida undosquamis	Saurida grandiquamis	SOLEIDAE Solea spp	SIGANIDAE Teuthis sigana	POMATIDAE Temnodon saltator	TRACHINIDAE Trachinus draco	TRICHIURIDAE Lepidopus candatus	Trichiurus lepturus	SPHYRAENIDAE Sphyraena spharaena	URANOSCOPIDAE Uranoscopus scaber	LOPHIIDAE Lophius piscatorius	ZEIDAE Zeus faber	BLENNIIDAE Blennius spp	SCORPAENIDAE Scorpaena spp	SCOMBRESOCIDAE Scomberesox	BELONIDAE Belone belone	STROMATEIDAE Stromateus fatola	CRUSTACEA Crabs	Palinurus vulgaris	Penaeus spp	CEPHALOPODS Sepia officinalis	CARTILAGENOUS FISH Acanthias spp	Mustelus spp	Myliobatis spp	Raja spp	Rhinobatus spp	Scyllium canicula	Squatina spp	Torpedo spp	Trygon spp	Chelonia *	Scaus crassiceps **	Lutianus spp ***
		19													16		18	3	15			8									5	6	7														
							9			0	5				8	4			0		0	7										2	3				0			0					
		0									3					7			0		11	10									4	1	5							1					
											2		0			8			0		6	9									3	1	4		0					0					
		10					14			0	3		0		13	5					11	6									12	2	4		0	0									
										0	9								0			7					8	6		5	1	4			1			3	2					
									0		2					6					0	8								1	2	4			1	3		4	2					
									0	0	6					8					0	9					10	7		3	1	5			1	4		3	2					
										0	2					3	0		0							7				1	4							0						
		0								0	3					4	10	0	0			9			0		6				1	2	7						0					
																12	5	14				6					9				4	8													
									0		5		0			7	0		0		0	9									3	4	2						0	0					
		0								0	0		0			5		0							0						2	1	3			3	4		1	2					
		0							0	0	0	5	0			4	13	0	0		0	8			0		10	17			1	2	6			3	4		1	2					
											3					5						7			0						1	2	4						0	0					
		0					0			0	2				0	9	0								0		0				4	1	3						0	0					
										12	3		0		11		13		0						0		0				4	1	2				0		0	0					
		17					0			19	1		0			14	16	3	13			8			0		0				5	6	7				0								
							4			0	1				8	3							0		0						0	2	7							1					
					0		7				0					2	0		0		0	0			0						6	1	3						1	0					
							7				9					2					8	10									11	1	6						1	2					
					0		9				0					4					0	8			0						7	1	5			0	0		1	0					
					0					0	10				12	2	0		0		9	8	0		0						7	1	3			0	0		1	0					
							0				0					2			0			0									3	1	4							1					
					0		10			0	9					5			0		7				0						12	1	3			0	0		1	0		0		
					0		0			0	6					5						0									7	1	3				0		1					
					0		0				15				12	2			0		19	13			0						6	1	3				0		1	0		0		
										0	0					0			5			7									2	1	3				0	0		1					
					0					0			0			0		0	7		0	10									2	1	3							0					
										0	0		0			5			0			8									2	1	6				0	2		1					
					0						0					5	0		0												3	1	2				0			1					
										0						3						0				5					2	1	6				0			0					
					0					0	0		0			4	0	0	9		0	8				13					2	1	3				0	2		1					

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*Turtle

**SCARIDAE

***Lutianus spp.- Red Sea immigrant fish

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SUMMARY OF FISH LANDED IN ORDER OF ABUNDANCE MAADIY

DATE \ LATIN NAMES OF FISH	SPARIDAE	Boops boops	Boops salpa	Charax puntazzo	Dentex dentex	Dentex gibbosus	Dentex macrophthalmes	Diplodus annularis	Diplodus sargus	Oblada melanura	Pagellus acarne	Pagellus erythrinus	Pagellus mormyrus	Pagrus ehrenbergi	Pagrus spinifer	Pagrus vulgaris	Sparus auratus	MUGILIDAE
APRIL 1978																		
10 April 78				0					0			13				6		
19 April 78				0												2		
23 April 78				0					0			0				2		
Summary				12					18			16				3		
MAY 1978																		
10 May 78																7		
17 May 78	12											8			14	13		
25 May 78	12														14	10		
31 May 78	10								6							9		
Summary	13								18			19			16	4		
JUNE 1978																		
8 June 78	5	0						0	0			8				6		
21 June 78	5								7		0							
29 June 78								0				0			9	10		
Summary	10							0				12			13	7		
JULY 1978																		
6 July 78	0								0			10				4		
12 July 78							0		0			7				8		0
15 July 78		0						0	0			10			0	8		
25 July 78												6						0
Summary																		

DATE \ LATIN NAMES OF FISH	Mugil spp	ATHERINIDAE	Atherina boyeri	ANGUILLIDAE	Anguilla vulgaris	SCOMBRIDAE	Auxis bisus	Euthynnus pelamis	Sarda sarda	Scomber scombrus	CLUPEIDAE	Sardinella spp	BALISTIDAE	Balistes spp	MONACANTHIDAE	Monacanthus spp	SCIAENIDAE	Corvina nigra
APRIL 1978																		
10 April 78				0							4		0					8
19 April 78		0		0							11		0		0			
23 April 78		17		18							0				0			
Summary		17		0							9		21		19			22
MAY 1978																		
10 May 78		4		15														5
17 May 78		7		16														
25 May 78		3		15														
31 May 78		2																7
Summary																		14
JUNE 1978																		
8 June 78		2		0											0			10
21 June 78		2									4							
29 June 78		4									3				0			0
Summary		2									15							14
JULY 1978																		
6 July 78		6		0														2
12 July 78		4													0			3
15 July 78		3									2				0			7
25 July 78											0							0
Summary																		

DATE \ LATIN NAMES OF FISH	Sciaena acquilla	Umbrina cirrosa	CEPHALACANTHIDAE	Dactylopterus pirapeda	TRIGLIDAE	Trigla spp.	ECHENEIDIDAE	Echeneis naucrates	SERRANIDAE	Epinephelus spp	Morone spp	Serranus spp	EXOCOETIDAE	Exocoetus volitans	GOBIIDAE	Gobius spp	HOLOCENTRIDAE	Holocentrus ruber
APRIL 1978																		
10 April 78					0					9					0			
19 April 78			21						24	9					5			
23 April 78					11					7					6			
Summary			25		15				27	13					8			
MAY 1978																		
10 May 78					3				16						8			
17 May 78					2					9					5			
25 May 78					2					8					4			
31 May 78					3													
Summary					2				23	15					7			
JUNE 1978																		
8 June 78					0					9								
21 June 78																		
29 June 78									0	7								
Summary									0	6								
JULY 1978																		
6 July 78					9					0								
12 July 78										2					0			
15 July 78									0	6								
25 July 78										5								
Summary																		

DATE \ LATIN NAMES OF FISH	LABRIDAE	Julis vulgaris	Labrus viridis	Xrichthys novacula	BRAMIDAE	Lepidotus cataloncus	GADIDAE	Merluccius merluccius	CARANGIDAE	Caranx crysos	Lichia glauca	Trachurus spp	MULLIDAE	Mullus spp	MURAENIDAE	Muraena he	PLATY
APRIL 1978																	
10 April 78							10						7				
19 April 78													3				
23 April 78							10						8				
Summary							14						5				
MAY 1978																	
10 May 78													11				
17 May 78											17						
25 May 78																	
31 May 78																	
Summary											24		21				
JUNE 1978																	
8 June 78							0						4				
21 June 78													3				
29 June 78											0						
Summary													9				
JULY 1978																	
6 July 78	0												0				
12 July 78											0		0				
15 July 78													11				
25 July 78													0				
Summary																	

1,2,3,... Order of Abundance 0- Other Fish

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A. 3-4 (CONT'D)

MAADIYA

Merluccius merluccius	CARANGIDAE	Caranx crysos	Lichia glauca	Trachurus spp.	MULLIDAE	Mullus spp.	MURAENIDAE	Muraena helena	PLATYCEPHALIDAE	Platycephalus indicus	SYNODENTIDAE	Saurida undosquamis	Saurus ailanticus	SOLEIDAE	Solea spp.	SIGANIDAE	Teuthis sigana	POMATIDAE	Temnodon saltator	TRACHINIDAE	Trachinus draco	TRICHIURIDAE	Lepidopus candatus	Trichiurus lepturus	SPHYRAENIDAE	Sphyraena sphyraena	URANOSCOPIDAE	Uranoscopus scaber	LOPHIIDAE	Lophius piscatorius	ZEIDAE	Zeus faber	BLENNIIDAE	Blennius spp.	SCORPAENIDAE	Scorpaena spp.	SCOMBERESOCIDAE	Scomberesox	BELONIDAE	Belone belone	STROMATEIDAE	Stromateus fiatola	CRUSTACEA	Crabs	Palinurus vulgaris	Penneaus spp	CEPHALOPODS	Sepia officinalis	CARTILAGENOUS FISH	Acanthias spp.	Mustelus spp.	Myliobatus spp.	Raja spp.	Rhinobatus spp.	Scyllium canicula	Squatina spp.	Torpedo spp.	Trygon spp.		Chelonia *	Scarus cretensis **	Lutianus spp. ***	
0						7									2		5									11						0				0								12		1		3					0				1						
						3									6		7		0		13			12		8		0				0												10		1		4				0					1	0					
10						8									4		9									5		0				0												12		1		3					0	0									
14						5									4		6		0		4			3		7		0				11				26								10		1		2				0	0	0			1	0					
						11							9		17		10				12			18		13						14												2		1		6					2	1									
				17									3		6						15			10		11																		4		1							3				1	2					
															6						13			11		9																		5		1		7					2				1						
													5								12			8																				11		1		4									2	1					
				24		21							10		11		20				6			5		12						22												8		1		9					2	4			1	3					
0						4									12		0		0		0			11		3		0				0												7		1		13					0										
						3																																								1		6										0					
				0									6		8				0					11		2						0												5		1																	
						9							11		8		0		0		0			5		4		0				0												3		1		16					0					0					
						0									8						0			7																				5		1		3									1	0					
				0		0							0		9		0				0			0																				6		1		5									0	0					
						11									5		0									9						0														1		4									0						
						0									0									0		4						0												3		1		2									0	0					

* Turtle ** SCARIDAE *** Lutianus spp.- Red Sea immigrant fish

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BEST AVAILABLE COPY

TABLE A.3-5

FISH LANDINGS[a]

Location: Eastern Harbor Date: Aug/Oct/Nov 77

Date	Crabs	Sardinella spp.	Penaeus spp.	Sepia officinalis	Chelonia spp.	Sciaena aquila	Solea spp.	Synodontidae	Pagrus spp.	Dicentrarchus spp.	Pomatomus saltatrix	Sparus auratus	Mugil spp.	Mullus spp.	Diplodus spp.	Epinephelus spp.	Other fishes	Total
August																		
Motor[b]	-	83500	22875	18205	-	12155	19125	28175	38661	-	6625	305	-	4[illegible]800	3510	13133	73005	364074
Sail[c]	-	25818	-	-	-	833	-	-	7	-	33	28	11	-	2125	25	2[illegible]26	63412
TOTAL	-	109318	22875	18205	-	12988	19125	28175	38668	-	6658	333	11	4[illegible]800	5635	13158	75831	427[illegible]6
October																		
Motor[b]	325	19805	9500	16950	200	6960	11850	21150	380	-	325	380	-	40170	2535	8050	49315	219595
Sail[c]	37	3825	-	-	-	314	-	-	9	-	-	20	86	11	818	22	2149	7291
TOTAL	362	23630	9500	16950	200	7274	11850	21150	389	-	325	400	86	40181	3353	8072	51464	226886
November																		
Motor[b]	-	-	9500	18550	-	8315	10925	22625	29728	-	625	1125	-	3[illegible]010	4060	5555	42840	70890
Sail[c]	-	3575	-	-	-	242	-	-	43	-	20	144	240	40	692	96	1958	7[illegible]50
TOTAL	-	3575	9500	18550	-	8557	10925	22625	29771	-	645	1269	240	3[illegible]050	4752	5651	44798	77940

[a] All fish landings are reported in kilograms.

[b] Taken by motor boat.

[c] Taken by Sail Boat.

TABLE A.3-6

FISH LANDINGS[a]

Location: Eastern Harbor Date: Sep 77

Date	Mullus spp.	Pagrus spp.	Epinephelus spp.	Solea spp.	Synodontidae	Sepia officinalis	Penaeus spp.	Sardinella spp.	Pomatomus saltatrix	Sciaena aquila	Diplodus spp.	Sparus auratus	Dicentrarchus spp.	Mugil spp.	Cartilaginous fishes	Other Fishes
1	1650	1455	130	125	925	650	1250	-	-	150	210	-	-	-	35	2430
2	1250	925	195	475	925	425	425	1080	-	425	110	-	-	-	-	1550
3	2675	2325	400	1150	2375	1475	2475	5	-	25	75	-	-	-	280	4035
4	1525	1386	737	950	900	500	425	1494	-	735	95	25	-	-	-	2363
5	1300	1035	390	275	650	600	275	11125	-	204	-	-	-	-	-	2711
6	375	660	40	275	325	400	750	105	-	472	240	-	-	-	80	1633
7	725	650	230	-	600	400	500	920	-	130	40	-	-	-	-	1335
8	950	425	360	550	670	425	125	775	-	833	336	-	-	-	157	1634
9	2050	3053	425	725	1650	1225	1375	-	-	125	150	25	-	-	250	3585
10	1975	1215	338	775	1025	550	400	1750	10	945	80	-	-	12	685	2056
11	800	625	-	75	550	425	625	2375	175	-	20	-	-	-	-	2565
12	2600	2000	-	1200	1255	950	700	1275	-	1090	30	-	-	26	-	2938
13	-	-	-	-	-	-	-	1245	-	13	50	-	-	14	-	55
14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
17	125	50	-	-	75	50	50	600	-	20	-	-	-	-	-	120
18	225	260	190	75	100	75	75	590	675	17	85	-	-	7	-	830
19	-	15	25	-	-	-	-	4670	-	-	-	-	-	-	-	310
20	1025	885	210	425	550	400	300	5150	6	417	114	-	-	-	300	218
21	525	960	430	-	-	-	-	6580	350	100	482	-	-	-	20	1675
22	2250	1850	-	1075	1200	825	525	5471	3	886	186	600	-	-	-	2817
23	2575	2150	300	425	1400	13500	1000	3235	250	18	400	-	-	-	425	5130
24	650	767	240	375	500	200	350	1184	-	277	193	-	-	-	-	740
25	825	890	350	125	374	450	350	2415	-	-	-	25	-	-	125	1195
26	450	500	50	350	375	225	275	585	-	230	70	15	-	-	-	662
27	2125	1935	555	425	1450	1250	675	1020	-	275	70	-	-	-	180	2777
28	1525	1600	365	650	1000	-	-	2005	-	-	86	-	-	-	-	1539
29	1875	2023	490	475	1275	900	800	1595	-	-	28	105	-	-	60	2109
30	1750	1425	260	850	775	350	400	1266	-	555	54	8	-	-	385	1384
TOTAL	33475	31398	7180	12250	21620	14450	14100	75449	600	8683	3428	821	-	59	3272	50099

[a] All fish landings are reported in kilograms.

TABLE A.3-7

FISH LANDINGS [a]

Location: Eastern Harbor Date: Dec 77

Date	Mullus spp.	Pagrus spp.	Epinephelus spp.	Solea spp.	Synodontidae	Penaeus spp.	Sardinella spp.	Pomatomus saltatrix	Sciaena aquila	Diplodus spp.	Sparus auratus	Dicentrarchus spp.	Mugil spp.	Cartilaginous Fishes	Chelonia spp.	Crabs	Sepia officinalis	Other fishes
1	225	495	195	-	125	125	625	-	-	45	199	-	-	-	-	-	175	412
2	1890	1890	717	875	1525	725	350	-	125	159	99	-	13	-	-	-	1300	110
3	1125	975	120	325	625	350	675	-	275	431	-	-	6	-	-	-	350	77
4	-	-	-	-	-	-	-	-	12	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	60	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	65	-	18	-	-	-	-	-
7	-	-	242	-	-	-	-	-	165	123	12	65	14	-	-	-	-	318
8	615	325	380	-	250	150	1090	-	265	328	275	-	14	-	-	-	325	1037
9	3689	3150	200	2375	2000	2350	45	-	875	361	125	-	226	-	-	-	1615	6146
10	-	165	165	-	-	-	-	-	-	84	100	-	28	-	-	-	-	312
11	176	175	310	100	125	75	-	-	140	169	25	60	-	-	-	7	153	871
12	2173	2083	150	675	1775	900	275	-	375	209	-	-	-	225	-	14	1625	2802
13	80	125	100	125	175	95	-	-	100	7	-	25	-	-	-	-	175	354
14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	33	40	-	-	-	-	-	3	35
18	-	-	-	-	-	-	-	-	-	-	153	-	-	-	-	-	-	-
19	188	350	450	175	50	75	-	-	545	226	610	-	-	-	-	-	85	1509
20	708	510	375	168	50	-	-	-	408	443	-	-	-	-	-	-	405	1631
21	759	570	110	875	675	550	-	-	75	34	-	35	-	-	-	-	229	1829
22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	14	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	183	50	150	125	75	-	-	-	425	99	-	375	125	-	35	150	25	525
26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27	579	75	25	575	450	75	-	-	-	30	-	-	-	-	-	-	278	1157
28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	-	-	75	-	-	-	-	-	-	9	-	115	-	-	-	-	-	138
30	875	935	280	575	500	-	-	-	225	471	237	-	35	125	-	6	375	1499
31	1077	705	321	850	600	375	-	25	175	257	225	135	137	45	35	70	500	2537
TOTAL	14193	15278	4655	7818	9000	5825	3060	25	4173	3518	2247	810	616	395	70	277	7618	26978

[a] All fish landings are reported in kilograms.

BEST AVAILABLE COPY

TABLE A.3-8

FISH LANDINGS[a]

Location: Eastern Harbor Date: Jan 78

Date	Mullus spp.	Pagrus spp.	Epinephelus spp.	Solea spp.	Synodontidae	Sepia officinalis	Penaeus spp.	Sciaena aquila	Diplodus spp.	Sparus auratus	Dicentrarchus spp.	Mugil spp.	Cartilaginous Fishes	Chelonia spp.	Crabs	Other Fishes
1	3875	2850	25	975	2675	850	-	750	275	3700						4750
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	4067	2650	37	1805	1140	1605	840	1041	146	595	-	-	-	-	-	1250
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	315	250	95	125	75	25	-	40	140	90	45	52	295		76	4145
13	-	35	135	-	-	-	-	3	140	100	30	-	-	-	-	340
14	575	625	40	550	350	-	-	13	37	25	25	-	-	-	-	60
15	525	515	310	250	250	250	-	-	135	-	-	-	-	-	-	975
16	600	785	195	325	300	300	175	450	35	-	-	-	-	-	-	770
17	500	520	-	125	225	225	75	-	86	50	60	-	-	-	-	350
18	275	325	160	425	25	475	75	150	-	-	-	-	-	-	-	1050
19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	7	-	100	-	-	-	-	155	151	34	120	45	35	-	-	270
23	650	580	165	335	220	-	-	120	214	33	90	7	-	-	-	995
24	478	200	210	450	550	25	75	80	134	75	35	-	10	-	-	1075
25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	-	-	-	-	-	-	-	75	72	-	-	-	-	-	-	525
29	1008	409	216	105	305	820	-	118	239	29	100	22	-	-	-	1510
30	583	475	225	550	600	75	325	209	160	15	125	50	-	25	-	2350
31	650	375	275	375	475	915	-	95	182	12	41	-	38	-	-	225
TOTAL	13463	10219	1913	6020	6715	4440	1465	3195	2000	4758	671	176	378	32	76	21440

[a] All fish landings are reported in kilograms.

TABLE A.3-9

FISH LANDINGS[a]

Location: Eastern Harbor Date: Feb 78

Date	Mullus spp.	Pagrus spp.	Epinephelus spp.	Solea spp.	Synodontidae	Sepia officinalis	Penaeus spp.	Sardinella spp.	Pomatomus saltatrix	Sciaena aquila	Diplodus spp.	Sparus auratus	Dicentrarchus spp.	Mugil spp.	Cartilaginous Fishes	Chelonia spp.	Crabs	Other fish
1	1350	1385	725	750	800	350	475	-	-	175	363	250	200	25	80	75	-	2642
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	550	765	325	425	425	250	250	-	-	395	173	50	265	-	107	70	-	1774
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	250	385	260	200	250	-	75	-	-	185	60	25	105	15	70	45	75	1353
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	1425	1550	530	1230	825	450	625	-	-	250	240	75	210	75	-	-	-	9550
14	1083	828	25	600	450	-	50	-	-	35	34	10	9	-	-	-	-	268
15	-	220	225	-	-	-	-	-	40	195	67	-	155	25	-	-	-	521
16	580	560	365	85	-	180	-	-	162	197	-	-	182	-	-	-	-	730
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	14	316	155	-	-	-	-	-	-	155	94	12	-	-	-	-	-	690
20	297	508	235	53	-	135	-	-	-	210	56	39	-	-	-	-	-	1231
21	707	735	435	575	500	375	225	-	-	330	486	341	52	-	-	-	-	2720
22	112	130	130	-	-	-	45	-	-	-	194	48	-	-	-	-	-	311
23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	26	-	-	-	-	-	-	-	-	-	46	68	-	-	-	-	-	959
25	133	470	335	75	75	145	75	-	-	280	89	4	-	-	-	-	10	849
26	498	645	565	-	75	-	-	-	-	-	487	86	8	-	-	-	295	4001
27	1731	1045	225	1575	1250	250	600	-	-	205	121	29	-	-	-	-	-	1116
28	1247	550	850	75	1275	1125	-	-	-	-	636	27	-	-	-	-	-	1359
TOTAL	10003	10092	5385	5643	5925	3260	2420	-	202	2612	3146	1064	1159	140	257	190	380	29133

[a]All fish landings are reported in kilograms.

BEST AVAILABLE COPY

TABLE A.3-10

FISH LANDINGS[a]

Location: Eastern Harbor Date: Mar 78

Date	Mullus spp.	Pagrus spp.	Epinephelus spp.	Solea spp.	Synodontidae	Sepia officinalis	Penaeus spp.	Sardinella spp.	Pomatomus saltatrix	Sciaena aquila	Diplodus spp.	Sparus aurotus	Morone spp.	Mugil spp.	Cartilaginous Fishes	Chelonia spp.	Crabs	Trachiurus spp.	Other Fishes
1	728	750	235	800	680	161	350	-	-	205	158	15	85	57	55	55	100	-	2064
2	1357	800	640	350	1150	874	250	-	-	-	861	39	-	-	25	-	125	-	1778
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	167	325	300	-	375	175	-	-	-	-	175	18	-	-	-	-	-	-	602
5	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	9
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	730	375	725	50	1125	825	-	-	-	-	787	35	150	-	10	-	-	-	-
9	800	845	280	875	675	200	-	-	40	230	131	65	-	105	18	-	-	-	1407
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3577
11	450	400	-	400	250	-	-	-	-	-	76	35	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1071
13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	-	440	-	775	400	125	350	-	-	-	288	50	-	40	18	-	-	250	1785
17	1675	975	870	775	325	125	175	-	-	-	273	-	-	-	-	-	-	-	1412
18	275	150	-	200	275	150	-	275	-	-	136	100	-	-	-	-	-	-	991
19	1029	390	305	1150	675	408	450	-	-	130	542	-	-	-	-	-	-	-	2621
20	1150	545	495	1475	1475	1350	425	-	-	50	1332	-	-	-	-	-	-	-	2515
21	875	400	775	400	175	-	-	-	-	-	11	-	-	-	-	-	-	-	1200
22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	486	125	100	275	625	384	-	-	-	-	171	-	-	-	-	-	-	-	798
27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	547	100	25	650	195	3	8	-	-	-	57	-	-	-	-	-	-	650	1685
31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	10269	6620	4750	8175	8400	4780	2008	275	40	615	5002	357	235	202	126	55	225	900	23515

[a]All fish landings are reported in kilograms.

TABLE A.3-11

FISH LANDINGS[a]

Location: Eastern Harbor Date: Apr 78

Date	Mullus spp.	Pagrus spp.	Epinephelus spp.	Solea spp.	Synodontidae	Sepia officinalis	Penaeus spp.	Sardinella spp.	Sciaena aquila	Diplodus spp.	Sparus aurata	Dicentrarchus labrax	Mugil spp.	Cartilaginous Fishes	Chelonia spp.	Crabs	Trachiurus spp.	Other Fishes
1	198	50	25	-	300	150	-	125	-	125	-	-	-	33	-	-	150	2052
2	739	525	325	635	505	372	250	-	40	176	39	-	-	-	-	-	-	2215
3	-	150	-	-	-	-	-	-	-	225	75	-	-	-	-	-	-	70
4	525	175	310	200	175	100	250	-	190	608	297	-	15	-	-	-	25	899
5	300	150	25	-	1025	300	-	11075	-	651	99	-	-	-	-	-	400	933
6	100	75	-	100	75	75	-	3409	-	283	125	-	-	-	-	-	2220	675
7	375	200	160	25	875	375	-	1425	35	500	107	-	-	-	-	-	700	1907
8	175	425	285	275	160	50	50	10375	80	373	-	100	40	95	-	-	100	1594
9	300	275	50	-	550	375	-	12650	-	492	-	-	-	-	-	-	167	2503
10	-	100	60	-	-	-	-	11020	-	188	7	25	-	-	-	-	68	438
11	75	50	-	-	-	-	-	7650	-	72	53	-	-	-	-	-	70	1861
12	550	300	335	500	425	57	50	1660	45	527	103	15	40	265	-	-	125	1283
13	525	275	80	300	850	400	-	4475	87	329	105	-	-	-	-	-	181	2729
14	400	575	445	400	400	382	325	12307	150	730	122	-	-	15	-	-	105	4212
15	500	320	-	-	560	428	-	10300	-	95	87	-	-	-	-	-	180	997
16	225	165	273	300	275	254	200	4156	515	1270	-	55	6	20	-	-	-	1088
17	900	870	380	225	400	250	300	-	205	255	48	-	-	10	-	-	50	1253
18	225	255	125	275	275	150	125	-	-	459	22	-	-	78	-	-	-	1001
19	-	-	-	-	-	-	-	-	-	-	69	45	-	-	-	-	25	-
20	425	175	350	300	375	400	325	-	480	347	74	-	-	125	-	-	-	1971
21	345	205	160	235	965	530	270	-	-	191	60	-	-	7	-	-	1080	1210
22	400	225	-	125	100	75	50	50	-	95	158	-	-	265	-	-	-	709
23	675	1250	625	700	1425	875	125	-	-	400	57	10	-	40	-	-	-	2722
24	-	-	-	-	-	-	-	-	-	-	38	-	-	12	-	-	-	-
25	-	-	-	-	-	-	-	25	-	-	255	-	-	-	-	-	-	-
26	225	300	100	-	200	150	-	1245	25	377	100	-	-	-	-	-	-	941
27	725	225	145	165	860	475	-	180	-	760	225	-	-	-	-	-	-	748
28	154	58	49	150	-	3	-	5525	-	176	-	-	-	-	-	-	-	908
29	560	304	-	-	600	-	-	945	-	104	25	-	-	-	-	-	-	59
30	625	600	375	425	350	500	275	-	-	427	-	-	-	-	-	-	-	2985
TOTAL	10246	8277	4682	5335	11725	6726	2595	99193	1852	10235	2350	250	101	965	-	-	5646	40663

[a] All fish landings are reported in kilograms.

TABEL A.3-12

FISH LANDINGS[a]

Location: Eastern Harbor Date: May 78

Date	Mullus spp.	Pagrus spp.	Epinephelus spp.	Solea spp.	Synodontidae	Sepia officinalis	Penaeus spp.	Sardinella spp.	Pomatomus saltatrix	Sciaena aquila	Diplodus spp.	Sparus auratus	Dicent-rarchus spp.	Cartila-ginous Fishes	Chelonia spp.	Crabs	Other Fishes
1	125	50	80	30	175	75	-	500	-	-	210	144	5	50	-	-	640
2	-	120	15	-	-	-	-	1980	-	-	216	337	-	-	-	-	3040
3	200	100	315	-	260	175	75	7900	-	40	70	150	-	60	25	-	1572
4	250	792	-	575	475	250	-	12560	-	-	182	193	45	-	-	-	3317
5	270	125	115	-	275	125	-	11700	-	-	171	180	-	-	-	-	2495
6	525	460	630	325	275	175	-	420	-	40	136	200	25	289	-	-	4975
7	-	-	-	-	-	-	-	5690	-	-	62	347	-	120	-	-	1755
8	475	207	110	-	325	150	100	2080	-	50	148	350	-	-	-	-	2900
9	200	150	225	-	100	-	-	3980	-	-	85	500	6[illegible]	30	-	25	3745
10	500	485	-	-	450	250	-	2345	-	65	220	100	-	-	-	-	891
11	825	400	215	100	1050	340	140	3700	-	-	153	320	-	200	-	-	2240
12	300	210	40	150	250	250	50	1020	-	-	248	133	-	-	-	-	1593
13	-	-	-	-	-	-	-	1180	-	60	307	150	-	75	-	-	1875
14	425	175	-	400	400	150	-	10440	-	-	158	28	25	-	-	-	3070
15	300	195	-	80	300	120	60	9380	-	85	280	92	-	145	-	-	7105
16	450	250	180	250	350	-	-	13470	-	-	265	106	-	50	-	-	20
17	780	395	45	-	660	-	-	3645	-	10	822	50	-	89	-	-	224
18	1225	775	60	800	1000	300	60	1320	-	24	655	42	-	80	-	-	176
19	-	-	185	-	-	210	-	226	-	145	535	50	-	-	-	-	68
20	625	70	165	100	-	-	-	320	-	290	615	117	-	155	-	-	129
21	315	130	145	150	550	240	130	328	27	370	175	89	-	-	-	-	265
22	700	90	190	200	200	-	50	420	-	210	345	86	-	155	-	-	148
23	450	195	130	140	440	100	140	481	325	95	590	121	-	-	-	-	85
24	125	105	273	175	150	-	-	325	-	-	629	134	-	255	-	-	207
25	475	230	190	200	640	280	270	379	1100	-	410	88	-	-	-	-	187
26	275	235	225	275	225	-	-	990	-	-	420	136	-	170	-	-	182
27	400	160	55	80	440	180	100	6760	350	-	185	31	-	165	-	-	505
28	625	225	190	275	200	-	-	1103	-	-	190	-	-	75	-	-	515
29	170	40	-	60	160	60	60	7413	-	-	-	-	-	90	-	-	251
30	725	765	505	100	600	575	75	880	-	-	575	-	-	315	-	-	447
TOTAL	11735	7134	4283	4465	9950	4005	1260	112935	1802	1484	9057	4274	16	2568	25	25	44622

[a] All fish landings are reported in kilograms.

TABLE A.3-13

FISH LANDINGS[a]

Location: Eastern Harbor Date: Jun 78

Date	Mullus spp.	Pagrus spp.	Epinephelus spp.	Solea spp.	Synodontidae	Sepia officinalis	Penaeus spp.	Sardinella spp.	Pomatomus saltatrix	Sciaena aquila	Diplodus spp.	Sparus auratus	Mugil spp.	Cartilaginous Fishes	Trachynotus ovatus	Crabs	Trachiurus spp.	Scomber scombrus	Other fishes
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	75	192	523	75	25	-	25	16808	335	-	149	57	-	270	-	-	140	-	1435
4	380	180	810	120	460	160	140	35760	390	300	251	844	-	430	-	-	-	-	623
5	125	125	245	125	75	-	-	12670	-	-	125	20	-	25	-	-	20	-	244
6	-	-	-	-	-	-	-	5060	-	-	88	42	-	-	-	-	-	-	318
7	-	-	-	-	-	-	-	3420	105	25	37	15	-	-	-	-	480	-	626
8	25	65	300	-	-	50	-	5230	1000	-	138	4	-	66	-	-	860	-	5135
9	25	60	275	25	25	-	-	12025	625	-	206	54	-	25	-	-	260	-	2558
10	3800	2825	915	250	875	1100	450	39168	-	435	519	187	-	85	-	-	425	-	4820
11	25	-	365	375	700	150	300	20410	123	-	147	17	-	525	190	-	135	980	1360
12	2350	2055	720	100	1125	725	1075	28230	875	380	244	12	-	876	583	-	280	1240	2916
13	650	1030	890	250	275	250	675	13510	876	-	693	217	-	170	-	-	1100	-	7569
14	1000	825	400	900	925	932	1225	18294	3156	375	435	97	-	175	115	-	80	1575	1499
15	575	1400	305	-	-	150	325	23555	1150	60	362	-	-	270	175	-	150	250	3892
16	-	50	170	-	-	-	-	19125	995	-	37	28	-	25	64	-	895	1775	1231
17	375	937	590	-	-	25	-	1235	1320	145	199	32	-	140	-	-	-	-	1845
18	525	1850	810	225	25	75	425	2005	2185	520	148	38	-	160	-	-	-	-	1890
19	875	780	230	350	250	200	475	2185	2800	155	405	232	-	90	105	-	-	-	2154
20	1825	1575	290	550	450	475	750	1070	3925	290	265	142	-	366	-	-	-	-	2211
21	1300	17250	875	375	650	250	200	1990	4175	515	142	181	-	550	15	5	-	-	4828
22	775	915	265	950	1050	225	475	3285	3440	75	320	130	-	157	50	-	-	-	3105
23	650	925	140	100	250	200	200	5305	2145	75	79	61	-	165	-	-	-	-	1584
24	75	75	65	75	75	25	75	790	2635	-	115	39	-	-	38	-	-	-	-
25	825	675	240	125	300	125	100	893	1379	331	132	6	-	-	219	-	-	-	925
26	475	375	150	400	325	100	175	15564	400	125	14	-	-	-	50	-	-	-	887
27	-	-	-	-	-	-	-	26705	1105	-	23	-	-	-	90	-	100	-	360
28	-	-	-	-	-	-	-	9015	1915	-	66	14	-	-	275	220	-	-	563
29	5	20	-	-	-	-	625	22300	1350	-	89	71	-	45	200	-	1175	850	3935
30	450	600	-	-	675	75	425	5425	1145	-	224	4	-	10	32	-	2075	475	3533
TOTAL	16185	18559	9573	5370	8535	5362	8140	352032	39549	3806	5352	2344	-	4625	2201	225	6375	7145	62026

[a] All fish landings are reported in kilograms.

TABLE A.3-14

FISH LANDINGS[a]

Location: Eastern Harbor Date: July 78

Date	Mullus spp.	Sparus spp.	Epinephelus spp.	Sciaena spp.	Sardinella spp.	Pagrus spp.	Solea Solea	Saurida spp.	Sepia spp.	Penaeus spp.	Sargus Sargus	Dicentrarchus spp.	Mugil spp.	Pomatomus Saltatrix	Other Fishes
1					6825						61			1680	90
2					17210										
3					12425									645	65
4					37805									3360	
5			820		33080									1465	1830
6					14080									300	580
7					11875									1000	150
8	650					300	360	1150	440		143			1220	1660
9					2225									475	1215
10		20			3150									300	150
11					900									1817	150
12					2235									1140	3600
13			250		775	25					63			1995	965
14					500									480	180
15	480		1595	555	185	960	120	440	380	940	147			2409	2825
16	620			480	3030	585	375	540	375	1260	74			745	5400
17	205	250	300	225	1745	225	125	475	125	650	125			705	1350
18	525			450	6110	625		1125	25	400	83			3525	1300
19	305	60	50	225	2835	250	50	625	125	750				1675	1253
20	275			350	4230	150	150	850	150	1175	62			1555	1575
21	125	90	192	600	24675	525	325	1325	250	2300				3828	3125
22	200			325	1872	100	125	925	125	1250	470				1790
23	900		500	325	1115	695	350	550	225	975				540	1550
24	700	41	160	325	173	650	250	260	275	550	102	25		1597	850
25	2600	135	775	95	142	1850	925	2450	525	2600	9			414	2684
26	675	17	1310	700		525	325	475	325	525	475		25	2582	2219
27	625	1015	465	125	1391	400	275	275	75	375	140			360	400
28	1850	160	695	50	892	1225	1150	1800	700	1700	26			573	4225
29	200	7	1430	800		322	50	125	50	435	65			1551	1780
30	2025	223	955	50	120	1435	575	825	625	775				1241	2100
31	775	80	1300	255		500	325	625	375	500				2123	1075
TOTAL	13735	2078	10797	5915	239517	11347	5855	14840	5180	17490	2064	25	25	41300	47608

[a] All fish landings are reported in kilograms.

TABLE A.3-15

FISH LANDINGS[a]

Location: Abu Kir Date: Aug 77

Date	Epinephelus spp.	Diplodus spp.	Mullus spp.	Mugil spp.	Sparus auratus	Pomatomus saltatrix	Dicentrarchus ovatus	Pagrus spp.	Synodontidae	Sardinella spp.	Sepia officinalis	Solea spp.	Crabs	Sciaena aquila	Panaeus spp.	Other Fisnes
1	-	-			-	-	-	-	-	75	170	130	130	-	825	600
2	60	140			-	-	-	35	-	-	80	120	250	-	550	390
3	60	60			-	-	-	15	-	490	115	155	315	-	805	625
4	360	35			-	-	-	35	-	220	85	80	250	-	390	580
5					-	-	-	-	-	-	120	175	-	-	790	435
6					-	-	-	-	-	-	115	135	25	-	595	455
7					-	-	-	-	-	315	-	-	220	-	-	-
8					-	-	-	-	-	510	10	15	-	-	65	60
9		15	25		-	-	-	-	-	500	70	55	185	-	280	270
10	60				-	-	-	30	-	100	160	142	75	-	1075	785
11	85		30	25	30	-	-	-	-	320	32	170	95	20	650	335
12		155			-	-	-	-	-	335	25	35	210	-	300	390
13	385	190	190		-	-	-	-	-	400	45	35	320	-	190	420
14	145	260	132		-	-	-	45	-	-	225	245	230	-	1110	745
15	85	145	15		-	-	-	-	-	260	82	140	125	-	420	435
16		105	20		-	-	-	-	-	-	115	210	75	-	830	695
17					-	-	-	-	-	-	45	75	90	-	282	360
18		60	25		-	-	-	-	-	-	55	65	170	-	220	210
19					-	-	-	-	-	-	15	20	-	-	115	100
20	200	135			-	-	-	-	200	-	82	145	165	-	610	395
21		60			-	-	-	-	195	-	155	170	80	-	730	765
22			100		-	-	-	-	-	-	97	102	-	-	512	335
23	320	235	200	75	-	-	-	-	-	-	115	75	250	570	485	900
24	95	350	235		-	-	-	-	-	-	120	152	182	790	855	745
25	60	215	230		-	-	-	-	-	-	104	215	295	-	922	870
26			90		-	-	-	-	-	-	50	35	150	-	245	225
27	70		220		-	-	-	-	-	-	39	92	75	-	512	370
28					-	-	-	-	-	-	-	-	-	-	-	-
29	95	155	340		-	-	-	60	-	-	67	46	180	-	563	410
30	430	260	270		-	60	-	80	-	-	45	45	97	155	380	465
31	270	215	305		-	-	-	80	-	-	85	100	210	-	385	575
TOTAL	2780	2790	2427	100	30	60	-	380	395	3525	2523	3179	4449	1535	15691	13945

[a]All fish landings are reported in kilograms.

TABLE A.3-16

FISH LANDINGS[a]

Location: Abu Kir Date: Sep 77

Date	Penaeus spp.	Crabs	Solea spp.	Sepia officinalis	Sardinella spp.	Synodontidae	Pagrus spp.	Dicentrarchus ovatus	Pomatomus saltatrix	Sparus auratus	Sciaena aquila	Mugil spp.	Mullus spp.	Diplodus spp.	Epinephelus spp.	Other Fishes
1	655	35	66	122	-	-	-	-	-	-	-	-	407	110	350	695
2	533	25	180	180	-	-	185	-	-	-	-	-	360	-	460	525
3	848	176	191	173	-	-	133	-	-	-	-	-	486	217	315	880
4	35	70	-	140	-	-	-	-	-	145	-	-	380	60	250	475
5	314	22	67	90	-	-	27	47	-	65	-	-	305	127	322	819
6	648	40	195	135	-	-	-	-	-	-	40	-	590	-	500	850
7	618	60	185	202	-	-	-	35	-	-	20	-	680	130	-	1022
8	414	177	85	120	-	-	162	-	-	-	-	-	260	32	385	350
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	235	177	45	60	-	-	35	-	-	-	-	30	180	90	470	215
11	319	112	47	64	50	-	145	-	-	-	-	25	95	165	700	705
12	208	92	50	10	-	-	35	-	-	-	-	-	131	212	240	315
13	503	175	89	95	-	-	85	65	35	-	60	-	620	160	835	1160
14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	69	15	10	15	-	-	-	-	-	-	-	-	25	-	-	-
18	38	219	59	69	-	-	65	-	-	-	80	-	132	102	80	410
19	242	110	95	83	-	-	35	-	-	-	-	-	200	214	265	595
20	250	284	100	92	-	-	35	-	-	-	130	-	255	75	70	705
21	765	215	259	275	-	-	-	-	-	-	182	-	860	215	-	1410
22	445	210	32	31	-	-	-	-	-	-	140	-	320	42	75	335
23	55	105	10	35	-	-	-	75	-	75	140	-	200	-	90	300
24	65	165	-	15	-	-	160	-	-	-	37	-	60	-	100	175
25	70	142	15	40	-	-	-	-	-	-	30	-	80	15	60	100
26	255	85	49	105	-	-	-	-	-	-	30	-	290	-	-	310
27	323	157	50	97	-	-	-	-	-	-		-	240	100	-	135
28	-	90	-	-	-	-	-	-	-	-	25	-	-	-	-	-
29	363	40	90	117	70	-	-	-	-	-	-	-	270	40	-	570
30	45	-	35	40	-	-	-	-	-	-	-	-	60	-	-	100
Total	8315	2998	2004	2405	120	-	1102	222	35	285	914	55	7486	2106	5567	13156

[a] All fish landings are reported in kilograms.

TABLE A.3-17

FISH LANDINGS[a]

Location: Abu Kir Date: Oct 77

Date	Epinephelus spp.	Diplodus spp.	Mullus spp.	Sciaena aquila	Mugil spp.	Sparus auratus	Pomatomus saltatrix	Dicentrarchus ovatus	Pagrus spp.	Synodontidae	Sardinella spp.	Sepia officinalis	Solea spp.	Crabs	Penaeus spp.	Other Fishes
1	-	50	580	130	-	-	-	-	-	-	180	215	225	285	555	775
2	60	-	360	150	-	-	-	-	30	-	-	160	115	155	370	505
3	80	110	165	100	40	-	-	-	40	-	-	65	55	365	215	470
4	360	60	580	150	60	255	-	50	40	-	-	355	-	482	120	855
5	-	-	590	40	-	280	-	-	-	-	-	255	-	130	345	820
6	182	140	370	90	-	220	-	75	65	-	-	115	-	160	260	540
7	280	105	565	190	30	385	-	-	105	-	-	260	146	265	430	1183
8	335	120	140	325	-	80	-	35	-	-	-	80	60	400	135	365
9	20	40	60	-	-	-	-	-	-	-	-	20	15	90	39	150
10	200	-	640	-	-	-	-	-	-	-	-	190	130	-	520	840
11	-	60	820	30	-	320	-	-	100	-	-	160	169	65	459	815
12	80	70	365	60	15	170	-	-	-	-	-	140	75	225	214	465
13	1190	530	330	100	40	265	-	80	285	-	-	82	70	399	225	1552
14	260	20	375	-	-	200	-	-	275	-	-	142	-	95	29	1205
15	550	-	665	-	-	345	-	-	35	-	-	205	-	150	431	1225
16	60	-	598	-	24	520	-	-	25	-	-	316	-	40	532	2130
17	-	75	220	-	-	195	-	-	60	-	-	100	-	-	125	415
18	-	60	620	-	-	300	-	-	105	-	-	160	-	-	260	865
19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	-	10	253	-	65	236	-	-	-	-	-	69	-	-	101	694
21	280	115	392	75	-	305	-	-	165	-	-	207	32	239	248	769
22	285	272	680	460	-	480	-	-	35	-	-	382	90	156	297	1758
23	-	54	91	40	-	74	-	-	-	-	-	65	30	55	37	250
24	-	-	420	-	-	380	-	-	-	-	-	289	-	-	489	730
25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	1015	105	235	480	-	160	-	-	-	-	-	134	-	25	228	615
27	340	40	440	470	40	300	-	-	25	-	-	249	-	-	320	215
28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	-	75	300	40	-	60	-	-	-	-	-	200	-	170	109	512
30	-	35	380	-	-	257	-	-	-	-	-	255	-	105	351	844
31	130	-	220	60	-	150	-	-	45	-	-	135	-	102	270	510
TOTAL	5707	2146	11454	2990	314	5937	-	240	1435	-	180	5005	1212	4158	7714	22072

[a] All fish landings are reported in kilograms.

TABLE A.3-18

FISH LANDINGS[a]

Location: Abu Kir Date: Nov 77

Date	Epinephelus spp.	Diplodus spp.	Mullus spp.	Sciaena aquila	Mugil spp.	Sparus auratus	Pomatomus saltatrix	Dicentrarchus ovatus	Pagrus spp.	Synodontidae	Sardinella spp.	Sepia officinalis	Solea spp.	Crabs	Penaeus spp.	Other Fishes
1	-	30	480	-	-	393	-	-	-	-	-	295	15	100	651	950
2	-	60	500	100	-	265	-	-	-	-	-	305	-	-	608	935
3	300	70	240	170	-	240	-	-	-	-	-	240	95	87	625	1147
4	170	20	210	70	-	222	-	-	25	-	-	285	-	25	497	880
5	-	40	210	20	-	200	-	-	40	-	420	180	40	-	235	700
6	645	115	109	14	-	112	-	-	-	-	-	98	59	87	296	955
7	-	100	375	90	40	210	-	-	-	-	-	300	153	159	557	898
8	-	-	257	15	-	180	-	-	-	-	-	240	93	54	640	745
9	-	15	287	100	-	248	-	-	-	-	-	319	157	40	712	1044
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	60	-	108	-	10	125	-	-	-	-	-	87	54	49	229	415
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	45	-	-	-	-	-	-	-	-	20	-	15	30	595
14	120	10	157	-	-	380	-	-	-	-	-	175	74	45	645	1050
15	395	65	155	40	-	110	-	-	-	-	-	105	60	65	209	605
16	95	-	343	-	-	342	-	-	15	-	-	344	-	-	546	825
17	-	-	162	-	-	157	-	-	-	-	-	175	40	127	318	545
18	737	157	231	-	-	-	-	-	14	-	-	120	87	-	385	1014
19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	227	147	150	150	-	94	-	-	80	-	-	110	47	-	219	710
25	335	75	285	140	-	245	-	-	260	-	-	200	125	-	456	770
26	-	-	540	-	-	325	-	-	-	-	-	295	165	-	566	835
27	30	-	205	-	-	99	-	-	-	-	-	60	38	3	201	370
28	-	-	140	-	-	100	-	-	-	-	-	100	-	-	124	235
29	260	-	75	32	-	70	-	-	-	-	-	45	-	102	140	260
30	-	-	120	-	-	110	-	-	-	-	-	160	-	-	308	485
TOTAL	3374	904	5384	941	50	4227	-	-	434	-	420	4258	1302	933	9197	16968

[a] All fish landings are reported in kilograms.

TABLE A.3-19

FISH LANDINGS[a]

Location: Abu Kir Date: Dec 77

Date	Epinephelus spp.	Diplodus spp.	Mullus spp.	Sciaena aquila	Mugil spp.	Sparus auratus	Pomatomus saltatrix	Dicent-rarchus spp.	Pagrus spp.	Synodontidae	Sardinella spp.	Sepia officinalis	Solea spp.	Crabs	Penaeus spp.	Other Fishes
1	490	380	-	-	-	250	-	-	-	-	-	255	-	-	451	942
2	-	70	225	32	-	135	-	-	-	-	-	169	-	10	291	502
3	360	-	160	-	-	435	-	-	-	-	-	140	-	-	295	595
4	-	-	95	-	-	175	-	-	-	-	-	155	-	-	344	440
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	-	40	52	-	15	49	-	-	-	-	-	39	-	-	123	195
8	360	167	175	30	-	160	75	-	125	-	-	175	65	-	351	509
9	-	-	327	-	-	290	-	-	-	-	-	299	-	85	613	895
10	-	167	140	40	-	70	25	-	-	-	-	100	-	45	210	376
11	560	105	65	80	-	70	-	-	260	-	-	65	-	-	117	351
12	-	-	222	-	-	195	-	-	-	-	-	240	147	-	472	490
13	-	-	495	-	-	415	-	-	-	-	-	451	260	-	852	1220
14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	-	65	99	100	-	125	-	-	-	-	-	79	57	-	244	387
19	140	60	75	75	-	100	-	-	-	-	-	52	39	-	185	425
20	440	-	300	-	-	155	-	-	-	-	-	180	80	-	505	840
21	-	-	265	-	-	225	-	-	-	-	-	250	119	-	594	730
22	-	-	141	45	-	100	-	-	-	-	-	100	67	-	282	270
23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	20	70	55	-	-	80	-	-	-	-	-	64	52	-	188	705
26	-	125	187	102	-	197	-	-	-	-	-	195	109	45	572	680
27	-	-	275	-	-	200	-	-	-	-	-	240	154	-	641	535
28	-	-	180	50	-	120	-	-	-	-	-	110	65	-	255	300
29	-	-	107	210	-	85	-	-	-	-	-	53	-	-	144	252
30	30	217	320	100	-	330	40	-	80	-	-	305	204	-	705	680
31	1010	202	340	-	-	290	-	-	10	-	-	385	110	-	440	1230
TOTAL	3410	1668	4300	864	15	4251	140	-	475	-	-	4101	1528	185	8874	13549

[a] All fish landings are reported in kilograms.

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TABLE A.3-20

FISH LANDINGS[a]

Location: Abu Kir Date: Jan 78

Date	Epinephelus spp.	Diplodus spp.	Sciaena aquila	Mugil spp.	Sparus auratus	Pomatomus saltatrix	Dicentrarchus spp.	Pagrus spp.	Synodontidae	Sardinella spp.	Sepia officinalis	Solea spp.	Mullus spp.	Crabs	Penaeus spp.	Other Fishes
1	110	-	-	-	340	-	-	-	-	-	380	209	460	-	574	1120
2	-	-	-	-	140	-	-	-	-	-	120	80	320	-	115	400
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	-	20	90	-	220	-	-	-	-	-	145	-	274	-	-	370
7	180	102	85	-	140	-	-	35	-	-	140	-	185	-	90	499
8	-	-	-	-	140	-	-	-	-	-	70	67	100	-	50	250
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	-	15	-	-	155	100	-	-	-	-	99	74	145	-	-	360
13	970	110	-	-	230	-	-	-	-	-	150	80	265	-	105	1370
14	420	250	-	-	330	-	-	-	-	-	335	185	480	-	480	1349
15	1370	235	80	-	10	75	-	110	-	-	75	-	135	-	94	1030
16	690	15	64	-	200	25	-	-	-	-	170	100	305	-	285	970
17	30	-	82	-	200	-	-	10	-	-	170	102	245	-	328	465
18	-	-	-	-	50	40	-	-	-	-	115	25	80	25	59	156
19	-	-	-	-	50	-	-	-	-	-	119	24	60	21	60	200
20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	71	-	-	-	-	-	119	151	125	-	172	310
23	290	30	-	-	119	-	-	-	-	-	270	120	165	-	264	980
24	-	40	70	15	100	40	-	-	-	-	115	135	155	-	204	560
25	-	20	-	-	360	-	-	-	-	-	435	310	385	-	555	1190
26	-	-	60	-	285	-	-	-	-	-	297	245	580	-	350	645
27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	190	75	40	-	35	-	-	-	-	-	204	145	45	-	74	540
30	10	165	60	-	-	-	-	15	-	-	367	110	240	-	92	580
31	20	15	-	-	210	-	-	-	-	-	335	177	325	-	170	695
TOTAL	4080	1092	691	15	3475	280	-	170	-	-	4390	2139	5074	46	4081	14083

[a] All fish landings are reported in kilograms.

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TABLE A.3-21

FISH LANDINGS[a]

Location: Abu Kir Date: Feb 78

Date	Penaeus spp.	Crabs	Solea spp.	Sepia officinalis	Sardinella spp.	Synodontidae	Pagrus spp.	Dicentrarchus ovatus	Pomatomus saltatrix	Sparus auratus	Mugil spp.	Sciaena aquila	Mullus spp.	Diplodus spp.	Epinephelus spp.	Other Fishes
1	322	-	372	605	-	-	35	80	-	560	-	-	600	130	210	1300
2	175	-	155	235	-	-	-	-	-	195	-	-	255	-	-	595
3	240	-	121	175	-	-	-	-	-	176	-	-	280	-	-	575
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	29	-	60	70	200	-	-	-	-	80	-	-	45	-	420	495
6	285	-	340	485	-	-	-	-	25	415	-	20	435	30	-	1045
7	110	-	55	60	-	-	-	-	-	70	-	-	100	-	-	225
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	42	-	25	60	-	-	-	-	-	25	-	-	-	45	-	130
12	440	-	195	245	410	-	-	-	60	225	-	-	320	30	-	860
13	465	-	225	370	-	-	65	-	30	295	-	-	360	100	250	1020
14	390	-	210	445	-	-	115	45	90	505	-	65	560	140	215	1117
15	444	-	125	230	-	-	-	-	-	-	-	-	-	235	-	615
16	240	-	70	120	-	-	140	-	-	135	-	80	220	-	-	430
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	115	-	-	110	-	-	-	-	-	-	-	-	60	-	-	140
20	180	-	35	90	-	-	15	-	-	100	-	-	140	40	-	290
21	220	-	85	160	-	-	-	-	-	95	-	-	145	-	85	370
22	485	-	335	320	-	-	-	-	-	325	-	-	480	-	-	1176
23	250	-	80	150	-	-	-	-	-	130	-	-	200	-	-	440
24	764	-	209	400	-	-	45	80	-	460	-	35	467	80	-	925
25	78	-	25	55	-	-	-	-	-	35	-	-	35	20	35	230
26	1042	-	380	140	-	-	30	-	-	115	20	-	135	100	-	1565
27	406	-	130	540	-	-	-	-	-	515	-	-	610	100	230	676
28	400	-	135	224	-	-	-	-	-	210	-	-	315	45	-	630
29	-	-	-	-	-	-	-	-	-	-	-	-				
TOTAL	7,122		3,367	5,289	610		445	205		4,666	20	200	5,752	1,235	1,445	14,848

[a] All fish landings are reported in kilograms.

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TABLE A.3-22

FISH LANDINGS[a]

Location: Abu Kir Date: Mar 78

Date	Epinephelus spp.	Diplodus spp.	Mullus spp.	Sciaena aquila	Mugil spp.	Sparus auratus	Pomatomus saltatrix	Dicentrarchus spp.	Pagrus spp.	Synodontidae	Sardinella spp.	Sepia officinalis	Solea spp.	Crabs	Penaeus spp.	Other Fishes
1	75	100	305	65	-	205	60	-	85	-	100	245	155	-	290	950
2	-	-	110	-	-	80	100	-	-	-	80	55	55	-	164	280
3	-	20	110	-	-	65	15	-	-	-	120	160	50	-	180	210
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	-	40	135	-	-	115	-	-	-	-	-	170	-	-	150	300
8	20	100	330	-	-	340	-	-	-	-	-	250	30	-	360	900
9	150	75	215	-	-	210	100	-	-	-	-	170	39	15	290	675
10	-	100	505	-	-	407	-	75	55	-	-	425	235	20	585	1510
11	-	-	200	-	-	165	-	-	-	-	-	145	75	-	165	490
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	-	-	240	-	15	320	-	-	-	-	-	150	35	-	249	869
17	32	75	95	-	-	200	115	-	-	240	-	125	-	10	170	335
18	100	95	85	-	-	95	-	-	70	-	-	135	55	30	160	505
19	20	20	45	-	-	-	70	-	-	-	-	100	30	-	110	330
20	480	110	65	20	-	95	-	-	-	140	-	35	-	-	120	745
21	-	-	325	-	-	210	-	-	-	215	-	100	100	-	210	490
22	-	-	95	-	-	85	-	-	-	70	-	65	30	-	100	170
23	-	-	67	-	-	85	-	-	-	115	-	40	18	-	93	245
24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30
26	-	-	168	-	-	-	-	-	-	850	-	-	-	-	1020	1685
27	-	-	-	-	-	-	-	-	-	315	-	40	-	-	165	225
28	-	-	-	-	-	-	150	-	-	30	-	10	-	30	30	75
29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	-	-	140	-	-	-	130	-	20	-	-	35	155
31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	912	735	3095	85	15	2817	610	75	210	2105	300	2440	1097	105	4646	11170

[a]All fish landings are reported in kilograms.

TABLE A.3-23

FISH LANDINGS[a]

Location: Abu Kir Date: Apr 78

Date	Epinephelus spp.	Diplodus spp.	Mullus spp.	Mugil spp.	Sparus auratus	Pomatomus saltatrix	Dicentrarchus spp.	Pagrus spp.	Synodontidae	Sardinella spp.	Sepia officinalis	Solea spp.	Crabs	Sciaena aquila	Penaeus spp.	Other Fishes
1	-	-	-	-	-	-	-	-	-	-	70	-	85	-	-	45
2	-	20	50	-	125	-	-	-	250	-	215	80	15	-	155	490
3	-	60	70	-	100	-	40	-	60	-	35	40	-	35	55	275
4	-	25	5	-	375	-	-	-	595	100	10	129	5	-	414	990
5	-	20	-	-	300	6	-	15	440	-	152	205	-	-	580	560
6	-	-	-	-	60	15	-	-	100	-	55	-	-	20	40	225
7	-	150	15	-	350	-	-	-	510	-	230	-	29	-	584	1290
8	60	115	30	-	265	-	-	-	390	-	167	134	91	-	608	885
9	80	245	195	-	310	-	-	220	385	80	165	116	20	-	631	1265
10	-	165	130	-	70	-	-	140	-	-	76	-	25	-	-	368
11	195	100	160	-	510	-	35	205	785	-	391	-	10	60	679	1330
12	80	80	196	-	471	-	-	35	705	-	154	-	-	6	728	1750
13	320	220	40	-	55	-	1	102	310	90	177	-	-	20	327	1145
14	-	200	-	-	100	25	-	60	510	-	167	-	-	-	687	792
15	20	35	-	-	100	-	-	120	310	105	69	19	15	-	419	740
16	95	190	170	-	-	-	85	60	175	-	192	55	5	35	320	635
17	-	95	165	-	-	-	75	100	360	640	170	95	-	20	610	915
18	320	-	-	-	-	-	-	170	455	500	187	60	-	-	632	775
19	-	-	-	-	-	-	-	-	285	-	190	105	-	40	480	535
20	85	35	102	-	-	-	-	65	220	560	125	-	-	-	345	415
21	190	310	150	-	-	-	105	265	630	140	360	244	53	-	1414	2170
22	115	45	-	-	-	-	-	39	240	-	150	107	25	-	340	485
23	420	115	-	-	-	-	-	170	585	-	300	215	64	-	928	1690
24	-	-	60	-	-	-	-	65	145	-	55	40	-	-	195	325
25	-	60	60	-	-	-	-	80	-	-	100	-	29	-	17	45
26	250	100	-	-	-	-	-	75	155	197	65	70	-	-	286	457
27	340	-	-	-	-	-	-	84	410	220	78	108	105	-	629	915
28	940	55	-	30	-	-	-	35	295	-	83	55	-	-	445	880
29	-	75	-	-	-	-	-	30	40	635	15	10	-	-	75	75
30	610	-	-	-	-	-	-	-	140	400	34	24	-	-	315	620
31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	4120	2515	1598	30	3191	46	341	2135	9485	3667	4237	1911	576	236	12938	23087

[a] All fish landings are reported in kilograms

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TABLE A.3-24

FISH LANDINGS[a]

Location: Abu Kir Date: May 78

Date	Epinephelus spp.	Diplodus spp.	Mullus spp.	Mugil spp.	Sparus auratus	Pomatomus saltatrix	Dicentrarchus spp.	Pagrus spp.	Synodontidae	Sardinella spp.	Sepia officinalis	Solea spp.	Crabs	Sciaena aquila	Penaeus spp.	Other Fishes
1	20	10	-	-	-	-	-	-	255	60	109	149	-	-	482	685
2	-	160	-	-	-	-	-	-	135	-	54	15	25	40	240	185
3	-	205	-	-	-	-	-	75	25	-	80	11	85	-	75	205
4	550	135	35	-	-	-	-	70	415	-	82	83	-	-	892	1195
5	-	-	-	-	-	-	-	75	220	-	-	55	90	45	372	475
6	315	125	151	-	100	-	-	20	440	835	50	25	-	200	895	1170
7	66	90	75	-	40	-	-	-	140	20	20	23	15	-	188	895
8	990	22	104	-	80	-	-	-	120	-	40	35	-	-	375	804
9	605	290	75	-	85	-	-	230	230	-	50	95	-	100	525	730
10	-	20	-	-	-	-	-	-	315	1180	72	182	27	-	729	582
11	440	160	75	-	-	-	-	90	135	40	25	60	105	-	335	720
12	630	200	60	-	-	-	-	91	170	-	130	65	35	35	350	1055
13	-	-	-	-	-	-	-	-	465	-	134	110	18	-	1065	1000
14	40	40	-	-	-	-	-	-	245	-	49	125	39	-	652	550
15	320	367	-	-	-	-	-	-	40	-	60	20	112	-	52	550
16	280	232	25	-	-	-	-	75	335	-	277	158	100	180	610	1214
17	335	265	60	-	-	75	35	285	370	230	125	75	45	70	610	1125
18	115	20	10	10	-	-	-	36	175	-	60	70	10	45	395	583
19	117	469	-	-	-	-	-	187	572	75	138	314	223	40	1716	1409
20	-	140	180	-	-	-	-	275	90	-	30	60	115	-	395	830
21	-	-	-	-	-	15	-	-	165	865	62	90	40	-	475	545
22	45	75	-	-	-	-	-	15	125	740	49	157	-	-	532	665
23	20	340	145	-	-	-	-	175	45	-	10	20	-	-	115	685
24	125	180	-	-	-	-	-	105	90	410	89	80	72	-	445	682
25	-	100	-	-	-	-	-	120	540	460	10	40	-	75	215	420
26	50	205	-	-	-	-	-	-	365	230	77	210	45	-	1295	1040
27	75	169	-	-	-	-	-	25	345	815	73	170	137	-	960	629
28	-	60	-	-	-	-	-	-	455	330	115	260	-	-	1320	965
29	-	100	75	-	-	-	-	150	90	265	45	70	-	60	480	590
30	300	180	85	-	60	-	-	435	320	550	90	200	-	-	930	1330
31	375	105	140	-	-	-	-	220	195	-	42	120	-	-	555	756
TOTAL	5813	4464	1295	10	365	90	35	2754	7627	7105	2247	3147	1338	890	18275	24269

(a) All fish landings are reported in kilograms.

TABLE A.3-25

FISH LANDINGS[a]

Location: Abu Kir Date: Jun 78

Date	Epinephelus spp.	Diplodus sargus	Mullus spp.	Sciaena aquila	Mugil spp.	Sparus auratus	Pomatomus saltatrix	Dicentrarchus spp.	Pagrus spp.	Synodontidae	Sardinella spp.	Sepia officinalis	Crabs	Penaeus spp.	Solea spp.	Other Fishes
1	15	-	-	-	-	-	-	-	-	115	-	65	56	240	100	185
2	-	95	-	-	75	-	77	-	-	45	-	27	134	150	32	332
3	70	-	-	-	-	-	-	-	40	-	650	-	90	-	-	160
4	140	175	-	-	60	-	-	-	-	115	250	-	125	394	52	1628
5	115	245	45	-	-	-	-	-	-	480	-	123	515	1649	346	4888
6	60	290	100	-	60	171	-	-	95	390	200	35	269	1338	232	4266
7	745	112	35	-	30	-	-	-	25	410	575	126	67	1315	290	5148
8	260	317	-	-	-	-	45	-	85	22	1615	90	170	705	121	3390
9	350	-	-	-	-	-	315	-	-	240	-	35	-	525	90	840
10	180	95	75	-	-	-	-	-	100	120	933	25	90	445	75	695
11	245	282	-	-	35	-	-	-	155	-	300	-	47	1431	295	805
12	215	49	60	-	-	-	-	-	272	40	1260	10	100	150	15	1110
13	510	425	145	-	-	-	-	-	275	405	975	145	115	1746	275	2490
14	700	110	-	-	-	-	-	-	445	170	300	45	185	500	110	1370
15	70	137	10	-	-	-	-	-	-	280	660	76	140	1022	240	1467
16	780	687	-	-	-	-	200	-	75	-	830	-	60	2334	508	2165
17	100	270	125	-	-	-	325	-	115	-	3609	-	60	919	-	432
18	80	280	14	-	-	-	-	-	-	-	4755	99	145	1550	245	1320
19	225	45	10	-	-	-	-	-	15	250	495	60	142	1385	195	1070
20	635	120	155	-	-	-	315	-	205	-	1015	25	130	335	60	780
21	90	102	10	-	-	-	-	-	55	150	30	45	25	760	135	854
22	45	60	-	15	-	-	35	-	-	100	145	60	64	410	115	750
23	260	90	-	-	-	-	-	-	-	-	1340	80	135	950	210	830
24	-	-	-	-	-	-	165	-	-	-	480	126	30	955	155	674
25	60	385	150	-	-	-	320	-	400	-	875	-	135	1007	135	839
26	175	100	-	-	-	-	25	-	40	-	520	-	98	-	-	647
27	460	155	-	-	-	-	45	-	-	-	69	44	-	1040	175	1155
28	362	195	40	-	-	-	197	-	85	-	-	17	25	790	157	870
29	160	-	25	-	-	-	95	-	15	-	1070	110	25	1035	235	1015
30	565	195	70	-	-	-	30	-	195	-	950	59	30	1230	270	1520
TOTAL	7672	5016	1069	15	260	171	2189	-	2692	3332	23901	1527	3107	26310	4868	43695

[a] All fish landings are reported in kilograms.

TABLE A.3-26

FISH LANDINGS[a]

Location: Abu Kir Date: July 78

Date	Epinephelus spp.	Diplodus spp.	Mullus spp.	Sciaena spp.	Pomatomus spp.	Sparus spp.	Pagrus spp.	Sardinella spp.	Sepia spp.	Solea spp.	Crabs	Penaeus spp.	Other Fishes
1	60	230	51		675		145		92	127	116	795	755
2	100	45			15		60		17	70	119	445	305
3	170	260	40		299		115	120		60		155	360
4	500	170	115		97		415	240	41	120	115	740	1650
5	335	510	80		110		160		71	150	199	1070	1885
6	555	172	25		25		190	300		420	290	1990	1765
7	430	335	10		305		14	1200	159	287	455	1616	1869
8	367				69		97	3505			61	1200	630
9	880	255	35		200		100	1420	25	65	310	400	1555
10	380	175	125				140	600		75	100	530	700
11	70	100			75		10		67	220	150	1385	1470
12	40	40			64		10		45	90	67	550	6090
13	210	35	26		152		15	880	80	160	95	1020	1104
14	206				150		75	785	69	105		1170	1275
15	510	400	39	115		35		954	15	30	35	240	650
16	900	210		85	190		300	1845	69	185	450	1085	1275
17	30	60			130		35	6800	14	30	93	205	280
18	115	20			197				65	115	135	740	770
19	615	422	15		590	225	75		90	158	181	987	875
20	370	187	94		456	135	35		100	115	35	935	9773
21	35				55		14		66	140	149	1100	645
22	259	150	47		43		65	2560	80	140	47	955	957
23													
24					100	95		730	75	75	115	1100	885
25				60	135	105			60	140	187	715	400
26	20			25	20	341			25	100	133	495	360
27						60			17	50	25	390	235
28						30			25	70		375	250
29	295			40	15			250			45		250
30	320	330	75		140	95	170	180	35	50	292	480	527
31					145	121		370	87	165	125	1095	1167
TOTAL	7772	4111	777	325	4472	935	2180	22406	1439	3402	4124	23963	40462

[a] All fish landings are reported in kilograms.

TABLE A.3-27

FISH LANDINGS[a]

Location: Maadiya Date: Sep 77

Date	Atherina boyeri	Sparus auratus	Crabs	Merluccius merluccius	Dicentrarchus ovatus	Dicentrarchus punctata	Mullus spp.	Penaeus spp.	Sardinella spp.	Saurus altanticus	Sepia officinalis	Solea spp.	Sphyraena sphyraena	Torpedo spp.	Trichiurus lepturus	Trigla spp.	Other fishes
6	-	30	-	50	-	-	150	160	2000	60	150	130	60	-	-	70	190
16	60	15	65	-	40	35	90	100	100	-	65	50	30	40	26	30	90
20	30	10	50	-	50	200	80	250	-	-	50	20	10	-	20	-	120
TOTAL	90	55	115	50	90	235	320	510	2100	60	265	200	100	40	46	100	400

Location: Maadiya Date: Oct 77

Date	Penaeus spp.	Sparus auratus	Sciaena aquila	Solea spp.	Crabs	Sardinella spp.	Atherina boyeri	Sphyraena sphyraena	Sepia officinalis	Scomberesox	Mullus spp.	Boops boops	Merluccius merluccius	Torpedo spp.	Other Fishes
9	750	300	600	30	150	120	40	50	200	450	-	-	-	-	300
16	150	70	-	50	300	-	-	30	120	-	270	30	-	-	170
23	300	40	-	120	80	10	60	15	160	-	100	-	30	20	200
TOTAL	1200	410	600	200	530	130	100	95	480	450	370	30	30	20	670

[a] All fish landings are reported in kilograms.

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TABLE A.3-28

FISH LANDINGS[a]

Location: Maadiya Date: Nov 77

Date	Penaeus spp.	Crabs	Mullus spp.	Solea spp.	Sardinella spp.	Sparus auratus	Sepia	Torpedo spp.	Dicentrarchus ovatus spp.	Sphyraena sphyraena	Scorpaena spp.	Gobius spp.	Mugil spp.	Diplodus spp	Teuthis sigana	Other Fishes
3	300	150	160	140	380	40	20	15	30	30	20	-	40	15	10	70
7	350	180	170	160	350	15	15	20	15	10	10	-	-	-	10	100
10	50	70	40	100	20	30	80	10	15	30	-	-	40	-	15	80
17	125	130	110	90	180	170	160	-	-	60	-	30	30	-	-	100
29	500	150	-	90	100	70	40	20	15	-	-	40	-	-	-	70
TOTAL	1325	680	480	580	1030	325	315	65	75	130	30	70	110	15	35	420

Location: Maadiya Date: Dec 77

Date	Penaeus spp.	Crabs	Mullus spp	Sparus auratus	Sepia officinalis	Solea spp.	Teuthis sigana	Pomatomus saltatrix	Sardinella spp.	Sphyraena sphyraena	Boops boops	Dicentrarchus ovatus spp.	Gobius spp.	Merluccius merluccius	Trigla spp.	Sciaena aquila	Saurus altanticus	Other fish
4	360	200	140	40	130	110	30	20	80	80	20	30	-	-	-	-	-	140
12	170	90	160	40	130	70	-	-	60	-	-	50	50	-	-	-	-	22[illegible]
20	350	100	120	50	150	80	15	-	90	-	15	100	70	80	50	30	15	16[illegible]
28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	880	390	420	130	410	260	45	20	230	80	35	180	120	80	50	30	15	48[illegible]

[a] Fish landings are reported in kilograms.

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TABLE A.3-29

FISH LANDINGS[a]

Location: Maadiya Date: Jan 78

Date	Penaeus spp.	Mullus spp.	Solea spp	Sepia officinalis	Crabs	Sparus auratus	Torpedo spp.	Gobius spp.	Sciaena aquila	Merluccius merluccius	Trichiurus lepturus	Sphyraena sphyraena	Triglа spp.	Sardinella spp.	Trygon spp.	Other Fishes
15	100	180	90	30	20	20	-	20	20	80	-	-	40	-	30	80
22	200	-	60	50	20	30	60	15	-	20	-	-	-	-	-	130
25	700	100	180	150	50	150	250	150	170	130	100	70	-	30	30	500
29	250	-	80	80	50	120	100	150	90	20	-	40	-	-	-	60
TOTAL	250	280	410	310	140	320	410	335	280	530	100	110	40	30	60	770

Location: Maadiya Date: Feb 78

Date	Penaeus spp.	Gobius spp.	Sepia officinalis	Sparus auratus	Solea spp.	Torpedo spp.	Crabs	Sciaena aquila	Mullus spp.	Dicentrarchus ovatus spp.	Trichiurus lepturus	Other Fishes
9	60	15	15	-	45	-	30	-	-	-	-	[illegible]
12	600	300	150	150	100	150	-	80	15	50	60	100
27	700	100	150	90	80	40	60	30	60	20	-	120
TOTAL	1360	415	315	240	225	190	90	110	75	70	60	120

Location: Maadiya Date: Mar 78

Date	Penaeus spp.	Crabs	Sepia officinalis	Sparus auratus	Solea spp.	Trachinus draco	Oblada melanura	Sphyraena sphyraena	Dicentrarchus ovatus spp.	Gobius spp.	Atherina boyeri	Torpedo spp.	Sciaena aquila	Dagellus mormyrus	Rhinobatus spp.	Boops boops	Other fishes
6	320	120	90	80	-	30	20	15	-	-	-	-	-	-	-	-	60
8	350	110	160	70	-	50	-	-	60	80	40	-	-	-	-	-	100
16	700	100	60	80	70	-	-	-	-	100	-	20	20	30	20	10	250
26	60	100	150	-	10	-	-	-	10	-	-	10	-	20	-	-	80
30	450	90	20	-	40	-	-	-	-	-	40	-	-	-	-	-	100
TOTAL	1880	520	480	230	120	80	20	15	70	180	80	30	20	50	20	10	590

[a] Fish landings are reported in kilograms.

TABLE A.3-30

FISH LANDINGS[a]

Location: Maadiya Date: Apr 78

Date	Penaeus spp.	Solea spp.	Sepia officinalis	Sparus auratus	Teuthis sigana	Mullus spp.	Dicentrarchus spp.	Sphyraena sphyraena	Crabs	Merluccius merluccius	Trigla spp.	Torpedo spp.	Gobius spp.	Sardinella spp.	Trachinus draco	Sciaena aquila	Other Fishes
10	600	320	300	150	160	100	40	20	20	20	-	160	200	200	-	60	230
19	800	80	180	200	50	120	60	30	30	-	-	400	100	20	10	-	300
23	300	50	80	100	20	30	40	60	10	15	10	-	60	-	-	-	120
25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	1700	450	560	450	230	250	140	110	60	35	10	560	160	220	10	60	650

Location: Maadiya Date: May 78

Date	Penaeus spp.	Crabs	Sciaena aquila	Atherina boyeri	Solea spp.	Sepia officinalis	Gobius spp.	Sparus auratus	Trigla spp.	Teuthis sigana	Saurus atlanticus	Torpedo spp.	Dicentrarchus spp.	Pagellus mormyrus	Sphyraena sphyraena	Trygon spp.	Other Fishes
10	500	40	20	30	10	20	20	30	70	10	-	-	-	-	-	-	150
17	400	40	-	20	30	-	30	-	100	-	50	15	10	20	-	-	100
25	1350	30	-	100	25	30	30	10	90	-	-	20	20	-	10	-	110
31	400	-	-	30	-	10	-	-	20	-	-	-	-	-	-	15	70
TOTAL	2650	110	20	180	65	60	80	40	280	10	50	35	30	20	10	15	430

[a] All fish landings are reported in kilograms

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TABLE A.3-31

FISH LANDINGS[a]

Location: Maadiya Date: Jun 78

Date	Penaeus spp.	Atherina boyeri	Sphyraena sphyraena	Mullus spp.	Boops boops	Crabs	Pagellus mormyrus	Dicentrarchus spp.	Sciaena aquila	Solea spp.	Trichiurus lepturus	Sepia officinalis	Sardinella spp.	Saurus atlanticus	Other Fishes
8	600	500	320	100	80	40	30	20	20	10	10	10	10	10	220
21	30	20	-	-	-	-	-	-	-	-	-	-	-	-	60
29	300	40	70	-	-	30	-	15	-	10	-	-	50	30	280
TOTAL	930	560	390	100	80	70	30	35	20	20	10	10	60	40	560

Location: Maadiya Date: July 78

Date	Penaeus spp.	Atherina boyeri	Solea spp.	Crabs	Sepia spp.	Sciana spp.	Dicentrarchus ovatus	Sphryaema spp.	Sparus spp.	Trigla spp.	Torpedo spp.	Trygon spp.	Dicentrarchus punctata	Pagellus spp.	Other Fishes
6	450	40	30	30	50	70	15	20	30	10	20	-	-	-	70
12	250	60	-	20	30	20	20	-	-	-	-	10	15	10	80
15	300	70	40	-	50	30	30	15	20	10	-	-	-	15	120
25	800	-	-	25	40	-	-	20	-	-	-	-	30	15	100
TOTAL	1800	170	70	75	170	120	65	55	50	20	20	10	45	40	370

[a] All fish landings are reported in kilograms.

SECTION A.4

SECTION A.4

ANALYSES OF FOULING ORGANISMS

Organisms Collected From Buoy and Chain

Date: 20 March 1978

Location: Inner current meter buoy, 2 km off Anfushi at Latitude 31° 13' 34", Longitude 29° 52' 11".

Sample 1, Scraped from the buoy itself.

Flora:

Green Algae:

Ulva Lactuca

Fauna:

Crustacea:

Lepas sp.

Sample 2, Scraped from the chain of the buoy, 4 m below the surface of the water.

Flora: Nil

Fauna:

Crustacea: *Cirripedia*

Lepas sp.

Sample 3, Scraped from the chain at 8 to 10 m depth.

Flora: Nil

Fauna:

Hydroidae:

Tubularia sp.

355

Sample 4, Scraped from the chain at 20 m depth

Flora: Nil

Fauna:

Hydroidae:

Tubularia sp.

Sample 5, Scraped from the end of the chain at the bottom, at 28 m depth. There was neither flora nor fauna.

Organisms Collected From Submerged Panels

Date: Panels submerged on 20 March 1978

Location: Inner current meter buoy, 2 km off Anfushi at Latitude 31° 13' 34", Longitude 29° 52' 11".

Panel 1, at 0.5 m depth. The weight of the fouling attached was 2 gm. On the first surface of the panel, 40 percent of the area was covered with a thin film of green algae, and 30 percent was covered with brown algae; in addition, there were dense colonies of Hydroidae on the algae.

Flora:

Green algae:

Chaetomorpha sp.	40% of the area
Brown algae:	30% of the area

Fauna:

Hydroidae:

Hydractinia echinatum	dense (colonies ≤1 mm long)
Tubularia larynx	2 colonies (up to 10 mm long)

On the second surface of Panel 1, twenty percent of the area was covered with dispersed green algae, less dense than on the first surface.

Flora:

Green algae	20% of the area

Fauna:

Crustacea

Caprella sp.	4 individuals

Panel 2, at 1.5 m depth. The weight of the fouling attached to the panel was 1 gm. On both surfaces only brown algae were found as a thin film covering 20 percent of each surface.

Panel 3, at 4.5 m depth. The weight of the fouling attached to the panel was less than 1 gm. The following was found on the first surface:

Flora:

Green algae	15% of the area (thin film)

Fauna:

Hydroidae:

Tubularia larynx	2 colonies

On the second surface was found:

Flora:

Brown algae	50% of the area (dispersed thin layer)

Fauna: Nil

Panel 4, at 5.5 m depth. The weight of the fouling attached to the panel was 9 gm. On the first surface, 75 percent of the area was covered with Hydroidae, and there were a few Amphipod tubes.

Flora: Nil

Fauna:

Hydroidae:

Laomedea flexuosa	Common
Campanularia verticillata	Few growing on Amphipod tubes
Tubularia mesembryantheum	1 colony (35 mm long) 5% of the area
Tubularia larynx	1 colony (21.5 mm long)

Crustacea:

Amphipod tubes	15 tubes

Eighty percent of the area of the second surface of Panel 4 was covered with Hydroidae. Twenty percent of the surface has dispersed patterns of Amphipod tubes.

Flora: Nil

Fauna:

Hydroidae:

Tubularia larynx	1 colony
Campanularia verticillata	Common
Laomedea flexuosa	Common
Obelia geniculata	Common

Crustacea:

Amphipod tubes	54 tubes

Panel 5, at 6.5 m depth. The weight of the fouling attached to the panel was 3.5 gm. On the first surface:

Flora: Nil

Fauna:

Hydroidae	90% of the area
Crustacea:	
Amphipod tubes	2 tubes

On the second surface:

Flora: Nil

Fauna:

Hydroidae	65% of the area

Panel 6, at 7.5 m depth. The weight of the fouling attached to the panel was less than 1 gm.

On the first surface:

Flora:

Brown algae:	75% of the area (Very thin film)

Fauna: Nil

On the second surface:

Flora:

Brown algae	75% of the area

Fauna:

Crustacea:

Amphipod tube	1 tube

Panel 7, at 10.5 m depth. The weight of the fouling attached to the panel was 1 gm. On the first surface, 95 percent of the area was covered with a thin film of detritus; in addition, there was one *Caprella* sp.

On the second surface 100 eprcent of the area was covered with detritus; in addition, there was on Tubularia Larynx.

This experiment indicates that the depth of maximum rate of growth of fouling organisms is 5.5 m, in the area investigated.

APPENDIX B

SUBCONTRACTOR AND FIELD EQUIPMENT

APPENDIX B

SUBCONTRACTOR AND FIELD EQUIPMENT

Subcontractor

Ocean Surveys, Inc., of Old Saybrook, CT, USA, were retained as subcontractors to CDM to undertake field operations. OSI supplied nearly all the field equipment, either importing it from the USA or buying or building it in Alexandria. OSI also supplied expatriate personnel to conduct day-to-day operations at sea. OSI were responsible for analysis and interpretation of the geophysical data. CDM retained responsibility for overall and detailed planning of field operations, and for reduction, analysis, interpretation, and engineering application of all data except for the geophysical studies.

Boats

For all oceanographic work, diesel-powered harbor tugboats, 14 to 16 m long, were chartered from Mohamed Abdel Aziz Mohamed General Services Co., 5 El Nasr Street, Alexandria. The boat most frequently used, "Gamil ya Naby," was equipped with a winch and lifting boom that was used for deploying buoys and anchors. From time to time, another tug providing a good working cabin but no lifting gear was used instead of, or in addition to, the "Gamil ya Naby".

An Avon Sportsman inflatable rubber raft with a 30-hp outboard motor was supplied by the subcontractor. It was used primarily as a diving platform to facilitate divers' entry to and return from the water.

Bottom Core Sampler

Ocean bottom cores were obtained with a Benthos gravity-core sampler, shown in a sketch on Figure B-1. The overall length was 3 m. The 89 mm O.D. core tube, with a 66 mm I.D. plastic tube insert, was 1.80 m long. With its lead weights, the mass of the core was approximately 143 kg. The cutter at the head of the core tube was ringed on the inside with spring steel flaps to help retain the soil sample driven inside.

When deployed, the corer was allowed to fall freely from the water surface to the bottom. After recovery, the plastic tube insert was cut to the length of the sample retained, sealed at the ends, and kept for labratory analysis.

Current Meter Implants

Current Meters

ENDECO Type 105 tethered, axial flow, ducted impeller current meters were used. Current speed and direction were recorded on 16 mm photographic film using a light-emitting diode. The meter casings were of polyvinyl chloride, and suitable for operation at depths of up to 150 m.

The meters are designed to be neutrally buoyant, and float with the impeller axis horizontal. On-site adjustments of weight and trim to meet local conditions of seawater density are required before initial deployment. The meters ride at the end of a rope tether about on m long.

The speed accuracy of the meters is ± 0.05 m/sec. The direction is accurate to ± 2 percent when the current speed is at least 0.025 m/sec. Values of direction and half-hourly average speed were recorded every 30 minutes. Film packs were sent to ENDECO in the US for processing. ENDECO then sent computer listings of half-hourly time, speed, and direction for each instrument to CDM in Alexandria. All subsequent manipulation of the data was done in Alexandria.

In all deployments, two meters were tethered to a single vertical cable stretched between an anchor on the sea bed and a subsurface buoy 8 to 9 m below the surface. The upper meter was tethered at a water depth of about 10m, while the lower meter was tethered at a distance above the bottom equal to one quarter to one third the water depth. Several modifications to this arrangement were used:

A. Weight anchor, subsurface buoy only (Figure B-2), with or without an additonal Danforth anchor. Sonar pinger beacon attached.

B. Weight anchor, subsurface buoy, and surface buoy with light and radar reflector connected to the subsurface buoy by a long heavy chain (Figure B-3).

C. Weight anchor and subsurface buoy alone on one string; and a surface buoy with light and radar relector connected by a separate cable-and-chain system to a separate weight anchor (Figure B-4).
The two weight anchors were connected by a 35 m long cable. A Danforth anchor chained to one of the weight anchors was set out to one side to provide further security against movement.

Mode "A" was tried first. It was thought that having no surface buoy would protect the string from vandalism, a problem often endured in current meter deployment. However, an alarmingly high loss rate from the implant site 10 km off Sidi Bishr (Station 1B) forced a reappraisal of the system.

Apparently, trawlers operating in the area near Station 1B were innocently engaging the implants and dragging them off station. (A meter string placed at Station 1B which shortly thereafter vanished, and which was recovered and returned to CDM eight months later by the Egyptian Navy, had shreds of fish netting tangled in its cable.) It was decided to add a large lighted surface buoy with a radar reflector to warn trawlers and merchant shipping of the presence of the string. Accordingly Mode "B" was developed and used in deployments in November and December. Mode "C" was later developed in and effort to produce yet greater reliability, and to eliminate the possibility that wave action on the surface buoy would be transmitted to the meter and affect the recording of current velocity. No trouble whatever was experienced with Mode "C" deployments.

It should also be noted that with the Mode "B" and Mode "C" deployments, notification of location was given to the Ports and Lighthouses Authority, which doubtless helped shipping avoid the implants. This had not been done with the Mode "A" implants.

Initially, the meters were serviced every month. Later, to reduce the chance of data loss by loss or malfunction of the instrument, the servicing interval was reduced to two weeks.

Surface Buoys

The surface buoys were fabricated locally of steel. They were cylinders about 800 mm in diameter and 1200 mm high. An early version, used in Mode "B" and shown on Figure B3-3, had a flashing light mounted 300 to 400 mm above the mean sea surface, with a metal-coated cardboard radar reflector tied to a short steel mast. The cardboard radar reflectors were quickly lost, probably due to waves but possibly due to vandals. A later version, used in Mode "C" and shown on Figures B-4 and B-5, carried the light much higher above the waves, keeping it drier and increasing its visibility. The radar reflector was fabricated of steel and welded to the light stanchion.

Subsurface Buoys

Subsurface buoy design and materials were regularly improved over the course of the project. Styrofoam spherical bouys 600 mm in diameter were used initially with the Mode "A" deployments. They were generally satisfactory, but there was some evidence that the styrofoam cells were subject to crushing and flooding at the 10 m deployment depth. For Mode "B" greater buoyancy was required, and conventional steel oil drums were used. However, these were subject to leakage, and were replaced with rugged inflatable plastic "Norwegian" subsurface buoys.

The "Norwegian" buoys were not only fastened to the implant system by their integral belaying thimble, but also by a coarse rope net covering the buoy and bound to the implant cable.

At the 10 m deployment depth, where the absolute pressure is about 2 atm, the buoys were carefully inflated only half full of air, so that should they be raised to the surface by accident or by vandals they would not burst in a possibly fatal explosion due to the reduced external pressure.

Dissolved Oxygen Meter

Dissolved oxygen level in the sea water was measured with a Hydrolab Model TDO-2 Dissolved Oxygen-Temperature Meter, using a passive polarographic cell mounted in a self circulating underwater sonde.

The instrument measures dissolved oxygen from zero to 100 percent saturation in two ranges; 0-10 ppm and 0-20 ppm. The instrument measures the dissolved-oxygen by partial pressures but the metered output is in ppm. The solubility of oxygen at a given temperature is automatically taken into account by the instrument so that ppm can be directly metered. The instrument can be calibrated using atmospheric oxygen or Winkler-standardized oxygen solution. The accuracy of the measurements are $\pm$ 2 percent of the reading plus 0.5 percent of the range. The response time is 10 sec for a step change in dissolved oxygen concentration.

Drogues

Each drogue consisted of two underwater sails in vertical planes intersecting at right angles, each sail measuring 600 mm x 2400 mm (see Figure B-6). On their lower edges, the sails were set on two 2400 mm aluminum rods. On their upper edges, the sails were stiffened by four 1100 mm wooden battens.

Sufficient weight was added to make the drogues somewhat negatively buoyant. A thin stainless steel cable tethered the drogue to a styrofoam surface float, 300 mm square and 50 mm thick. A color-coded indentification flag flew from a slender mast on the float.

Tether lengths of 0.5, 2, 4, 8, 16, 24, 32, and 48 m were used. Usually four to six drogues with varying tether lengths were deployed simultaneously, at approximately the same location, and followed for four to six hours. The locations were noted for each drogue every 30 to 45 minutes by means of the Cubic Autotape navigation system. A complete listing of the drogue data is available in unpublished Memorandum No. 8.

It was sometimes difficult to keep track of all the drogues on days when seas were rough, and particularly when drogues tended to scatter in a variety of directions. A program was developed for a portable calculator that was capable of predicting the location in terms of "Autotape"

measurements at a given time based on the previously reported speed and direction of the drogue. This program was successfully used to locate difficult-to-follow drogues based on previous positions, and decreased the overall loss of drogues during the project.

Fathometer

Bathymetry (bottom profile) data were gathered using a Raytheon Model DE-719 Fathometer, a portable solid state instrument. A transducer was mounted on 6-foot sectional tube, that was mounted over the side of the boat. The transducer projected an 8° beam at 534 soundings per minute. Depth sounding range up to 410 ft (125 m) was possible using the range doubling switch.

The bottom profile was recorded on a continous paper strip. Horizontal control of the bottom profiling was maintained by recording events on the profile paper and recording event position with the Autotape navigation system.

Fluorometer

A Turner Model 10 Series Fluorometer was used to detect dye concentrations during studies of the existing outfall and dilution studies. The fluorometer is a solid state field instrument measuring concentrations about 13 times per second. Instrument sensitivity is to within 10 parts per 10^{12} using Rhodamine B dye while the linear precision is $\pm$ 1 readable to 0.5 percent of full scale. A range scale multipiler can increase scale sensitivity to a maximum of 100 times.

Horizontal Control

For convenience, a rectangular coordiante system with its origin at the northwest turret of Kait Bey Fort was, with very few exceptions, used throughout the project. The origin of this system is at 31° 12' 48" N Latitude, 29° 53' 05" E Longitude, and is 945 115 m N, 508 625 m E of the origin of the coordinate system used by the Egyptian Government Mapping Service.

A cubic Industial Corporation Model DM 40 A "Autotape" system was used for most of the navigation required for the project. This system utilizes microwave phase comparison between a shipboard interrogator and two onshore responders to provide distances between the vessel and shore units. The "Autotape" system has a range of over 50 kilometers and is accurate to within 1 meter. Distances are digitally displayed on an electronic panel on board the boat and updated at 1 second intervals. The system proved to be practical and accurate, with very few problems other than minor battery and antenna deployment troubles.

For work on the Kait Bey, Ramleh, and Abu Kir alignments, the onshore responders were at the northwest turret of Fort Kait Bey and on the balcony of a seaside residence in Laurent, nine km to the northeast ("French's Apartment"). For work on the Agamy alignment, the responders were at the Agamy Palace Hotel and (in the early months) on the beach seven km to the southwest, or (in the latter months) at the northwest turret of Kait Bey Fort. For drogue studies in Abu Kir Bay, the responders were set up at the Coastal Erosion Station in Abu Kir Village and at the Arab Maritime Transport Academy in El Tarh. The locations of these stations are shown in Table B-1.

For sampling that did not require the degree of precision provided by the "Autotape" system, a horizontal sextant was used to measure angles subtended by pairs of landmarks. The locations of some of these landmarks is given in Table B-1.

Also shown in Table B-1 are the nominal locations of the sampling stations and current meter sites regularly used, in terms of Range 1 and Range 2 (distances, usually, from "French's Apartment" and Kait Bey Fort, respectively), the Egyptian National Grid System, the CDM system centered on Kait Bey Fort, and Latitude/Longitude.

A program developed for a Hewlett-Packard HP-97 programmable calculator was used to convert the Range 1 and Range 2 distances to rectangular coordinates. Given the location coordinates of the appropriate pair of Autotape onshore responder sites, and given the "R1" and "R2" distances from the ship to the two responders, this program would compute the survey ship's location in the rectangular coordinate system.

For drogue studies, the clock time as well as the "R1" and "R2" distances was entered for each drogue position. Not only the north and east coordinates of the drogue position, but also the average speed and direction of the drogue from its immediately preceding position, would be calculated.

Salinometers

Two instruments were used. A Hydrolab TC-2 conductivity-temperature meter was used from July through December 1977, and a Beckman RS5-3 induction salinometer was used thereafter.

The Hydrolab instrument consisted of a remote conductivity probe, about 80 m of cable and a box for the electronics and display dial. The instrument was ultimately rejected because of insufficient control over calibration drift and because of resolution of readings insufficient for project needs.

TABLE B-1

LOCATION OF HORIZONTAL CONTROL AND SAMPLING LOCATIONS

Station	Range 1	Range 2	Egyptian National Grid System		CDM Coordinate System		Latitude	Longitude
			Northing	Easting	Northing	Easting		
French's Apart. Autotape Antenna (R1)	-	9209	949 216	516 878	4101	8253	31° 15' 02"N	29° 57' 18"E
Fort Kait Bey Autotape Antenna (R2)	9209	-	945 115	508 525	0	0	31° 12' 48"N	29° 55' 05"E
Current Meters 1AU, 1AL	3631	10 144	952 576	515 497	7461	6872	31° 13' 36"N	29° 52' 18"E
Current Meters 1BU, 1BL	10 585	14 333	958 891	512 580	13 776	3955	31° 20' 23"N	29° 55' 38"E
Current Meters 2AU, 2AL	9758	1847	946 564	507 480	1449	-1145	31° 13' 36"N	29° 52' 18"E
Current Meters 2BU, 2BL	12 904	10 623	955 259	505 470	10 144	-3155	31° 18' 38"N	29° 51' 38"E
Current Meters 2CU, 2CL	13 028	8629	952 572	504 283	7457	-4342	31° 16' 54"N	29° 50' 18"E
Current Meters 1CU, 1CL	5050	10 785	953 873	514 919	8758	6264	31° 17' 32"N	29° 56' 55"E
Plankton Station-Kait Bey Sta 1	9750	1850	946 573	507 486	1458	-1139		
Sta 2	10 000	5000	949 804	506 888	4689	-1737		
Sta 3	13 100	10 800	955 397	505 322	10 282	-3303		

TABLE B-1 (continued)

LOCATION OF HORIZONTAL CONTROL AND SAMPLING LOCATIONS

Station		Range 1	Range 2	Egyptian National Grid System		CDM Coordinate System	
				Northing	Easting	Northing	Easting
Kait Bey Alignment	Sta. 1	9300	1000	945 993	508 147	878	-478
	Sta. 2	9700	2000	946 760	507 487	1645	-1138
	Sta. 3	10 100	3000	947 573	506 905	2458	-1720
	Sta. 4	10 400	4000	948 501	506 496	3386	-2129
	Sta. 5	11 000	5000	949 288	505 871	4173	-2754
	Sta. 6	11 400	6000	950 248	505 518	5133	-3107
	Sta. 7	12 100	7000	951 048	504 911	5933	-3714
	Sta. 8	12 700	8000	951 951	504 469	6836	-4156
	Sta. 9	13 600	9000	952 657	503 714	7542	-4911
	Sta. 10	14 100	10 000	953 705	503 505	8590	-5120

TABLE B-1 (continued)

LOCATION OF HORIZONTAL CONTROL AND SAMPLING LOCATIONS

Station		Range 1	Range 2	Egyptian National Grid System		CDM Coordinate System	
				Northing	Easting	Northing	Easting
Ramleh Alignment	Sta. 1	1000	9723	950 214	516 903	5099	8278
	Sta. 2	2000	9825	951 153	516 376	6038	7751
	Sta. 3	3000	10 065	952 058	515 912	6943	7287
	Sta. 4	4000	10 435	952 970	515 494	7855	6869
	Sta. 5	5000	10 445	953 675	514 611	8560	5986
	Sta. 6	6000	10 550	954 338	513 748	9223	5123
	Sta. 7	7000	11 000	955 142	513 147	10 027	4522
	Sta. 8	8000	11 370	955 843	512 391	10 728	3766
	Sta. 9	9000	12 000	956 677	511 839	11 562	3214
	Sta. 10	10 000	12 255	957 173	510 815	12 058	2190

TABLE B-1 (continued)

LOCATION OF HORIZONTAL CONTROL AND SAMPLING LOCATIONS

Station		Range 1	Range 2	Egyptian National Grid System		CDM Coordinate System	
				Northing	Easting	Northing	Easting
Abu Kir Alignment	Sta. 1	10 000	18 820	956 826	523 358	11 711	14 733
	Sta. 2	10 260	18 800	957 782	522 517	12 667	13 892
	Sta. 3	10 580	18 860	958 537	521 874	13 422	13 249
	Sta. 4	10 950	18 950	959 255	521 241	14 140	12 616
	Sta. 5	11 420	19 100	960 020	520 569	14 905	11 944
	Sta. 6	11 950	19 300	960 772	519 910	15 657	11 285
	Sta. 7	12 550	19 500	961 567	519 094	16 452	10 469
	Sta. 8	13 200	19 830	962 315	518 494	17 200	9869
	Sta. 9	13 880	20 180	963 060	517 856	17 945	9231
	Sta. 10	14 600	20 570	963 811	517 203	18 696	8578

TABLE B-1 (continued)

LOCATION OF HORIZONTAL CONTROL AND SAMPLING LOCATIONS

Station	Range 1	Range 2	Egyptian National Grid System		CDM Coordinate System	
			Northing	Easting	Northing	Easting
Arab Maritime Trans Academy			951 480	529 830	6365	21 205
Coastal Erosion Station			956 095	526 030	10 980	17 405
Pillbox on Fort Tip Abu Kir Peninsula			957 685	526 500	12 570	17 875
Beacon, Nelson Island			960 908	529 768	15 793	21 143
Minaret, S.W. Corner Fort Abu Kir Village			957 095	525 715	11 980	17 090

TABLE B-1 (continued)

LOCATION OF HORIZONTAL CONTROL AND SAMPLEING LOCATIONS

Station	Range 1	Range 2	Egyptian National Grid System		CDM Coordinate System	
			Northing	Easting	Northing	Easting
Agamy Palace Hotel Autotape Antenna (R1)			935 958	498 218	-9157	-10 407
Beach Autotape Antenna (R2)			931 374	492 560	-13 741	-16 065

As for the Beckman RS5-3, the sensor consists of an electrodeless toroidal conductivity cell and a thermistor type temperature sensor sealed to the end of a PVC jacketed cable with a steel member to prevent breakage.

The salinometer is sealed in a water tight case and powered by two internally mounted 8.4 volt batteries.

The instrument measures conductivity in the range of 0-60 millimhos/cm with an accuracy of ± 0.50 millimhos/cm by direct reading and ± 0.050 millimhos/cm using calibration curves.

Temperature is measured within a range of 0-40° C. and is accurate to ± 0.50° C. by direct reading and ± 0.050° C using calibration curves.

The salinity can be measured in the range of 0-40 percent by direct reading within a temperature range of 0-27° C and ± 0.050 percent using calibration curves. Salinity is calculated by the instrument utilizing a self-contained circuit that computes salinity based on the conductivity and temperature values.

The calibration of the RS5-3 can be quickly checked and adjusted in the field by taking appropriate calibration readings when a wire loop of specified resistance is connected through the toroidal probe. In addition, calibrations were regularly obtained by immersing the probe in a sufficiently large volume of seawater, whose salinity was determined with a laboratory salinometer, which was in turn calibrated with a "Copenhagen" standard seawater sample.

Seismic Profilers

Both a "sparker" and a "boomer plate" were used (but not simultaneously). The sparker provided subbottom profile information to a greater depth than the boomer, while the boomer provided better resolution, a more refined picture, than the sparker.

The spark array was an EG&G Model 267A, three-element cage. The power supply was an EG&G Model 232A, 3.8 KV, with 5 sec/Kj charge rate. The hydrophone was an EG&G Model 263C, 16-element array.

The Ocean Surveys Inc. "Hi-Definition Boomer" used consists of an EG&G Model 261 boomer plate specially modified to provide single-pulse output. The power supply was a 300-joule OSI Model 300B.

Side Scan Sonar

The ocean bottom off Alexandria in the area of the outfall alignments was surveyed using a Klein Side Scan Sonar Model 400 system. The sonar system consisted of a Model 402A Towfish containing both sound sending and receiving electronics, and a Model 401 Dual Channel Recorder.

Water Sampler

A Wildco Model 1930 automatic water sampler was used to collect water samples for water quality analysis during the project. The sampler had a capacity of 3 litres and was closed by a weighted "messenger."

Weather Station

A Meteorology Research Inc. Model 1071 self-contained mechanical weather station was used to measure wind speed, wind direction and temperature for the duration of the project.

The station was mounted on a 5 m high pole on top of the project staff house at 477 El Guish Street, Sidi Bishr in Alexandria (Lat. 31°15'14"N Long. 30°58'32"E). The station was approximately 21 m above sea level.

Wind speed, direction and temperature were continuously recorded on a plastic-coated, pressure-sensitive strip chart.

Wind direction was measured by a ball-bearing-mounted single blade aluminum vane with nose dampening. Direction is directly read from the strip chart.

Wind speed was measured by a cup anemometer employing three 11.4 mm diameter conical aluminum cups. Wind run was recorded on the strip chart and speed was calculated using the wind run and time scale.

Temperature was measured by a spiral coil bimetallic element located under a shield on the outside of the weather station facing north. The high range of the dual range temperature senor utilized was capable of temperatures between -30° F (-34° C) and +120° F (49° C).

The strip chart was advanced by a hand-wound clockwork mechanism. The chart speed was 1 cm per hour.

The accuracy of the station is specified so that wind direction is within ± 1 percent of full scale, wind run (speed) is within ± 2 percent and the temperature is within ± 3° F (± 1.7° C).

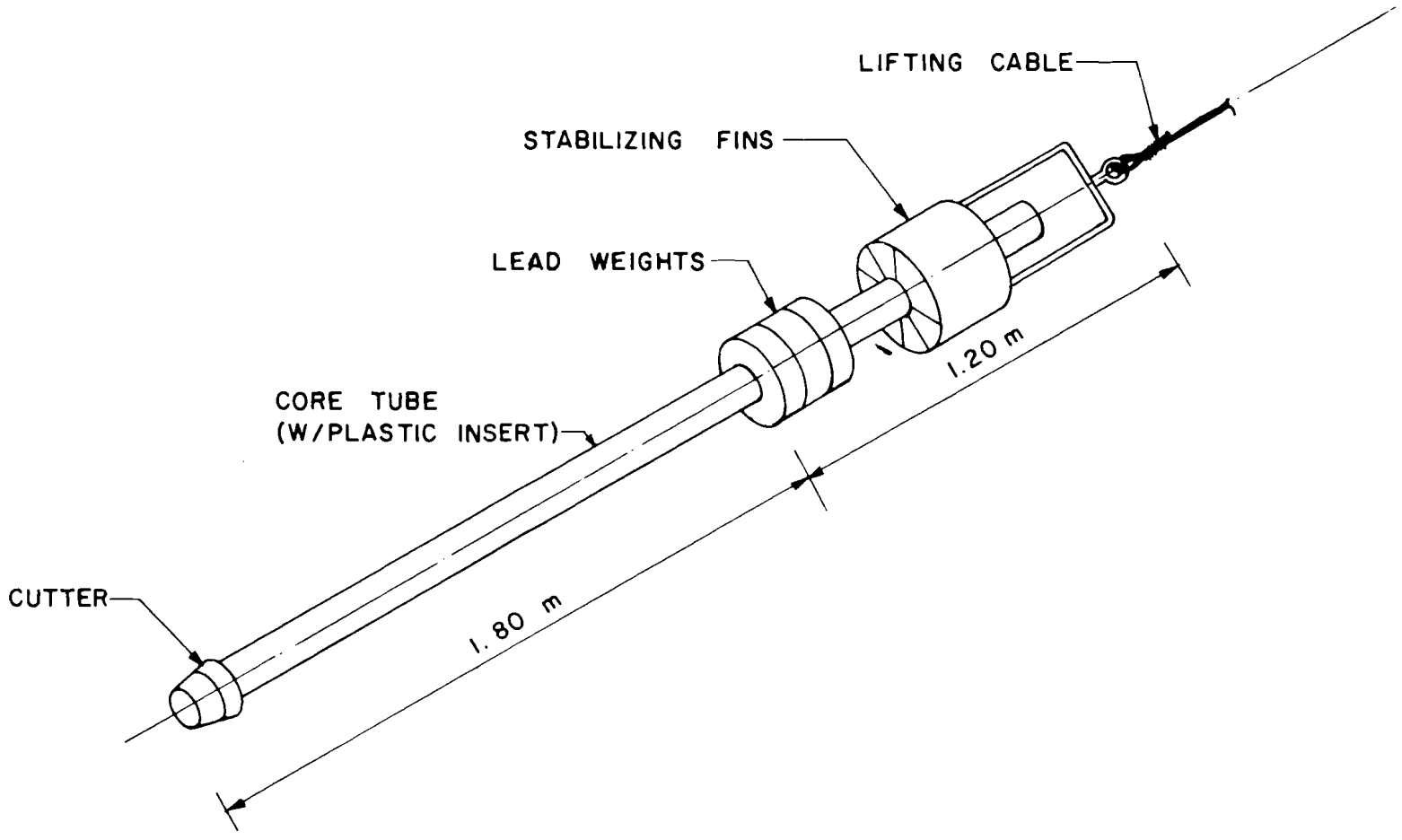
Only wind direction and speed were required for project analyses, and only these data were obtained from the strip charts. Hourly values of wind speed and direction have been tabulated in unpublished Memorandum No. 5. Temperature data were not tabulated.

There were some operational problems with the weather station in the early part of the project. The station was initially mounted on a lightweight pole held in place with guide wires. The only way to service the station was to unfasten the guides and lower the complete apparatus to the staff house roof. Since this operation was cumbersome it was only performed every few weeks or at least once a month, and long periods could pass before any malfunction could be discovered and corrected.

A heavyweight pole with ladder steps was subsequently fabricated for the weather station so that a man could climb the pole and service the station regularly. Since that time, the station was checked almost daily and very little data information was lost.

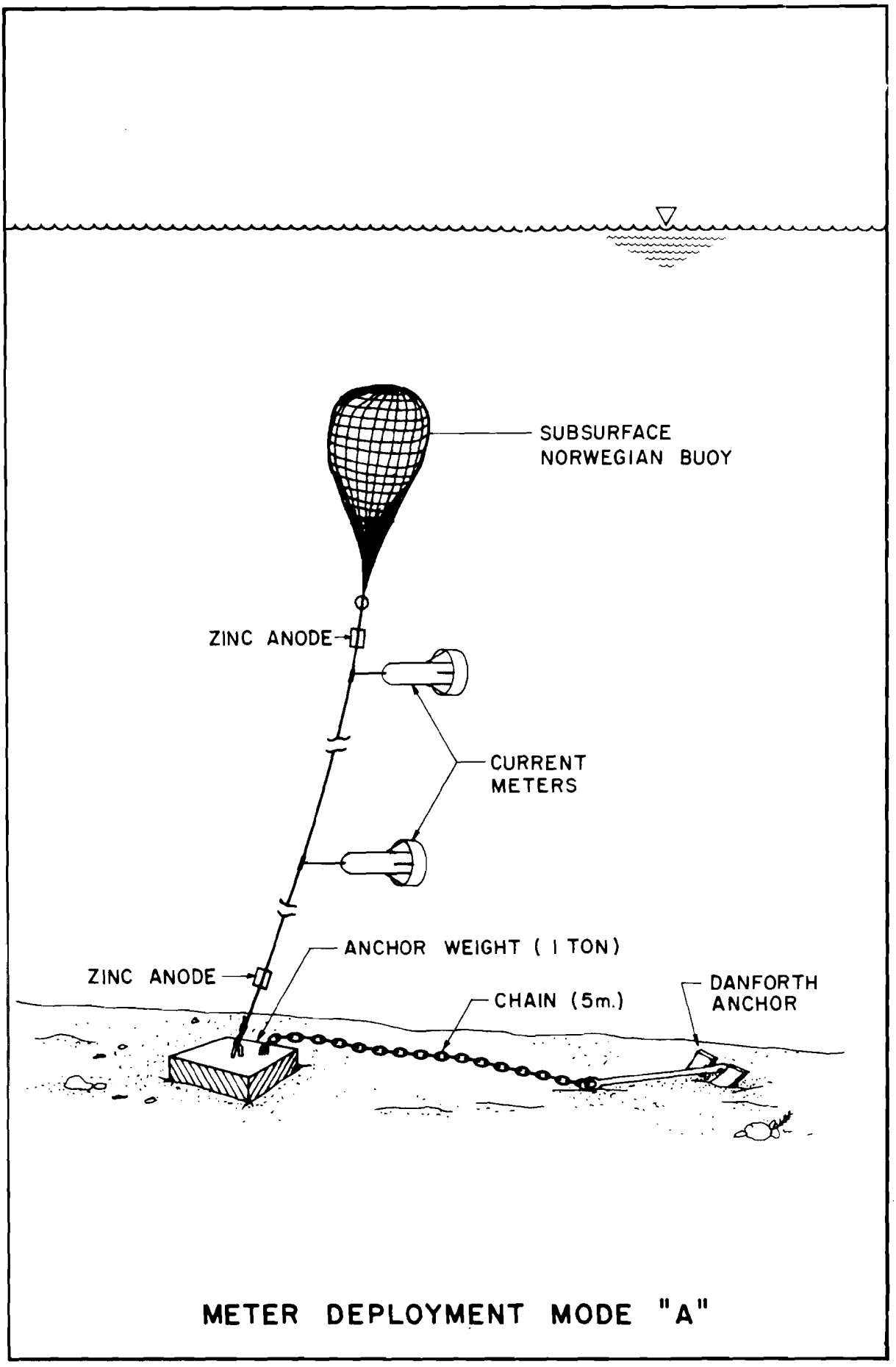
Interpreting the wind data presented a minor difficulty in that the higher speeds were intrinsically difficult to calculate accurately from the strip chart. The resolution at the highest speeds was at best ± 5 m/sec. At lower wind speeds the chart is easier to interpret, and the wind speed could be reported to the nearest 0.1 m/sec with reasonable accuracy.

The wind direction is difficult to interpret directly from the strip chart because the markings obliterate the scale below. An overlay reproduction of the scale enabled the wind direction to be reported to the nearest 15° with good accuracy.



BOTTOM CORE SAMPLER

FIGURE B-1



METER DEPLOYMENT MODE "A"

FIGURE B – 2

377

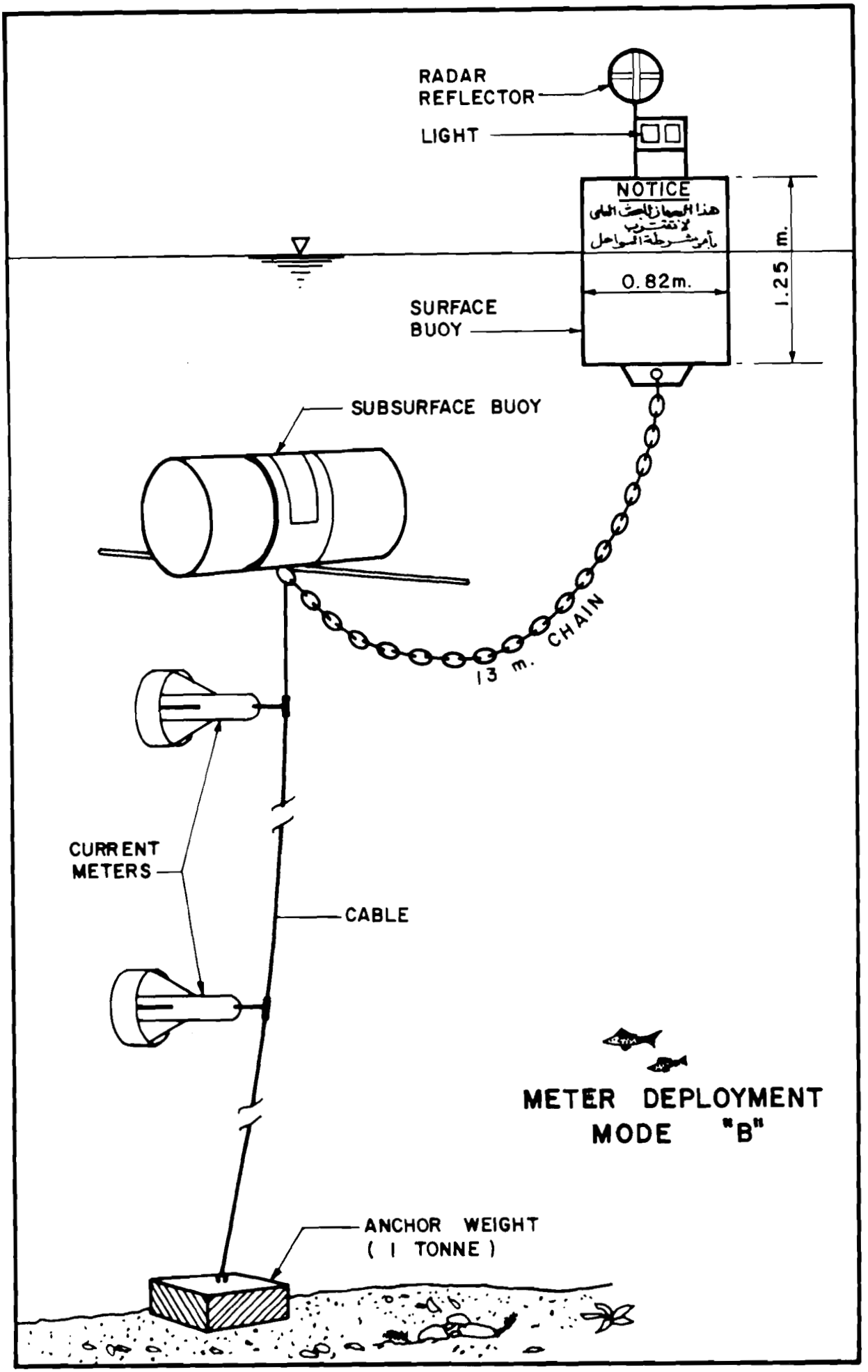
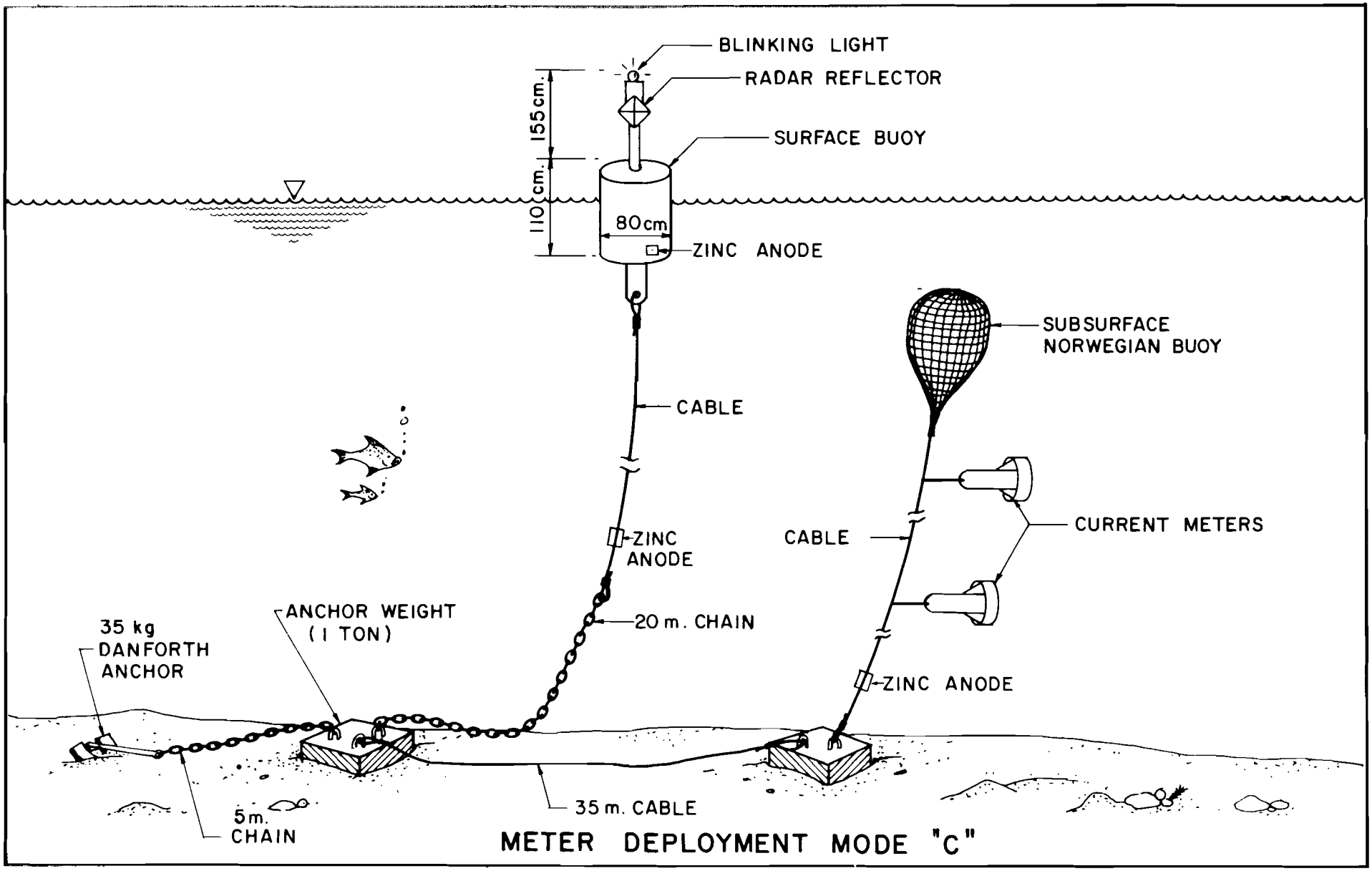
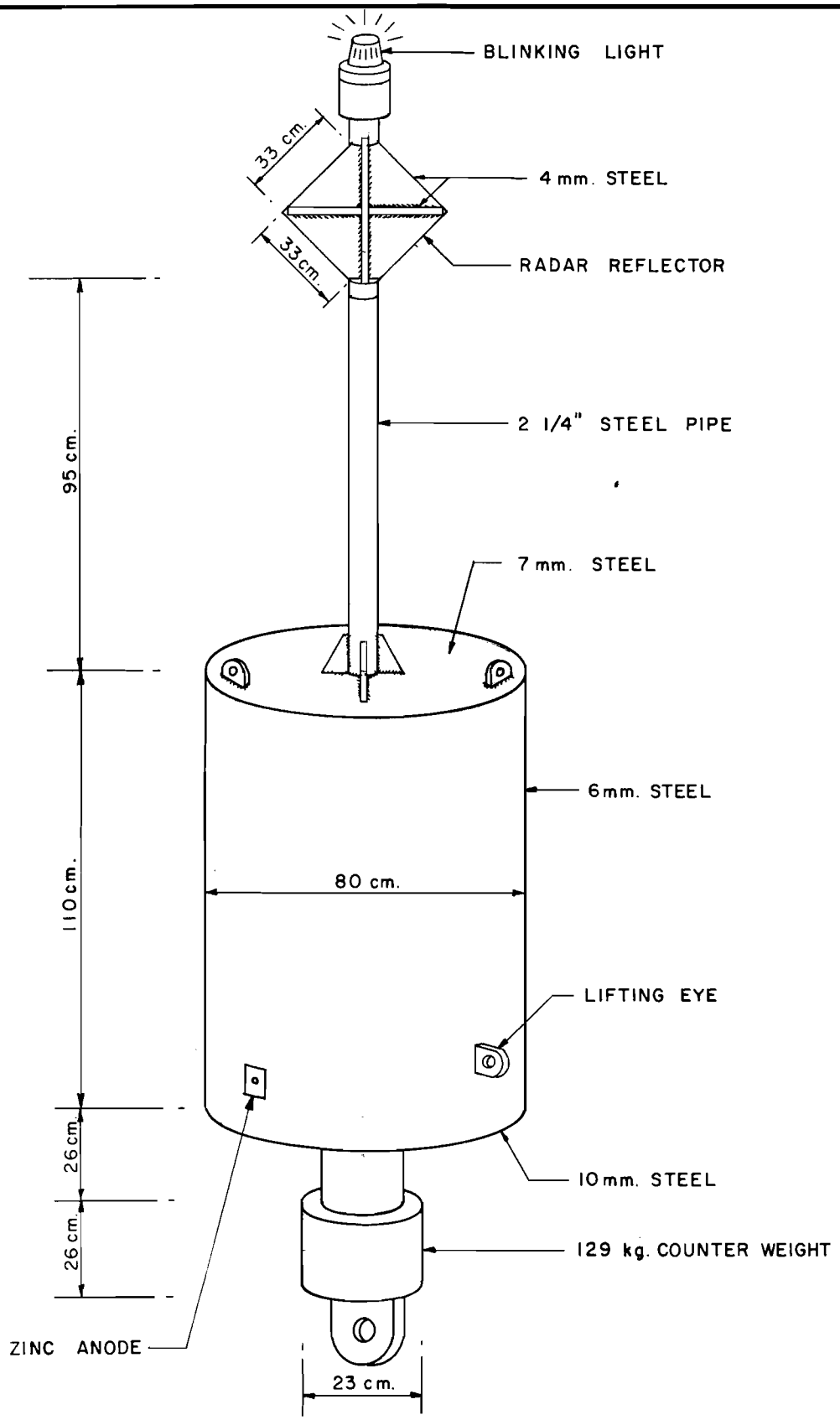

RADAR
REFLECTOR
LIGHT
NOTICE
هذا الجهاز للبحث العلمي
لا تقترب
بأمر شرطة السواحل
0.82m.
1.25 m.
SURFACE
BUOY
SUBSURFACE BUOY
13 m. CHAIN
CURRENT
METERS
CABLE
METER DEPLOYMENT
MODE "B"
ANCHOR WEIGHT
(1 TONNE)

FIGURE B – 3



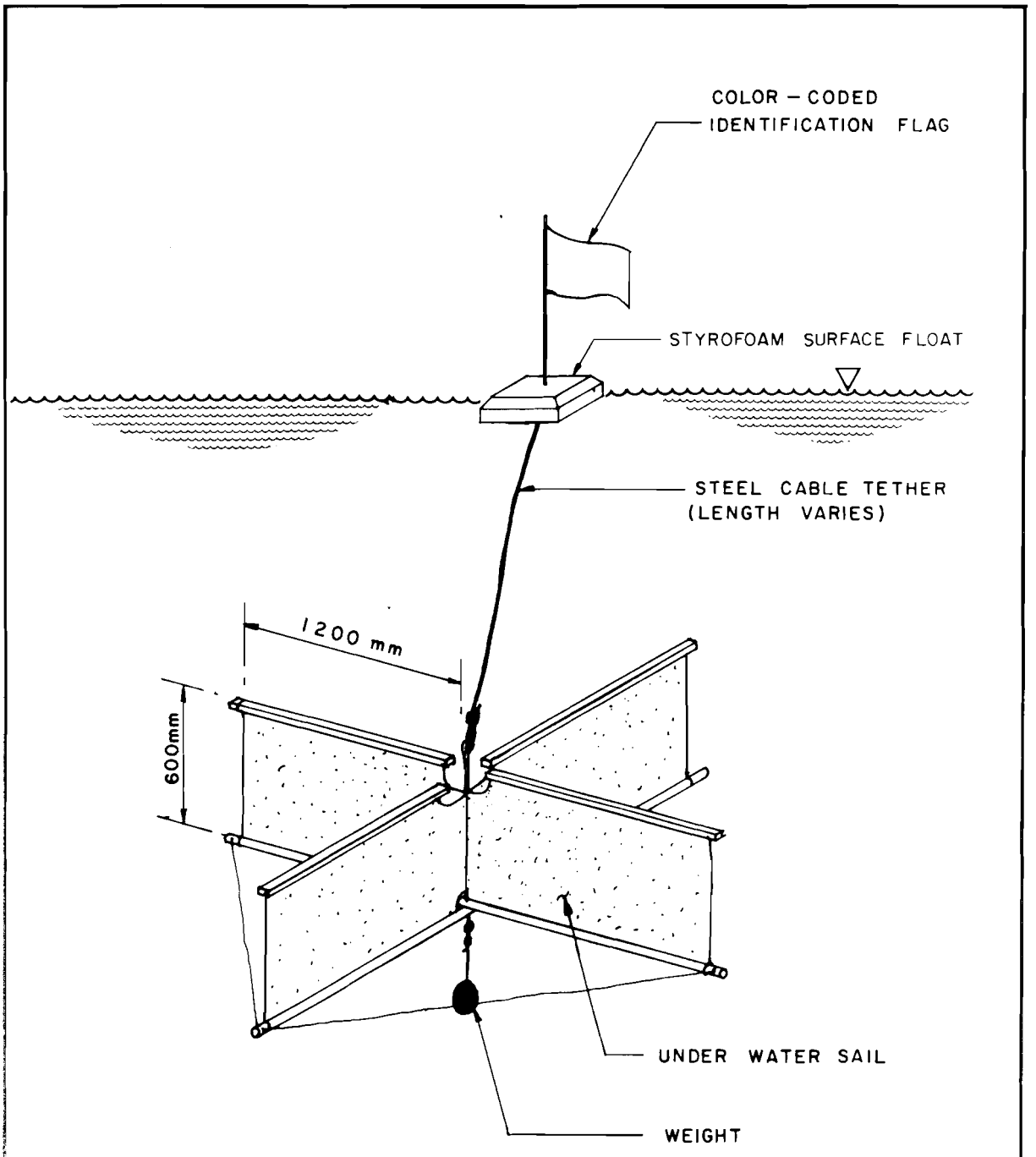
METER DEPLOYMENT MODE "C"

FIGURE B-4



SURFACE BUOY
USED IN MODE "C" DEPLOYMENTS

FIGURE B-5



TYPICAL DROGUE

FIGURE B-6

APPENDIX C

VELOCITY AND EXCURSION DISTRIBUTION OF CURRENTS

APPENDIX C

VELOCITY AND EXCURSION DISTRIBUTION OF CURRENTS

The 58 tables in this Appendix are speed and direction frequency distributions of current meter readings. Such tables were discussed in Section 3.1 and an example was provided in Table 3-22.

The 21 figures in this Appendix are Rose diagrams that show the directional distributions and length of current velocity excursions as determined from the data collected in each current meter station for the time period or periods indicated on each figure. The concept of current velocity excursion was discussed in Section 3.1, and an example of an excursion Rose diagram was provided in Figure 3-11.

TABLE C-1

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 1 AU Date: 21 Jul 77 - 31 Jul 77

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	.40	.20	.40	.40	1.41	-	-	-	-	-	3.01
20	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	.20	-	.40	-	-	-	-	.60
40	-	.40	.20	.40	1.01	.20	-	-	-	-	2.21
50	.20	1.22	1.01	1.82	2.02	1.82	.40	-	-	-	8.49
60	.40	.61	3.85	2.83	2.02	2.63	1.82	.40	.20	-	14.76
70	1.01	1.62	4.05	3.44	2.02	1.62	1.21	.20	-	-	15.17
80	.81	1.21	.81	-	.40	-	-	-	-	-	3.23
90	.20	.40	.81	-	-	-	-	-	-	-	1.41
100	-	.20	.20	-	-	-	-	-	-	-	.40
110	-	-	-	-	-	-	-	-	-	-	-
120	-	.20	-	-	-	-	-	-	-	-	.20
130	-	-	-	-	-	-	-	-	-	-	-
140	-	-	-	-	-	-	-	-	-	-	-
150	-	-	-	-	-	-	-	-	-	-	-
160	-	-	-	-	-	-	-	-	-	-	-
170	-	-	-	-	-	-	-	-	-	-	-
180	-	-	-	-	-	-	-	-	-	-	-
190	-	-	-	-	-	-	-	-	-	-	-
200	-	-	-	-	-	-	-	-	-	-	-
210	-	-	-	-	-	-	-	-	-	-	-
220	-	-	-	-	-	-	-	-	-	-	-
230	-	-	.20	.40	-	-	-	-	-	-	.60
240	-	.61	1.82	.20	.20	-	-	-	-	-	2.83
250	.40	.20	2.02	-	-	-	-	-	-	-	2.62
260	.81	1.62	2.02	.61	-	-	-	-	-	-	5.06
270	.20	.20	.61	-	-	-	-	-	-	-	1.01
280	3.65	1.21	.40	-	-	-	-	-	-	-	5.26
290	4.05	1.01	-	-	-	-	-	-	-	-	5.06
300	3.03	.40	-	-	-	-	-	-	-	-	3.43
310	.81	.20	-	-	-	-	-	-	-	-	1.01
320	.61	1.62	-	-	-	-	-	-	-	-	2.23
330	.20	-	-	-	-	-	-	-	-	-	.20
340	1.21	1.41	.40	.20	-	.20	-	-	-	-	3.42
350	.81	1.41	1.21	-	1.01	.40	-	-	-	-	4.84
360	1.21	3.04	2.22	-	1.41	3.63	.81	-	-	-	12.34
TOTAL	20.01	18.99	22.23	10.30	10.49	12.33	4.24	.60	.20	-	

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TABLE C-2

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 1 AL Date: 21 Jul 77 - 31 Jul 77

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	-	.20	-	-	-	-	-	-	-	.20
20	-	1.63	-	.61	-	-	-	-	-	-	2.24
30	.81	2.44	.41	.81	.20	-	-	-	-	-	4.67
40	1.22	3.46	1.02	1.22	.41	-	-	-	-	-	7.33
50	1.83	5.70	4.47	5.08	1.42	.20	-	-	-	-	18.70
60	.61	2.03	4.67	5.08	1.63	.41	-	-	-	-	14.43
70	1.02	2.03	3.05	2.44	1.22	.20	-	-	-	-	9.96
80	1.02	.81	.61	.20	.20	-	-	-	-	-	2.84
90	1.22	1.42	-	-	-	.20	-	-	-	-	2.84
100	.41	.61	-	-	-	-	-	-	-	-	1.02
110	.41	-	-	-	-	-	-	-	-	-	.41
120	.20	.41	-	-	-	-	-	-	-	-	.61
130	.20	.20	-	-	-	-	-	-	-	-	.40
140	.41	-	-	-	-	-	-	-	-	-	.41
150	.20	-	-	-	-	-	-	-	-	-	.20
160	.41	-	-	-	-	-	-	-	-	-	.41
170	.41	.20	-	-	-	-	-	-	-	-	.61
180	.20	-	-	-	-	-	-	-	-	-	.20
190	-	-	-	-	-	-	-	-	-	-	-
200	.61	-	-	-	-	-	-	-	-	-	.61
210	.61	1.02	-	-	-	-	-	-	-	-	1.63
220	1.42	7.32	1.63	-	-	-	-	-	-	-	10.37
230	1.63	9.35	.61	-	-	-	-	-	-	-	11.59
240	1.02	3.66	.20	-	-	-	-	-	-	-	4.88
250	.41	.51	-	-	-	-	-	-	-	-	1.02
260	.41	-	-	-	-	-	-	-	-	-	.41
270	.20	-	-	-	-	-	-	-	-	-	.20
280	-	-	-	-	-	-	-	-	-	-	-
290	-	-	-	-	-	-	-	-	-	-	-
300	.81	-	-	-	-	-	-	-	-	-	.81
310	-	-	-	-	-	-	-	-	-	-	-
320	-	-	-	-	-	-	-	-	-	-	-
330	-	-	-	-	-	-	-	-	-	-	-
340	.20	.20	.20	-	-	-	-	-	-	-	.60
350	.20	.20	-	-	-	-	-	-	-	-	.40
360	-	-	-	-	-	-	-	-	-	-	-
TOTAL	18.10	43.30	17.07	15.44	5.08	1.01	-	-	-	-	

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TABLE C-3

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 1 BU Date: 21 Jul 78 - 31 Jul 78

Direction	Speed (m/sec x 10^{-2}) 0-5	5-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	-	-	-	-	-	-	-	-	-	-
20	-	-	.20	.40	.40	-	-	-	-	-	1.00
30	-	-	.60	1.39	.80	-	-	-	-	-	2.79
40	-	.60	2.99	8.16	5.77	1.99	.80	-	-	-	20.31
50	.20	.20	2.19	6.56	5.77	6.96	3.98	.20	-	-	26.06
60	-	.20	.80	1.79	3.97	5.17	2.79	-	-	-	14.72
70	-	-	-	-	.60	1.00	-	-	-	-	1.60
80	-	.40	-	-	.20	-	-	-	-	-	.60
90	1.00	2.98	.40	.40	-	-	-	-	-	-	4.78
100	1.00	3.38	.80	-	-	-	-	-	-	-	5.18
110	.60	.60	-	-	-	-	-	-	-	-	1.20
120	1.59	1.79	-	-	-	-	-	-	-	-	3.38
130	1.20	.60	.40	-	-	-	-	-	-	-	2.20
140	1.00	1.20	-	-	-	-	-	-	-	-	2.20
150	1.20	.40	-	-	-	-	-	-	-	-	1.60
160	1.99	.40	-	-	-	-	-	-	-	-	2.39
170	1.20	.60	-	-	-	-	-	-	-	-	1.80
180	1.39	.40	-	-	-	-	-	-	-	-	1.79
190	.20	.20	-	-	-	-	-	-	-	-	.40
200	1.00	.80	-	-	-	-	-	-	-	-	1.80
210	.60	-	-	-	-	-	-	-	-	-	.60
220	.40	.20	-	-	-	-	-	-	-	-	.60
230	.20	.60	-	-	-	-	-	-	-	-	.80
240	.20	.60	-	-	-	-	-	-	-	-	.80
250	-	-	-	-	-	-	-	-	-	-	-
260	-	-	-	-	-	-	-	-	-	-	-
270	-	-	-	-	-	-	-	-	-	-	-
280	-	-	-	-	-	-	-	-	-	-	-
290	-	-	-	-	-	-	-	-	-	-	-
300	-	-	-	-	-	-	-	-	-	-	-
310	-	-	-	-	-	-	-	-	-	-	-
320	-	-	-	-	-	-	-	-	-	-	-
330	-	-	-	-	-	-	-	-	-	.20	.20
340	-	-	-	-	-	-	-	-	-	-	-
350	-	-	-	-	-	-	-	-	-	-	-
360	-	-	-	-	-	-	-	-	-	-	-
TOTAL	14.97	16.15	8.38	19.70	17.51	15.12	7.57	.20	-	.20	

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TABLE C-4

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 1 AU Date: 1 Aug 77 - 15 Aug 77

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	.42	.14	-	-	-	.14	.28	-	-	-	.98
20	.14	-	-	-	-	-	-	-	-	-	.14
30	.42	.14	-	.14	-	-	-	-	-	-	.70
40	.28	.83	.28	.28	.14	-	-	-	-	-	1.81
50	.69	2.77	1.53	1.81	.69	.83	-	-	-	-	8.32
60	1.11	4.57	3.06	2.35	2.36	1.39	.42	-	-	-	15.26
70	.28	4.16	3.60	2.22	1.67	1.81	.28	-	.14	-	14.16
80	.42	.97	.97	.97	.28	.83	-	-	-	-	4.44
90	.14	.83	.28	-	-	-	-	-	-	-	1.25
100	.42	-	-	.14	-	-	-	-	-	-	.56
110	-	-	-	-	-	-	-	-	-	-	-
120	-	-	-	-	-	-	-	-	-	-	-
130	.42	-	-	-	-	-	-	-	-	-	.42
140	.28	-	-	-	-	-	-	-	-	-	.28
150	-	-	-	-	-	-	-	-	-	-	-
160	.42	-	-	-	-	-	-	-	-	-	.42
170	.42	-	-	-	-	-	-	-	-	-	.42
180	.56	-	-	-	-	-	-	-	-	-	.56
190	-	.14	-	-	-	-	-	-	-	-	.14
200	.14	.28	-	-	-	-	-	-	-	-	.42
210	-	-	-	-	-	-	-	-	-	-	-
220	.14	.42	.14	-	-	-	-	-	-	-	.70
230	-	-	.28	.56	-	-	-	-	-	-	.84
240	.14	.83	1.39	1.53	-	-	-	-	-	-	3.89
250	-	.83	1.81	1.11	-	-	-	-	-	-	3.75
260	.28	1.11	2.35	2.49	-	-	-	-	-	-	6.23
270	.42	.83	1.67	.42	-	-	-	-	-	-	3.34
280	.83	1.81	.97	.56	.14	-	-	-	-	-	4.31
290	.69	2.50	.28	.56	-	-	-	-	-	-	4.03
300	3.18	.69	.14	-	-	-	-	-	-	-	4.01
310	3.05	1.25	-	-	-	-	-	-	-	-	4.30
320	3.05	.97	.28	-	-	-	-	-	-	-	4.30
330	.69	.56	-	-	-	-	-	-	-	-	1.25
340	.56	.28	-	.14	.14	-	-	-	-	-	1.12
350	.42	.14	-	.14	.14	-	-	.28	-	-	1.12
360	1.39	.97	.28	.56	.69	1.11	1.11	.28	-	-	6.39
TOTAL	21.40	28.02	19.31	15.98	6.25	6.11	2.09	.56	.14	-	

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TABLE C-5

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 1 AL Date: 1 Aug 77 - 15 Aug 77

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	.14	-	-	-	-	-	-	-	-	-	.14
20	.28	.56	.69	.28	-	-	-	-	-	-	1.81
30	.28	.69	2.09	.83	.42	-	-	-	-	-	4.31
40	.42	1.25	1.80	1.39	.14	.28	-	-	-	-	5.28
50	1.39	2.93	4.70	3.04	1.25	.56	.14	-	-	-	14.01
60	2.22	1.53	2.78	2.08	.42	-	-	-	-	-	9.03
70	1.66	.69	.28	.42	.28	-	-	-	-	-	3.33
80	.69	.97	.14	-	-	-	-	-	-	-	1.80
90	1.39	.42	-	-	-	-	-	-	-	-	1.81
100	.14	.14	-	-	-	-	-	-	-	-	.28
110	.83	.14	-	-	-	-	-	-	-	-	.97
120	.69	.42	-	-	-	-	-	-	-	-	1.11
130	.56	-	-	-	-	-	-	-	-	-	.56
140	1.53	.14	-	-	-	-	-	-	-	-	1.67
150	1.67	.42	-	-	-	-	-	-	-	-	2.09
160	.69	.14	-	-	-	-	-	-	-	-	.83
170	.56	-	-	-	-	-	-	-	-	-	.56
180	.42	.14	-	-	-	-	-	-	-	-	.56
190	.56	.14	-	-	-	-	-	-	-	-	.70
200	.42	.69	.28	-	-	-	-	-	-	-	1.39
210	1.25	2.50	1.39	.28	-	-	-	-	-	-	5.42
220	1.94	5.54	3.75	.97	-	-	-	-	-	-	12.20
230	1.94	5.67	4.03	.28	-	-	-	-	-	-	11.92
240	.97	2.50	.97	-	-	-	-	-	-	-	4.44
250	1.39	1.39	.69	-	-	-	-	-	-	-	3.47
260	1.11	.28	-	-	-	-	-	-	-	-	1.39
270	1.53	.14	-	-	-	-	-	-	-	-	1.67
280	1.81	-	-	-	-	-	-	-	-	-	1.81
290	1.11	.14	-	-	-	-	-	-	-	-	1.25
300	.56	-	-	-	-	-	-	-	-	-	.56
310	.28	.14	-	-	-	-	-	-	-	-	.42
320	.42	-	-	-	-	-	-	-	-	-	.42
330	-	.28	-	-	-	-	-	-	-	-	.28
340	.42	.14	-	-	-	-	-	-	-	-	.56
350	.14	-	-	-	-	-	-	-	-	-	.14
360	-	-	-	-	-	-	-	-	-	-	-
TOTAL	31.41	30.13	23.59	9.57	2.51	.84	.14	-	-	-	

TABLE C-6

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 1 BU Date: 1 Aug 77 - 7 Aug 77

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-	-	-	-	-
50	-	-	.31	.62	1.54	.31	-	-	-	-	2.78
60	-	-	2.47	8.32	8.02	1.54	-	-	-	-	20.35
70	-	.93	1.85	1.85	.31	-	-	-	-	-	4.94
80	-	.93	-	-	-	-	-	-	-	-	.93
90	-	.93	.31	-	-	-	-	-	-	-	1.24
100	-	1.23	-	-	-	-	-	-	-	-	1.23
110	.31	.62	.31	-	-	-	-	-	-	-	1.24
120	-	1.85	.31	-	-	-	-	-	-	-	2.16
130	.31	.31	-	-	-	-	-	-	-	-	.62
140	.31	.31	-	-	-	-	-	-	-	-	.62
150	.31	-	-	-	-	-	-	-	-	-	.31
160	.31	-	-	-	-	-	-	-	-	-	.31
170	-	.31	-	-	-	-	-	-	-	-	.31
180	-	-	-	-	-	-	-	-	-	-	-
190	-	-	.93	-	-	-	-	-	-	-	.93
200	.31	-	3.09	.93	-	-	-	-	-	-	4.33
210	-	.62	4.01	3.09	.31	-	-	-	-	-	8.03
220	.31	4.31	6.79	4.01	.31	-	-	-	-	-	15.73
230	-	2.78	8.94	8.02	2.16	.62	-	-	-	-	22.52
240	-	1.85	4.94	3.40	1.23	-	-	-	-	-	11.42
250	-	-	-	-	-	-	-	-	-	-	-
260	-	-	-	-	-	-	-	-	-	-	-
270	-	-	-	-	-	-	-	-	-	-	-
280	-	-	-	-	-	-	-	-	-	-	-
290	-	-	-	-	-	-	-	-	-	-	-
300	-	-	-	-	-	-	-	-	-	-	-
310	-	-	-	-	-	-	-	-	-	-	-
320	-	-	-	-	-	-	-	-	-	-	-
330	-	-	-	-	-	-	-	-	-	-	-
340	-	-	-	-	-	-	-	-	-	-	-
350	-	-	-	-	-	-	-	-	-	-	-
360	-	-	-	-	-	-	-	-	-	-	-
TOTAL	2.17	16.98	34.26	30.24	13.88	2.47	-	-	-	-	

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TABLE C-7

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 AU Date: 3 Aug 77 - 15 Aug 77

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-
30	-	.17	-	-	-	-	-	-	-	-	.17
40	.17	-	-	-	-	-	-	-	-	-	.17
50	.50	1.17	2.16	.83	.33	-	-	-	-	-	4.99
60	.17	1.83	5.00	3.16	.66	.17	-	-	-	-	10.99
70	.83	2.00	6.17	5.33	1.83	1.67	1.50	.50	-	-	19.83
80	.17	3.51	2.33	5.67	3.33	2.67	2.67	.50	-	-	20.85
90	-	1.83	.33	1.33	1.83	1.83	.33	-	-	-	7.48
100	-	.66	-	-	.17	.17	-	-	-	-	1.00
110	.17	.17	-	-	-	-	-	-	-	-	.34
120	.17	.17	-	-	-	-	-	-	-	-	.34
130	-	.17	-	-	-	-	-	-	-	-	.17
140	-	.17	-	-	-	-	-	-	-	-	.17
150	-	.17	-	-	-	-	-	-	-	-	.17
160	.17	-	-	-	-	-	-	-	-	-	.17
170	.17	-	-	-	-	-	-	-	-	-	.17
180	-	-	-	-	-	-	-	-	-	-	-
190	-	-	-	-	-	-	-	-	-	-	-
200	-	-	-	-	-	-	-	-	-	-	-
210	-	-	-	-	-	-	-	-	-	-	-
220	-	-	-	-	-	-	-	-	-	-	-
230	-	-	-	-	-	-	-	-	-	-	-
240	-	-	.17	.17	-	-	-	-	-	-	.34
250	.83	.66	.50	.17	-	-	-	-	-	-	2.16
260	1.50	2.18	.33	.33	-	-	-	-	-	-	4.34
270	5.17	3.17	.33	.17	-	-	-	-	-	-	3.84
280	4.16	.33	.50	-	-	-	-	-	-	-	4.99
290	2.16	.66	.50	-	-	-	-	-	-	-	3.32
300	1.50	1.00	-	-	-	-	-	-	-	-	2.50
310	1.17	.66	-	-	-	-	-	-	-	-	1.83
320	1.83	2.00	-	-	-	-	-	-	-	-	3.83
330	.17	.33	-	-	-	-	-	-	-	-	.50
340	-	-	-	-	-	-	-	-	-	-	-
350	.17	-	-	-	-	-	-	-	-	-	.17
360	-	-	-	-	-	-	-	-	-	-	-
TOTAL	21.18	23.01	18.32	17.16	8.15	6.51	4.50	1.00	-	-	

TABLE C-8

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 AL Date: 3 Aug 77 - 15 Aug 77

Speed (m/sec x 10^{-2})

Direction	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	1.00	-	-	-	-	-	-	-	-	-	1.00
20	-	-	-	-	-	-	-	-	-	-	-
30	.50	-	-	-	-	-	-	-	-	-	.50
40	.83	.67	.17	.17	-	-	-	-	-	-	1.84
50	3.67	1.83	3.00	1.83	.50	-	-	-	-	-	10.83
60	6.33	2.67	6.67	5.33	.67	-	-	-	-	-	21.67
70	5.67	1.17	1.50	1.33	.50	-	-	-	-	-	10.17
80	1.83	.50	.33	.50	-	-	-	-	-	-	3.16
90	1.17	-	-	-	-	-	-	-	-	-	1.17
100	.50	-	-	-	-	-	-	-	-	-	.50
110	.17	-	-	-	-	-	-	-	-	-	.17
120	.83	-	-	-	-	-	-	-	-	-	.83
130	.67	-	-	-	-	-	-	-	-	-	.67
140	.33	-	-	-	-	-	-	-	-	-	.33
150	.50	-	-	-	-	-	-	-	-	-	.50
160	.67	-	-	-	-	-	-	-	-	-	.67
170	.67	-	-	-	-	-	-	-	-	-	.67
180	.83	-	-	-	-	-	-	-	-	-	.83
190	1.00	.17	-	-	-	-	-	-	-	-	1.17
200	.50	-	-	-	-	-	-	-	-	-	.50
210	.83	.33	-	-	-	-	-	-	-	-	1.16
220	1.17	.17	-	-	-	-	-	-	-	-	1.34
230	1.50	.33	-	.17	-	-	-	-	-	-	2.00
240	3.83	.83	1.17	.33	1.00	-	-	-	-	-	7.16
250	1.67	-	-	.17	-	-	-	-	-	-	1.84
260	.83	.33	-	-	-	-	-	-	-	-	1.16
270	1.00	-	-	-	-	-	-	-	-	-	1.00
280	.17	-	-	-	-	-	-	-	-	-	.17
290	-	-	-	-	-	-	-	-	-	-	-
300	.50	-	-	-	-	-	-	-	-	-	.50
310	.83	-	-	-	-	-	-	-	-	-	.83
320	.83	-	-	-	-	-	-	-	-	-	.83
330	.33	-	-	-	-	-	-	-	-	-	.33
340	.83	-	-	-	-	-	-	-	-	-	.83
350	.50	-	-	-	-	-	-	-	-	-	.50
360	.67	-	-	-	-	-	-	-	-	-	.67
TOTAL	43.16	9.00	12.84	9.83	2.67	-	-	-	-	-	

TABLE C-9

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 BU Date: 3 Aug 77 to 15 Aug 77

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	.34	.50	-	-	-	-	.84
30	-	-	-	.34	.67	.67	-	-	-	-	1.68
40	-	-	.34	1.51	.17	-	.17	-	-	-	2.19
50	-	-	1.01	1.85	.67	.17	.33	-	-	-	4.03
60	-	-	3.68	4.03	1.17	.50	1.01	-	-	-	10.39
70	-	.67	3.19	5.54	2.01	.67	.50	-	-	-	12.58
80	-	1.17	3.02	2.52	1.34	.17	-	-	-	-	8.22
90	.17	.67	2.18	1.68	.50	.17	-	-	-	-	5.37
100	.17	.67	1.17	1.68	1.34	.17	-	-	-	-	5.20
110	-	.67	.33	.50	1.01	.17	-	-	-	-	2.68
120	.17	.33	.84	-	.17	-	-	-	-	-	1.51
130	-	.33	.50	.34	.34	-	-	-	-	-	1.51
140	-	-	.34	.50	-	-	-	-	-	-	.84
150	-	.17	1.01	-	-	-	-	-	-	-	1.18
160	-	.17	-	-	-	-	-	-	-	-	.34
170	-	.33	.17	-	-	-	-	-	-	-	.50
180	-	.50	.17	-	-	-	-	-	-	-	.67
190	.34	1.01	-	-	-	-	-	-	-	-	1.35
200	.17	1.01	.33	-	-	-	-	-	-	-	1.51
210	.17	1.01	.50	-	-	-	-	-	-	-	1.68
220	.17	1.01	1.17	-	-	-	-	-	-	-	2.35
230	.33	.67	1.17	-	-	-	-	-	-	-	2.17
240	.17	.34	-	.33	.33	-	-	-	-	-	1.17
250	.17	.84	.50	.84	.17	-	-	-	-	-	2.52
260	.17	.84	1.51	1.85	2.18	.67	-	-	-	-	7.22
270	.17	.33	.84	3.02	2.85	1.85	.34	-	-	-	9.40
280	.33	.33	.34	1.17	.84	.34	-	-	-	-	3.35
290	-	.33	.17	1.01	.84	.34	-	-	-	-	2.69
300	-	-	.17	.50	.34	.33	-	.17	-	-	1.51
310	-	.17	-	-	.50	.50	.17	-	-	-	1.34
320	-	-	-	-	.17	.33	-	-	-	-	.50
330	-	-	.33	.34	-	-	-	-	-	-	.67
340	-	-	-	-	-	-	-	-	-	-	-
350	-	.17	-	-	-	-	-	-	-	-	.17
360	-	.34	-	-	-	-	-	-	-	-	.34
TOTAL	2.70	14.08	25.15	29.55	17.95	7.55	2.52	.17	-	-	

TABLE C-10

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 BL Date: 3 Aug 77 - 15 Aug 77

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	.33	.33	.17	-	-	-	-	-	-	-	.83
20	.33	-	-	-	-	-	-	-	-	-	.33
30	.67	.67	.67	-	-	-	-	-	-	-	2.01
40	.33	1.34	2.34	.84	-	-	-	.17	-	-	5.02
50	1.17	1.17	4.68	1.67	.17	.17	.33	-	.17	-	10.53
60	.33	1.17	1.34	3.85	4.18	1.84	1.67	-	-	-	14.38
70	.84	1.34	2.84	1.67	1.67	1.51	-	.17	-	-	10.04
80	.67	.17	2.17	.67	.67	.17	-	-	-	-	4.52
90	1.51	1.67	.50	1.17	.33	.50	-	-	-	-	5.68
100	1.84	2.17	.33	1.51	.67	-	-	-	-	-	6.52
110	2.51	.33	.84	-	.17	-	-	-	-	-	3.85
120	.33	-	-	-	-	-	-	-	-	-	.33
130	-	-	-	-	-	-	-	-	-	-	-
140	-	-	-	-	-	-	-	-	-	-	-
150	-	-	-	-	-	-	-	-	-	-	-
160	-	-	-	-	-	-	-	-	-	-	-
170	-	-	-	-	-	-	-	-	-	-	-
180	-	-	-	-	-	-	-	-	-	-	-
190	-	-	-	-	-	-	-	-	-	-	-
200	-	-	-	-	-	-	-	-	-	-	-
210	-	-	-	-	-	-	-	-	-	-	-
220	-	-	-	-	-	-	-	-	-	-	-
230	-	.17	-	.84	.33	-	-	-	-	-	1.34
240	.17	1.00	.33	1.51	.84	-	-	-	-	-	3.85
250	-	.33	1.17	2.51	.33	-	-	-	-	-	4.34
260	.17	1.00	2.17	1.51	-	-	-	-	-	-	4.85
270	.50	-	.67	.84	1.51	.67	-	-	-	-	4.19
280	.33	-	.50	1.34	-	.17	-	-	-	-	2.34
290	1.17	.33	.50	2.84	.17	-	-	-	-	-	5.01
300	.17	-	-	.50	.17	-	-	-	-	-	.84
310	.84	.33	.17	.17	.17	-	-	-	-	-	1.68
320	.33	.33	.17	-	-	-	-	-	-	-	.83
330	.33	.67	.17	-	-	-	-	-	-	-	1.17
340	1.67	1.17	-	-	-	-	-	-	-	-	2.84
350	.67	.17	.17	-	-	-	-	-	-	-	1.01
360	1.17	-	.17	-	-	-	-	-	-	-	1.34
TOTAL	18.38	15.86	22.07	23.44	11.38	6.03	2.00	.34	.17	-	

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TABLE C-11

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 1 AU Date: 16 Aug 77 - 31 Aug 77

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	.69	.28	.41	-	-	-	-	-	-	-	1.38
20	.14	.28	-	-	-	-	-	-	-	-	.42
30	.69	-	-	-	-	-	-	-	-	-	.69
40	.41	.69	.41	.14	.14	-	-	-	-	-	1.79
50	1.38	1.52	.96	1.24	-	-	-	-	-	-	5.10
60	2.33	4.67	3.86	2.89	.41	.28	-	-	-	-	14.44
70	.96	3.43	3.85	2.07	.83	.28	-	-	-	-	11.42
80	.96	1.38	.96	.55	.14	-	-	-	-	-	3.99
90	1.10	.41	-	-	-	-	-	-	-	-	1.51
100	.41	-	-	-	-	-	-	-	-	-	.41
110	.14	-	-	-	-	-	-	-	-	-	.14
120	.14	-	-	-	-	-	-	-	-	-	.14
130	-	-	-	-	-	-	-	-	-	-	-
140	.28	-	-	-	-	-	-	-	-	-	.28
150	.55	-	-	-	-	-	-	-	-	-	.55
160	.41	-	-	-	-	-	-	-	-	-	.41
170	.55	-	-	-	-	-	-	-	-	-	.55
180	-	-	-	-	-	-	-	-	-	-	-
190	-	-	-	-	-	-	-	-	-	-	-
200	.28	.14	.28	-	-	-	-	-	-	-	.70
210	.14	.96	-	.14	.14	-	-	-	-	-	1.38
220	.28	1.38	1.38	.28	.28	.14	-	-	-	-	3.74
230	.41	2.34	1.79	.41	-	-	-	-	-	-	4.95
240	1.24	2.61	3.85	1.10	.55	-	-	-	-	-	9.35
250	1.24	2.20	2.75	.83	.55	-	-	-	-	-	7.57
260	.96	1.52	1.52	.96	.28	-	-	-	-	-	5.24
270	1.10	.41	.55	.28	-	-	-	-	-	-	2.34
280	.69	.28	.83	.28	-	-	-	-	-	-	2.08
290	.28	.41	.14	-	-	-	-	-	-	-	.83
300	.96	1.38	-	-	-	-	-	-	-	-	2.34
310	1.24	1.52	.14	-	-	-	-	-	-	-	2.90
320	1.93	2.61	.41	-	-	-	-	-	-	-	4.95
330	.41	.83	-	-	-	-	-	-	-	-	1.24
340	.41	1.79	-	-	-	-	-	-	-	-	2.20
350	.83	.28	-	-	-	-	-	-	-	-	1.11
360	.55	2.34	.14	-	-	-	-	-	-	-	3.03
TOTAL	24.09	35.66	24.23	11.17	3.32	.70	-	-	-	-	

TABLE C-12

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 1 AL Date: 16 Aug 77 - 31 Aug 77

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	.13	-	-	-	-	-	-	-	-	.13
20	-	.26	.13	-	-	-	-	-	-	-	.39
30	.92	.65	.65	-	-	-	-	-	-	-	2.22
40	.92	1.30	2.35	.78	-	-	-	-	-	-	5.35
50	2.48	2.88	4.85	1.57	.65	-	-	-	-	-	12.43
60	3.67	4.18	3.40	1.44	.13	-	-	-	-	-	12.82
70	2.09	2.48	1.44	.26	-	-	-	-	-	-	6.27
80	.92	.78	.26	-	-	-	-	-	-	-	1.96
90	1.30	.39	.13	-	-	-	-	-	-	-	1.82
100	.78	.13	-	-	-	-	-	-	-	-	.91
110	.52	-	-	-	-	-	-	-	-	-	.52
120	.39	-	-	-	-	-	-	-		-	.39
130	.13	-	-	-	-	-	-	-	-	-	.13
140	.78	.13	-	-	-	-	-	-	-	-	.91
150	.52	.13	-	-	-	-	-	-	-	-	.65
160	.92	-	-	-	-	-	-	-	-	-	.92
170	.65	-	-	-	-	-	-	-	-	-	.65
180	.78	-	-	-	-	-	-	-	-	-	.78
190	.92	.13	-	-	-	-	-	-	-	-	1.05
200	1.83	1.70	-	-	-	-	-	-	-	-	3.53
210	2.35	4.19	1.18	.13	-	-	-	-	-	-	7.85
220	2.89	5.90	1.83	.26	-	-	-	-	-	-	10.88
230	2.62	2.75	1.96	.13	-	-	-	-	-	-	7.46
240	2.36	1.57	.13	-	-	-	-	-	-	-	4.06
250	1.30	.52	-	-	-	-	-	-	-	-	1.82
260	.92	.26	-	-	-	-	-	-	-	-	1.18
270	.78	-	-	-	-	-	-	-	-	-	.78
280	.39	-	-	-	-	-	-	-	-	-	.39
290	.39	-	-	-	-	-	-	-	-	-	.39
300	.52	-	-	-	-	-	-	-	-	-	.52
310	.65	.13	-	-	-	-	-	-	-	-	.78
320	.39	-	-	-	-	-	-	-	-	-	.39
330	.52	-	-	-	-	-	-	-	-	-	.52
340	.52	-	-	-	-	-	-	-	-	-	.52
350	.52	.39	-	-	-	-	-	-	-	-	.91
360	3.54	.13	-	-	-	-	-	-	-	-	3.67
TOTAL	41.18	31.11	18.31	4.57	.78	-	-	-	-	-	

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TABLE C-13

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 AU Date: 16 Aug 77 - 31 Aug 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	.91	-	-	-	-	-	-	-	-	-	.91
20	.52	-	-	-	-	-	-	-	-	-	.52
30	.52	-	-	-	-	-	-	-	-	-	.52
40	.39	.26	-	-	-	-	-	-	-	-	.65
50	1.17	.39	.52	.39	-	-	-	-	-	-	2.47
60	.91	2.22	3.92	2.22	.91	.13	-	-	-	-	10.31
70	1.17	3.92	5.47	3.39	2.09	.52	-	-	-	-	16.56
80	.39	2.09	1.44	.91	.26	.26	-	-	-	-	5.35
90	.26	1.04	.65	.13	-	-	-	-	-	-	2.08
100	.13	.26	-	-	-	-	-	-	-	-	.39
110	-	.26	-	-	-	-	-	-	-	-	.26
120	-	-	-	-	-	-	-	-	-	-	-
130	.13	-	-	-	-	-	-	-	-	-	.13
140	.13	-	-	-	-	-	-	-	-	-	.13
150	.13	-	-	-	-	-	-	-	-	-	.13
160	-	-	-	-	-	-	-	-	-	-	-
170	-	-	-	-	-	-	-	-	-	-	-
180	.13	-	-	-	-	-	-	-	-	-	.13
190	.26	-	-	-	-	-	-	-	-	-	.26
200	.26	-	-	-	-	-	-	-	-	-	.26
210	1.04	-	-	-	-	-	-	-	-	-	1.04
220	.39	.39	-	-	-	-	-	-	-	-	.78
230	.65	1.17	.52	.39	-	-	-	-	-	-	2.73
240	.65	1.44	2.48	2.48	.65	-	-	-	-	-	7.70
250	.91	2.74	4.56	4.56	1.56	.13	-	-	-	-	14.46
260	1.44	2.35	2.48	2.09	.79	-	-	-	-	-	9.15
270	.65	2.75	1.30	1.17	.65	.13	-	-	-	-	6.65
280	.79	2.22	.65	-	.13	-	-	-	-	-	3.79
290	1.30	1.56	-	-	-	-	-	-	-	-	2.86
300	1.44	1.96	-	-	-	-	-	-	-	-	3.40
310	1.56	1.17	-	-	-	-	-	-	-	-	2.73
320	.13	.65	-	-	-	-	-	-	-	-	.78
330	.13	.39	-	-	-	-	-	-	-	-	.52
340	.26	.13	-	-	-	-	-	-	-	-	.39
350	.52	-	-	-	-	-	-	-	-	-	.52
360	-	-	-	-	-	-	-	-	-	-	-
TOTAL	19.27	29.36	23.99	17.73	7.04	1.17	-	-	-	-	

TABLE C-14

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 AL Date: 16 Aug 77 - 31 Aug 77

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	.91	.13	-	-	-	-	-	-	-	-	1.04
20	.39	-	-	-	-	-	-	-	-	-	.39
30	.13	-	-	-	-	-	-	-	-	-	.13
40	2.47	.26	.13	.52	-	-	-	-	-	-	3.38
50	3.39	3.78	2.48	2.09	1.30	.13	-	-	-	-	13.17
60	2.87	5.47	5.47	5.21	.78	.26	-	-	-	-	20.33
70	2.73	1.30	.91	.66	.52	-	-	-	-	-	6.12
80	1.17	.26	.13	-	-	-	-	-	-	-	1.56
90	.78	-	-	-	-	-	-	-	-	-	.78
100	1.43	-	-	-	-	-	-	-	-	-	1.43
110	.52	-	-	-	-	-	-	-	-	-	.52
120	.39	-	-	-	-	-	-	-	-	-	.39
130	.52	-	-	-	-	-	-	-	-	-	.52
140	.13	-	-	-	-	-	-	-	-	-	.13
150	.26	-	-	-	-	-	-	-	-	-	.26
160	.39	-	-	-	-	-	-	-	-	-	.39
170	.13	.13	-	-	-	-	-	-	-	-	.26
180	.39	-	-	-	-	-	-	-	-	-	.39
190	.78	-	-	-	-	-	-	-	-	-	.78
200	.52	-	-	-	-	-	-	-	-	-	.52
210	1.04	.93	-	-	-	-	-	-	-	-	1.43
220	1.43	2.87	.52	-	-	-	-	-	-	-	4.82
230	2.87	6.51	2.60	.26	-	-	-	-	-	-	12.24
240	3.65	3.52	1.56	-	-	-	-	-	-	-	8.73
250	2.60	1.56	.26	-	-	-	-	-	-	-	4.42
260	1.82	.91	-	-	-	-	-	-	-	-	2.73
270	1.04	-	-	-	-	-	-	-	-	-	1.04
280	.39	-	-	-	-	-	-	-	-	-	.39
290	.26	-	-	-	-	-	-	-	-	-	.26
300	.52	-	-	-	-	-	-	-	-	-	.52
310	-	-	-	-	-	-	-	-	-	-	-
320	.13	-	-	-	-	-	-	-	-	-	.13
330	.13	-	-	-	-	-	-	-	-	-	.13
340	.78	-	-	-	-	-	-	-	-	-	.78
350	1.04	.13	-	-	-	-	-	-	-	-	1.17
360	4.42	.65	-	-	-	-	-	-	-	-	5.07
TOTAL	42.42	27.87	14.33	8.74	2.60	.39	-	-	-	-	

TABLE C-15

FREQUENCY DISTRIBUTION OF SPEED CURRENT AND DIRECTION

Meter: 2 BU Date: 16 Aug 77 - 31 Aug 77

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	-	-	-	-
40	.13	.26	.52	.26	-	-	-	-	-	-	1.17
50	-	3.38	1.43	-	-	-	-	-	-	-	4.81
60	.27	4.05	1.17	.13	-	-	-	-	-	-	5.62
70	.13	3.12	1.17	-	-	-	-	-	-	-	4.42
80	.26	3.77	1.43	-	-	-	-	-	-	-	5.46
90	.39	1.56	1.04	-	-	-	-	-	-	-	2.99
100	.26	1.95	.91	-	-	-	-	-	-	-	3.12
110	.39	2.34	.39	-	-	-	-	-	-	-	3.12
120	.65	1.95	.13	.39	-	-	-	-	-	-	3.12
130	.52	1.04	.26	-	-	-	-	-	-	-	1.82
140	.13	-	.13	-	-	-	-	-	-	-	.26
150	-	-	.26	-	-	-	-	-	-	-	.26
160	.13	.13	.13	-	-	-	-	-	-	-	.39
170	.65	1.04	-	-	-	-	-	-	-	-	1.69
180	.39	1.17	-	-	-	-	-	-	-	-	1.56
190	.52	.26	.13	-	-	-	-	-	-	-	.91
200	.52	1.17	-	-	-	-	-	-	-	-	1.69
210	1.17	.91	.13	.13	-	-	-	-	-	-	2.34
220	1.04	1.17	.52	.26	-	-	-	-	-	-	2.99
230	1.17	1.56	1.17	.39	.26	-	-	-	-	-	4.55
240	1.30	1.83	1.69	.91	.13	-	-	-	-	-	5.86
250	.65	2.09	3.53	1.43	.26	-	-	-	-	-	7.96
260	.65	2.22	3.65	3.27	.13	-	-	-	-	-	9.92
270	1.04	1.44	2.74	2.61	.91	.26	-	-	-	-	9.00
280	1.18	2.74	1.43	.39	-	-	-	-	-	-	5.74
290	1.43	2.86	.39	-	-	-	-	-	-	-	4.68
300	1.78	2.34	.13	-	-	-	-	-	-	-	3.25
310	.52	-	-	-	-	-	-	-	-	-	.52
320	.13	-	-	-	-	-	-	-	-	-	.13
330	-	-	-	-	-	-	-	-	-	-	-
340	-	-	-	-	-	-	-	-	-	-	-
350	-	.13	-	-	-	-	-	-	-	-	.13
360	.13	-	-	-	-	-	-	-	-	-	.13
TOTAL	16.53	46.48	24.48	10.17	1.69	.26	-	-	-	-	

TABLE C-16

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 BL Date: 16 Aug 77 - 31 Aug 77

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	.13	-	-	-	-	-	-	-	-	-	.13
20	.39	.39	.13	-	-	-	-	-	-	-	.91
30	1.17	.52	.13	-	-	-	-	-	-	-	1.82
40	1.17	1.04	-	-	-	-	-	-	-	-	2.21
50	2.09	1.43	.52	.13	-	-	-	-	-	-	4.17
60	.91	1.30	1.82	.91	-	-	-	-	-	-	4.94
70	1.17	1.04	1.43	.52	-	-	-	-	-	-	4.16
80	.39	1.04	1.43	.91	-	-	-	-	-	-	3.77
90	.26	.52	.39	-	-	-	-	-	-	-	1.17
100	.39	.26	.13	-	-	-	-	-	-	-	.78
110	1.04	-	.13	-	-	-	-	-	-	-	1.17
120	.65	.39	-	-	-	-	-	-	-	-	1.04
130	1.04	.39	.13	-	-	-	-	-	-	-	1.56
140	.91	1.82	.91	-	-	-	-	-	-	-	3.64
150	.91	1.30	1.30	-	-	-	-	-	-	-	3.51
160	.52	.65	.26	-	-	-	-	-	-	-	1.43
170	.52	.91	.13	-	-	-	-	-	-	-	1.56
180	.26	.13	-	-	-	-	-	-	-	-	.39
190	.26	.39	-	-	-	-	-	-	-	-	.65
200	.91	.91	-	-	-	-	-	-	-	-	1.82
210	1.30	1.30	1.04	.52	-	-	-	-	-	-	4.16
220	.78	1.57	2.34	.65	.26	-	-	-	-	-	5.60
230	.78	1.69	2.09	.91	.52	-	-	-	-	-	5.99
240	1.43	2.21	1.95	2.47	.78	-	-	-	-	-	8.84
250	1.30	1.69	2.08	1.56	.52	.13	.13	.13	-	-	7.54
260	1.04	1.30	2.47	1.30	.39	1.04	.26	-	-	-	7.80
270	1.30	.39	1.82	.39	.26	.26	-	-	-	-	4.42
280	.91	1.04	.78	-	-	-	-	-	-	-	2.73
290	1.04	.39	.39	-	-	-	-	-	-	-	1.82
300	.13	.26	-	-	-	-	-	-	-	-	.39
310	.39	.52	.39	-	-	-	-	-	-	-	1.30
320	.52	.39	.13	-	-	-	-	-	-	-	1.04
330	.26	.26	.13	-	-	-	-	-	-	-	.65
340	1.04	.52	-	-	-	-	-	-	-	-	1.56
350	1.30	.78	-	-	-	-	-	-	-	-	2.08
360	.78	.26	-	-	-	-	-	-	-	-	1.04
TOTAL	29.39	29.00	24.45	10.27	2.73	1.43	.39	.13	-	-	

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TABLE C-17

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 1 AU Date: 1 Sep 77 - 15 Sep 77

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	.28	-	-	-	-	-	-	-	-	-	.28
20	.83	.28	-	-	-	-	-	-	-	-	1.11
30	1.67	1.11	-	-	-	-	-	-	-	-	2.78
40	1.11	2.22	1.53	.14	-	-	-	-	-	-	5.00
50	3.75	5.13	3.33	1.81	.14	-	-	-	-	-	14.16
60	3.32	3.47	1.11	2.08	.83	-	-	-	-	-	10.81
70	3.46	3.33	.56	.56	.14	-	-	-	-	-	8.05
80	1.39	.28	-	-	-	-	-	-	-	-	1.67
90	1.94	.83	-	-	-	-	-	-	-	-	2.77
100	.97	-	-	-	-	-	-	-	-	-	.97
110	1.11	.14	-	-	-	-	-	-	-	-	1.25
120	.69	-	-	-	-	-	-	-	-	-	.69
130	.56	-	-	-	-	-	-	-	-	-	.56
140	.14	-	-	-	-	-	-	-	-	-	.14
150	-	.28	-	-	-	-	-	-	-	-	.28
160	.14	.14	-	-	-	-	-	-	-	-	.28
170	.28	.14	-	-	-	-	-	-	-	-	.42
180	.56	.28	-	-	-	-	-	-	-	-	.84
190	.42	-	-	-	-	-	-	-	-	-	.42
200	1.39	.28	-	-	-	-	-	-	-	-	1.67
210	.69	.28	-	-	-	-	-	-	-	-	.97
220	.83	.83	.14	-	-	-	-	-	-	-	1.80
230	1.25	1.39	.28	-	-	-	-	-	-	-	2.92
240	2.08	2.22	.97	.14	-	-	-	-	-	-	5.41
250	1.67	.97	.28	-	-	-	-	-	-	-	2.92
260	2.22	1.94	.14	-	-	-	-	-	-	-	4.30
270	2.64	2.36	-	-	-	-	-	-	-	-	5.00
280	2.08	1.25	-	-	-	-	-	-	-	-	3.33
290	1.67	.28	-	-	-	-	-	-	-	-	1.95
300	2.50	.28	-	-	-	-	-	-	-	-	2.78
310	.69	-	-	-	-	-	-	-	-	-	.69
320	1.81	.14	-	-	-	-	-	-	-	-	1.95
330	1.53	.28	-	-	-	-	-	-	-	-	1.81
340	3.47	.56	-	-	-	-	-	-	-	-	4.03
350	1.53	.56	.56	-	-	-	-	-	-	-	2.65
360	1.11	.14	.14	.14	-	-	-	-	-	-	1.53
TOTAL	51.78	31.39	9.04	4.87	1.11	-	-	-	-	-	

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TABLE C-18

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 1 AL Date: 1 Sep 77 - 14 Sep 77

	Speed (m/sec x 10^{-2})										
Direction	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	.62	.46	-	-	-	-	-	-	-	-	1.08
20	.31	.31	.31	-	-	-	-	-	-	-	.93
30	1.08	2.16	.62	-	-	-	-	-	-	-	3.86
40	1.39	2.16	.62	.31	.15	-	-	-	-	-	4.63
50	1.54	2.47	3.84	1.23	-	-	-	-	-	-	9.08
60	3.53	2.76	2.62	.77	-	-	-	-	-	-	9.68
70	3.69	3.24	1.39	-	-	-	-	-	-	-	8.32
80	2.93	1.70	.15	-	-	-	-	-	-	-	4.78
90	1.39	.62	-	-	-	-	-	-	-	-	2.01
100	.46	-	-	-	-	-	-	-	-	-	.46
110	.46	.31	-	-	-	-	-	-	-	-	.77
120	.93	.15	-	-	-	-	-	-	-	-	1.08
130	.62	-	-	-	-	-	-	-	-	-	.62
140	1.08	-	-	-	-	-	-	-	-	-	1.08
150	.31	-	-	-	-	-	-	-	-	-	.31
160	.31	-	-	-	-	-	-	-	-	-	.31
170	1.54	.62	-	-	-	-	-	-	-	-	2.16
180	.93	.15	-	-	-	-	-	-	-	-	1.08
190	2.00	-	-	-	-	-	-	-	-	-	2.00
200	1.85	1.08	-	-	-	-	-	-	-	-	2.93
210	1.85	1.54	-	-	-	-	-	-	-	-	3.39
220	3.23	3.08	.31	-	-	-	-	-	-	-	6.62
230	2.00	1.70	.15	-	-	-	-	-	-	-	3.85
240	5.08	1.54	-	-	-	-	-	-	-	-	6.62
250	5.38	.62	-	-	-	-	-	-	-	-	6.00
260	3.08	.46	-	-	-	-	-	-	-	-	3.54
270	.31	.31	-	-	-	-	-	-	-	-	.62
280	1.85	.31	-	-	-	-	-	-	-	-	2.16
290	.46	-	-	-	-	-	-	-	-	-	.46
300	.93	.31	-	-	-	-	-	-	-	-	1.24
310	1.08	.15	-	-	-	-	-	-	-	-	1.23
320	1.39	.46	.31	-	-	-	-	-	-	-	2.16
330	1.08	.31	.62	-	-	-	-	-	-	-	2.01
340	.46	.31	-	-	-	-	-	-	-	-	.77
350	1.08	.15	-	-	-	-	-	-	-	-	1.23
360	-	-	-	-	-	-	-	-	-	-	-
TOTAL	56.23	29.44	10.94	2.31	.15	-	-	-	-	-	

TABLE C-19

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 AU Date: 1 Sep 77 - 12 Sep 77

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	.18	.18	-	-	-	-	-	-	-	-	.36
20	.72	.90	-	-	-	-	-	-	-	-	1.62
30	2.90	.90	-	-	-	-	-	-	-	-	3.80
40	1.63	1.44	.90	-	-	-	-	-	-	-	3.97
50	3.79	6.50	6.68	1.63	.18	-	-	-	-	-	18.78
60	3.07	5.60	5.24	5.24	1.08	.72	-	-	-	-	20.95
70	2.53	2.71	1.63	1.44	1.08	.90	.18	-	-	-	10.47
80	1.44	1.26	2.17	.18	-	-	-	-	-	-	5.05
90	-	.90	1.08	-	-	-	-	-	-	-	1.98
100	.18	.54	.18	-	-	-	-	-	-	-	.90
110	-	-	-	-	-	-	-	-	-	-	-
120	-	-	-	-	-	-	-	-	-	-	-
130	-	-	-	-	-	-	-	-	-	-	-
140	-	-	-	-	-	-	-	-	-	-	-
150	-	-	-	-	-	-	-	-	-	-	-
160	-	-	-	-	-	-	-	-	-	-	-
170	-	-	-	-	-	-	-	-	-	-	-
180	.36	-	-	-	-	-	-	-	-	-	.36
190	.18	-	-	-	-	-	-	-	-	-	.18
200	-	-	-	-	-	-	-	-	-	-	-
210	.18	-	-	-	-	-	-	-	-	-	.18
220	.36	.72	-	-	-	-	-	-	-	-	1.08
230	.36	1.08	-	-	-	-	-	-	-	-	1.44
240	.18	1.44	.72	-	-	-	-	-	-	-	2.34
250	.36	2.35	1.81	.36	-	-	-	-	-	-	4.88
260	.72	2.90	.90	.18	-	-	-	-	-	-	4.70
270	1.81	3.25	.36	-	-	-	-	-	-	-	5.42
280	1.26	.72	-	-	-	-	-	-	-	-	1.98
290	1.08	.54	-	-	-	-	-	-	-	-	1.62
300	1.08	.18	-	-	-	-	-	-	-	-	1.26
310	1.63	.36	-	-	-	-	-	-	-	-	1.99
320	1.81	.54	-	-	-	-	-	-	-	-	2.35
330	1.44	-	-	-	-	-	-	-	-	-	1.44
340	.36	.36	-	-	-	-	-	-	-	-	.72
350	-	-	-	-	-	-	-	-	-	-	-
360	-	.18	-	-	-	-	-	-	-	-	.18
TOTAL	29.61	35.55	21.67	9.03	2.34	1.62	.18	-	-	-	

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TABLE C-20

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 AL Date: 1 Sep 77 - 12 Sep 77

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	.72	-	-	-	-	-	-	-	-	-	.72
20	.36	-	-	-	-	-	-	-	-	-	.36
30	3.98	1.44	-	-	-	-	-	-	-	-	5.42
40	5.24	3.79	.90	-	-	-	-	-	-	-	9.93
50	5.77	5.97	2.35	.36	-	-	-	-	-	-	14.45
60	4.16	12.45	7.77	1.63	.18	-	-	-	-	-	26.19
70	1.81	5.97	4.51	1.81	.36	-	-	-	-	-	14.46
80	1.26	.90	.90	.54	-	-	-	-	-	-	3.60
90	1.63	.36	-	.36	-	-	-	-	-	-	2.35
100	.90	-	-	-	-	-	-	-	-	-	.90
110	1.08	.18	-	-	-	-	-	-	-	-	1.26
120	1.08	-	-	-	-	-	-	-	-	-	1.08
130	1.26	.18	-	-	-	-	-	-	-	-	1.44
140	.36	-	-	-	-	-	-	-	-	-	.36
150	.90	-	-	-	-	-	-	-	-	-	.90
160	.54	-	-	-	-	-	-	-	-	-	.54
170	-	-	-	-	-	-	-	-	-	-	-
180	.18	-	-	-	-	-	-	-	-	-	.18
190	.18	-	-	-	-	-	-	-	-	-	.18
200	-	-	-	-	-	-	-	-	-	-	-
210	.18	-	-	-	-	-	-	-	-	-	.18
220	.72	.18	-	-	-	-	-	-	-	-	.90
230	1.44	.90	.18	-	-	-	-	-	-	-	2.52
240	.36	1.44	.36	-	-	-	-	-	-	-	2.16
250	.36	.36	-	-	-	-	-	-	-	-	.72
260	.54	-	-	-	-	-	-	-	-	-	.54
270	.36	-	-	-	-	-	-	-	-	-	.36
280	.18	-	-	-	-	-	-	-	-	-	.18
290	.18	-	-	-	-	-	-	-	-	-	.18
300	.18	-	-	-	-	-	-	-	-	-	.18
310	-	-	-	-	-	-	-	-	-	-	-
320	.36	-	-	-	-	-	-	-	-	-	.36
330	-	-	-	-	-	-	-	-	-	-	-
340	.54	-	-	-	-	-	-	-	-	-	.54
350	1.44	.18	-	-	-	-	-	-	-	-	1.62
360	2.17	.18	-	-	-	-	-	-	-	-	2.35
TOTAL	40.42	34.48	16.97	4.70	.54	-	-	-	-	-	

TABLE C-21

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 BU Date: 1 Sep 77 - 12 Sep 77

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	.55	-	-	-	-	-	-	-	-	-	.55
20	-	-	-	-	-	-	-	-	-	-	-
30	.18	.55	.18	-	-	-	-	-	-	-	.91
40	.37	.18	.55	-	-	-	-	-	-	-	1.10
50	2.19	2.01	1.64	-	-	-	-	-	-	-	5.84
60	1.46	.91	2.19	.47	-	-	-	-	-	-	4.93
70	1.64	.18	1.46	2.19	-	-	-	-	-	-	5.47
80	1.28	.37	.55	1.46	-	-	-	-	-	-	3.66
90	-	-	.91	.73	-	-	-	-	-	-	1.64
100	1.28	1.09	.18	-	-	-	-	-	-	-	2.55
110	.55	1.28	-	-	-	-	-	-	-	-	1.83
120	.37	-	-	-	-	-	-	-	-	-	.37
130	.73	-	-	-	-	-	-	-	-	-	.73
140	2.19	-	-	-	-	-	-	-	-	-	2.19
150	1.28	-	-	-	-	-	-	-	-	-	1.28
160	1.09	.37	-	-	-	-	-	-	-	-	1.46
170	2.55	.55	-	-	-	-	-	-	-	-	3.10
180	2.92	.37	-	-	-	-	-	-	-	-	3.29
190	1.28	-	-	-	-	-	-	-	-	-	1.28
200	1.82	-	-	-	-	-	-	-	-	-	1.82
210	2.01	.18	-	-	-	-	-	-	-	-	2.19
220	.55	.18	-	-	-	-	-	-	-	-	.73
230	2.19	1.09	.18	-	-	-	-	-	-	-	3.46
240	1.64	2.55	1.46	-	-	-	-	-	-	-	5.65
250	1.82	4.38	4.57	.18	-	-	-	-	-	-	10.95
260	2.92	3.84	2.39	.18	-	-	-	-	-	-	9.31
270	2.01	3.47	.91	.18	-	-	-	-	-	-	6.57
280	.73	2.37	.91	-	-	-	-	-	-	-	4.01
290	1.82	1.28	-	-	-	-	-	-	-	-	3.10
300	1.46	.91	-	-	-	-	-	-	-	-	2.37
310	.91	.18	-	-	-	-	-	-	-	-	1.09
320	.37	.18	-	-	-	-	-	-	-	-	.55
330	.73	-	-	-	-	-	-	-	-	-	.73
340	.73	-	-	-	-	-	-	-	-	-	.73
350	.73	-	-	-	-	-	-	-	-	-	.73
360	.18	-	-	-	-	-	-	-	-	-	.18
TOTAL	44.53	28.47	18.06	5.29	-	-	-	-	-	-	

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TABLE C-22

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 BL Date: 1 Sep 77 - 12 Sep 77

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	.55	.18	-	-	-	-	-	-	-	-	.73
20	2.01	.37	-	-	-	-	-	-	-	-	2.38
30	2.92	1.28	-	-	-	-	-	-	-	-	4.20
40	3.10	1.64	.37	-	-	-	-	-	-	-	5.11
50	2.01	1.82	1.46	.73	-	-	-	-	-	-	6.02
60	2.19	.91	1.64	1.28	-	-	-	-	-	-	6.02
70	.91	1.28	1.46	.73	-	-	-	-	-	-	4.38
80	.73	.55	.73	.18	-	-	-	-	-	-	2.19
90	.37	-	-	-	-	-	-	-	-	-	.37
100	.73	.37	-	-	-	-	-	-	-	-	1.10
110	.37	.91	.18	-	-	-	-	-	-	-	1.46
120	.91	.18	-	-	-	-	-	-	-	-	1.09
130	1.09	-	.18	-	-	-	-	-	-	-	1.27
140	.37	1.28	-	-	-	-	-	-	-	-	1.65
150	.18	.18	-	-	-	-	-	-	-	-	.36
160	.55	.37	-	-	-	-	-	-	-	-	.92
170	.73	.18	-	-	-	-	-	-	-	-	.91
180	.55	-	-	-	-	-	-	-	-	-	.55
190	1.28	.73	-	-	-	-	-	-	-	-	2.01
200	2.74	1.82	-	-	-	-	-	-	-	-	4.56
210	2.01	.55	-	-	-	-	-	-	-	-	2.56
220	1.09	1.28	1.09	-	-	-	-	-	-	-	3.46
230	1.46	1.09	1.64	.18	-	-	-	-	-	-	4.37
240	1.46	2.37	1.64	.55	-	-	-	-	-	-	6.02
250	2.74	3.47	1.28	-	-	-	-	-	-	-	7.49
260	2.19	2.74	1.64	-	-	-	-	-	-	-	6.57
270	1.64	1.09	.91	.18	-	-	-	-	-	-	3.82
280	2.74	.37	-	-	-	-	-	-	-	-	3.11
290	2.01	.18	-	-	-	-	-	-	-	-	2.19
300	.91	.18	-	-	-	-	-	-	-	-	1.09
310	2.37	.73	-	-	-	-	-	-	-	-	3.10
320	1.64	.18	-	-	-	-	-	-	-	-	1.82
330	1.28	-	-	-	-	-	-	-	-	-	1.28
340	.37	-	-	-	-	-	-	-	-	-	.37
350	.73	-	-	-	-	-	-	-	-	-	.73
360	-	-	-	-	-	-	-	-	-	-	-
TOTAL	48.93	28.28	14.22	3.83	-	-	-	-	-	-	

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TABLE C-23

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 1 AU Date: 16 Sep 77 - 24 Sep 77

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	.23	.46	-	.23	.23	-	-	-	-	-	1.15
20	1.16	.46	-	.69	.46	.46	-	-	-	-	3.23
30	2.78	.69	.69	-	.69	.46	.23	-	-	-	5.54
40	1.16	2.08	.69	-	.23	-	-	-	-	-	4.16
50	.69	4.87	.93	-	-	-	-	-	-	-	6.49
60	.46	4.17	1.16	-	-	-	-	-	-	-	5.79
70	-	.69	.23	-	-	-	-	-	-	-	.92
80	-	-	-	-	-	-	-	-	-	-	-
90	-	-	-	-	-	-	-	-	-	-	-
100	-	.23	-	-	-	-	-	-	-	-	.23
110	-	-	-	-	-	-	-	-	-	-	-
120	-	.23	-	-	-	-	-	-	-	-	.23
130	-	.23	.23	-	-	-	-	-	-	-	.46
140	-	-	-	-	-	-	-	-	-	-	-
150	-	-	-	-	-	-	-	-	-	-	-
160	-	-	-	-	-	-	-	-	-	-	-
170	-	-	-	-	-	-	-	-	-	-	-
180	-	-	-	-	-	-	-	-	-	-	-
190	-	-	-	-	-	-	-	-	-	-	-
200	-	-	-	-	-	-	-	-	-	-	-
210	.23	-	-	-	-	-	-	-	-	-	.23
220	1.85	.23	-	-	-	-	-	-	-	-	2.08
230	3.01	3.70	1.62	.46	-	-	-	-	-	-	8.79
240	2.32	7.65	4.18	.69	-	-	-	-	-	-	14.84
250	2.55	10.44	1.85	.23	-	-	-	-	-	-	15.07
260	1.62	3.25	1.16	-	-	-	-	-	-	-	6.03
270	5.10	.69	-	-	-	-	-	-	-	-	5.79
280	4.86	.23	-	-	-	-	-	-	-	-	5.09
290	4.17	.23	-	-	-	-	-	-	-	-	4.40
300	2.78	-	-	-	-	-	-	-	-	-	2.78
310	1.62	.23	-	-	-	-	-	-	-	-	1.85
320	1.85	-	.23	-	-	-	-	-	-	-	2.08
330	.46	.23	-	-	-	-	-	-	-	-	.69
340	-	-	-	-	-	-	-	-	-	-	-
350	.23	-	-	-	-	-	-	-	-	-	.23
360	.23	.23	-	-	-	-	-	-	-	-	.46
TOTAL	39.36	41.22	12.97	2.30	1.61	.92	.23	-	-	-	

TABLE C-24

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 1 AL Date: 16 Sep 77 - 24 Sep 77

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	.40	-	-	-	-	-	-	-	-	-	.40
20	-	.40	-	-	-	-	-	-	-	-	.40
30	.40	1.19	.20	-	-	-	-	-	-	-	1.79
40	1.79	3.77	.20	-	-	-	-	-	-	-	5.76
50	1.79	5.95	1.98	-	-	-	-	-	-	-	9.72
60	.80	2.39	.80	-	-	-	-	-	-	-	3.99
70	.20	.20	-	-	-	-	-	-	-	-	.40
80	.60	-	-	-	-	-	-	-	-	-	.60
90	.60	.20	-	-	-	-	-	-	-	-	.80
100	.20	-	-	-	-	-	-	-	-	-	.20
110	.80	-	-	-	-	-	-	-	-	-	.80
120	.20	-	-	-	-	-	-	-	-	-	.20
130	.20	-	-	-	-	-	-	-	-	-	.20
140	.80	-	-	-	-	-	-	-	-	-	.80
150	-	-	-	-	-	-	-	-	-	-	-
160	.40	-	-	-	-	-	-	-	-	-	.40
170	.20	-	-	-	-	-	-	-	-	-	.20
180	-	-	.20	-	-	-	-	-	-	-	.20
190	.40	.40	.60	-	-	-	-	-	-	-	1.40
200	1.79	.80	-	-	-	-	-	-	-	-	2.59
210	1.39	2.19	.40	-	-	-	-	-	-	-	3.98
220	3.37	5.36	.80	-	-	-	-	-	-	-	9.53
230	5.76	8.53	1.79	-	-	-	-	-	-	-	16.08
240	7.54	6.55	.60	-	-	-	-	-	-	-	14.69
250	2.97	2.58	.20	-	-	-	-	-	-	-	5.75
260	2.78	.40	-	-	-	-	-	-	-	-	3.18
270	1.99	.99	-	-	-	-	-	-	-	-	2.98
280	1.79	2.19	-	-	-	-	-	-	-	-	3.98
290	.60	1.59	.20	-	-	-	-	-	-	-	2.39
300	.80	.40	-	-	-	-	-	-	-	-	1.20
310	.80	.40	-	-	-	-	-	-	-	-	1.20
320	.80	.20	-	-	-	-	-	-	-	-	1.00
330	.40	-	-	-	-	-	-	-	-	-	.40
340	.60	.20	-	-	-	-	-	-	-	-	.80
350	.20	-	-	-	-	-	-	-	-	-	.20
360	-	-	-	-	-	-	-	-	-	-	-
TOTAL	43.36	46.88	7.97	-	-	-	-	-	-	-	

TABLE C-25

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 AU Date: 20 Sep 77 - 7 Oct 77

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	-	-	-	-	-	-	-	-	-	-
20	.25	-	-	-	-	-	-	-	-	-	.25
30	.12	.25	-	-	-	-	-	-	-	-	.37
40	.12	.25	-	-	-	-	-	-	-	-	.37
50	.12	.25	-	-	-	-	-	-	-	-	.37
60	.49	.49	-	-	-	-	-	-	-	-	.98
70	.25	.49	.37	-	-	-	-	-	-	-	1.11
80	.49	.12	-	-	-	-	-	-	-	-	.61
90	.12	.12	-	-	-	-	-	-	-	-	.24
100	.25	.24	-	-	-	-	-	-	-	-	.49
110	.37	-	-	-	-	-	-	-	-	-	.37
120	.12	-	-	-	-	-	-	-	-	-	.12
130	.25	-	-	-	-	-	-	-	-	-	.25
140	.25	-	-	-	-	-	-	-	-	-	.25
150	.12	-	-	-	-	-	-	-	-	-	.12
160	.25	-	-	-	-	-	-	-	-	-	.25
170	.25	-	-	.12	-	-	-	-	-	-	.37
180	.25	-	-	-	-	-	-	-	-	-	.25
190	.62	-	-	-	-	-	-	-	-	-	.62
200	.74	.24	-	-	-	-	-	-	-	-	.98
210	1.60	.62	.62	-	-	.12	-	-	-	-	2.96
220	2.97	5.69	4.70	1.11	.12	1.23	.25	-	-	-	16.07
230	3.47	7.43	7.41	4.07	3.21	2.59	1.48	.37	-	-	30.03
240	3.34	5.57	3.83	4.57	4.67	3.46	1.35	.25	.12	-	27.16
250	2.23	.98	.37	.49	.87	.87	.25	.12	-	-	6.18
260	.86	.37	-	-	-	-	-	-	-	-	1.23
270	.37	-	-	-	-	-	-	-	-	-	.37
280	1.11	.37	-	-	-	-	-	-	-	-	1.48
290	.12	-	-	-	-	-	-	-	-	-	.12
300	.98	.12	-	-	-	-	-	-	-	-	1.10
310	.37	.12	-	-	-	-	-	-	-	-	.49
320	.62	-	-	-	-	-	-	-	-	-	.62
330	.37	.12	-	-	-	-	-	-	-	-	.49
340	-	-	-	-	-	-	-	-	-	-	-
350	-	-	-	-	-	-	-	-	-	-	-
360	-	-	-	-	-	-	-	-	-	-	-
TOTAL	23.84	23.84	17.30	10.36	8.87	8.27	3.33	.74	.12	-	

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TABLE C-26

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 AL Date: 20 Sep 77 - 7 Oct 77

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	.25	.74	.12	-	-	-	-	-	-	-	1.11
20	.87	.87	-	.12	-	-	-	-	-	-	1.86
30	.86	2.22	.99	.87	-	-	-	-	-	-	4.94
40	1.11	.99	2.72	.37	-	-	-	-	-	-	7.54
50	1.48	1.23	2.72	1.11	-	-	-	-	-	-	6.54
60	1.60	1.60	1.48	.25	-	-	-	-	-	-	4.93
70	.24	.62	-	-	-	-	-	-	-	-	.86
80	.37	.12	-	-	-	-	-	-	-	-	.49
90	.12	-	-	-	-	-	-	-	-	-	.12
100	.49	-	-	-	-	-	-	-	-	-	.49
110	.25	-	-	-	-	-	-	-	-	-	.25
120	.12	-	-	-	-	-	-	-	-	-	.12
130	.62	-	-	-	-	-	-	-	-	-	.62
140	.37	-	-	-	-	-	-	-	-	-	.37
150	.37	-	-	-	-	-	-	-	-	-	.37
160	.49	-	-	-	-	-	-	-	-	-	.49
170	.74	.25	-	-	-	-	-	-	-	-	.99
180	.49	.49	-	-	-	-	-	-	-	-	.98
190	1.24	.49	.12	-	-	-	-	-	-	-	1.85
200	.86	1.24	.62	.12	-	-	-	-	-	-	2.84
210	1.86	2.11	1.60	.74	.12	.12	.12	-	-	-	6.67
220	3.21	4.69	2.84	3.09	1.85	.75	.37	-	-	-	16.80
230	1.86	3.83	3.70	2.11	2.47	.49	.74	.25	.12	-	15.57
240	3.09	1.60	2.47	1.48	.74	.37	.25	-	-	-	10.00
250	.49	.37	.25	.12	.12	-	-	-	-	-	1.35
260	.74	.25	.25	-	-	-	-	-	-	-	1.24
270	.75	.49	-	-	-	-	-	-	-	-	1.24
280	.74	.12	-	-	-	-	-	-	-	-	.86
290	.62	.12	-	-	-	-	-	-	-	-	.74
300	.49	-	-	-	-	-	-	-	-	-	.49
310	.37	-	-	-	-	-	-	-	-	-	.37
320	-	.12	-	-	-	-	-	-	-	-	.12
330	.37	-	-	-	-	-	-	-	-	-	.37
340	.74	-	-	-	-	-	-	-	-	-	.74
350	.25	-	-	-	-	-	-	-	-	-	.25
360	.12	.12	-	-	-	-	-	-	-	-	.24
TOTAL	28.64	24.68	19.88	12.36	5.67	1.73	1.48	.25	.12	-	

TABLE C-27

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 BU Date: 20 Sep 77 - 7 Oct 77

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	.24	1.23	-	-	-	-	-	-	-	1.47
20	-	.12	.37	-	-	-	-	-	-	-	.49
30	.24	.49	.37	-	-	-	-	-	-	-	1.10
40	.37	.86	-	-	-	-	-	-	-	-	1.23
50	.74	.61	-	-	-	-	-	-	-	-	1.35
60	.37	.74	-	-	-	-	-	-	-	-	1.11
70	.24	.37	-	-	-	-	-	-	-	-	.61
80	.61	.24	-	-	-	-	-	-	-	-	.85
90	.37	.24	-	-	-	-	-	-	-	-	.61
100	.12	.24	.24	-	-	-	-	-	-	-	.60
110	.24	.24	.37	-	-	-	-	-	-	-	.85
120	.24	.24	-	-	-	-	-	-	-	-	.48
130	-	.49	-	-	-	-	-	-	-	-	.49
140	.49	.49	-	-	-	-	-	-	-	-	.98
150	.61	.74	.24	-	-	-	-	-	-	-	1.59
160	.37	.98	.49	-	-	-	-	-	-	-	1.84
170	.98	1.35	.12	-	-	-	-	-	-	-	2.45
180	.24	.98	.24	-	-	-	-	-	-	-	1.46
190	.37	1.35	.12	-	-	-	-	-	-	-	1.84
200	.49	.98	.12	-	-	-	-	-	.12	-	1.71
210	.24	.86	.12	-	-	-	.12	.12	-	-	1.46
220	.49	.98	.37	.12	.24	.86	.61	.37	-	-	4.04
230	.37	1.84	1.35	.98	2.34	1.59	2.95	.98	.24	-	12.64
240	.12	.74	.61	1.23	2.58	1.59	1.97	.98	-	.24	10.06
250	.98	1.10	.49	.74	1.97	1.35	2.83	1.59	.74	.49	12.28
260	.74	1.23	1.48	.98	1.23	1.47	.61	.74	.74	.49	9.72
270	.61	1.10	.98	.61	.61	.86	.12	.12	.37	-	5.38
280	.12	1.10	1.10	-	-	.12	.12	-	-	-	2.56
290	.61	1.10	.24	.12	-	-	-	-	-	-	2.07
300	.12	.12	.12	-	-	-	-	-	-	-	.36
310	.61	.86	-	-	-	-	-	-	-	-	1.47
320	.74	.49	-	-	-	-	-	-	-	-	1.23
330	.74	1.48	.98	-	.12	-	-	-	-	-	3.32
340	1.73	2.58	1.84	-	.12	.24	-	-	-	-	6.51
350	.12	.86	.49	.12	-	-	-	-	-	-	1.59
360	.24	.49	.49	.37	-	-	-	-	-	-	1.59
TOTAL	15.67	28.92	14.57	5.27	9.21	8.09	9.33	4.90	2.21	1.22	

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TABLE C-28

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 BL Date: 20 Sep 77 - 7 Oct 77

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-46	46-50	Total
10	-	-	-	-	-	-	-	-	-	-	-
20	1.10	.12	-	-	-	-	-	-	-	-	1.22
30	1.34	.49	-	-	-	-	-	-	-	-	1.83
40	.73	-	-	-	-	-	-	-	-	-	.73
50	.49	.49	-	-	-	-	-	-	-	-	.98
60	.73	.12	-	-	-	-	-	-	-	-	.85
70	.49	.12	-	-	-	-	-	-	-	-	.61
80	1.46	.12	-	-	-	-	-	-	-	-	1.58
90	1.34	-	-	-	-	-	-	-	-	-	1.34
100	1.10	.12	-	-	-	-	-	-	-	-	1.22
110	1.10	.12	-	-	-	-	-	-	-	-	1.22
120	.37	.61	-	-	-	-	-	-	-	-	.98
130	.61	.97	-	-	-	-	-	-	-	-	1.58
140	.85	.97	-	-	-	-	-	-	-	-	1.82
150	.49	.97	-	-	-	-	-	-	-	-	1.46
160	.49	1.95	-	-	-	-	-	-	-	-	2.44
170	.97	2.07	-	-	-	-	-	-	-	-	3.04
180	.73	1.58	.12	-	-	-	-	-	-	-	2.43
190	.61	.73	.12	-	-	-	-	-	-	-	1.46
200	.61	1.10	-	-	-	-	-	-	-	-	1.71
210	.61	.24	-	-	.24	.12	-	-	-	-	1.33
220	.49	.61	.97	.37	-	-	.12	-	.12	-	2.68
230	.24	.85	.24	.61	1.46	.97	.61	-	-	.12	5.10
240	1.22	1.21	1.46	.85	1.70	4.02	2.43	.49	.24	-	13.62
250	.96	1.46	1.22	1.83	3.41	4.98	1.70	.85	.12	-	16.53
260	.61	.85	.49	.97	3.40	4.38	1.34	.12	.12	-	12.28
270	.24	.61	.85	1.70	1.10	1.22	-	-	-	-	5.72
280	-	.37	1.10	1.46	.49	.12	-	-	-	-	3.54
290	-	.61	2.07	.61	-	-	-	-	-	-	3.29
300	-	.12	.73	.37	.12	-	-	-	-	-	1.34
310	.24	.24	.49	.49	.24	-	-	-	-	-	1.70
320	.37	.12	.24	.12	-	-	-	-	-	-	.85
330	.24	.24	-	-	-	-	-	-	-	-	.48
340	.12	-	.12	-	-	-	-	-	-	-	.24
350	.12	.49	-	-	-	-	-	-	-	-	.61
360	.12	.37	-	-	-	-	-	-	-	-	.49
TOTAL	21.31	21.04	10.22	9.38	12.16	15.81	6.20	1.46	.60	.12	

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TABLE C-29

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 AU Date: 12 Jan 78 - 18 Jan 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-
30	-	.33	.66	-	-	-	-	-	-	-	.99
40	.99	1.99	1.32	.33	-	-	-	-	-	-	4.63
50	2.32	3.65	9.94	7.29	1.99	-	-	-	-	-	25.19
60	.33	3.98	2.66	3.97	1.66	-	-	-	-	-	12.60
70	-	3.65	.99	1.32	-	-	-	-	-	-	5.96
80	.99	2.32	.33	-	-	-	-	-	-	-	3.64
90	1.32	1.66	-	-	-	-	-	-	-	-	2.98
100	.33	1.99	-	-	-	-	-	-	-	-	2.32
110	.33	.66	-	-	-	-	-	-	-	-	.99
120	.33	.33	-	-	-	-	-	-	-	-	.66
130	.66	.66	-	-	-	-	-	-	-	-	1.32
140	.33	-	-	-	-	-	-	-	-	-	.33
150	.33	-	-	-	-	-	-	-	-	-	.33
160	.66	.33	-	-	-	-	-	-	-	-	.99
170	.33	-	-	-	-	-	-	-	-	-	.33
180	2.99	.33	-	-	-	-	-	-	-	-	3.32
190	.33	-	-	-	-	-	-	-	-	-	.33
200	.99	-	-	-	-	-	-	-	-	-	.99
210	.33	-	-	-	-	-	-	-	-	-	.33
220	.66	.33	-	.33	-	-	-	-	-	-	1.32
230	.99	-	.33	-	-	-	-	-	-	-	1.32
240	-	.66	.66	-	-	-	-	-	-	-	1.32
250	1.32	.66	2.32	.33	-	-	-	-	-	-	4.63
260	-	1.66	2.66	.66	-	-	-	-	-	-	4.98
270	-	.99	4.98	.66	-	-	-	-	-	-	6.63
280	.66	.33	1.99	.33	-	-	-	-	-	-	3.31
290	1.32	.33	.66	-	-	-	-	-	-	-	2.31
300	.33	.33	-	-	-	-	-	-	-	-	.66
310	.33	.33	-	-	-	-	-	-	-	-	.66
320	-	.33	-	-	-	-	-	-	-	-	.33
330	-	-	-	-	-	-	-	-	-	-	-
340	1.32	-	-	-	-	-	-	-	-	-	1.32
350	.66	-	-	-	-	-	-	-	-	-	.66
360	.33	-	-	-	-	-	-	-	-	-	.33
TOTAL	21.81	27.83	29.50	15.22	3.65	-	-	-	-	-	

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TABLE C-30

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 AL Date: 12 Jan 78 - 4 Feb 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10.	.27	.55	.09	-	-	.09	.09	-	-	-	1.09
20	.09	.09	-	-	-	-	.09	-	-	-	.27
30	.18	.46	.64	-	-	-	.09	-	-	-	1.37
40	.27	.64	1.55	.36	.27	.09	.09	-	-	-	3.27
50	1.19	2.02	3.29	2.01	.82	.46	.46	.09	-	-	10.34
60	1.09	3.58	4.58	2.47	1.00	.82	1.00	.09	-	-	14.63
70	.91	3.02	1.82	1.00	.36	.73	.64	-	-	-	8.48
80	.18	1.19	-	.09	.09	.18	.27	-	-	-	2.00
90	.64	.18	-	-	-	.09	-	-	-	-	.91
100	.55	-	-	-	-	-	-	-	-	-	.55
110	.73	.09	.09	-	-	-	.09	-	-	-	1.00
120	.36	.09	-	-	-	-	-	-	-	-	.45
130	.36	.27	-	-	-	-	-	-	-	-	.63
140	.09	.18	-	-	-	-	-	-	-	-	.27
150	.18	.18	-	-	-	-	-	-	-	-	.36
160	.09	-	-	-	-	-	-	-	-	-	.09
170	.09	.27	-	-	-	-	-	-	-	-	.36
180	-	.18	.18	-	-	-	-	-	-	-	.36
190	.09	-	.18	-	-	-	-	-	-	-	.27
200	.18	.18	-	-	-	-	-	-	-	-	.36
210	.09	.46	.46	-	-	-	-	-	-	-	1.01
220	-	.46	.73	-	-	-	-	-	-	-	1.19
230	.18	.27	.73	-	-	-	-	-	-	-	1.18
240	.18	1.91	.73	.27	.18	.18	-	-	-	-	3.45
250	.09	.55	.46	.64	.82	.09	-	-	-	-	2.65
260	.36	1.37	.55	.55	1.09	.18	-	-	-	-	4.10
270	.18	.55	.27	.36	.36	.09	-	-	-	-	1.81
280	.55	.73	.46	.55	1.19	.18	-	-	-	-	3.66
290	.36	.82	.82	.27	.64	.09	-	-	-	-	3.00
300	.27	.82	.82	.73	.18	-	.18	-	-	-	3.00
310	.18	.91	1.46	.73	.82	.55	.55	.18	-	-	5.38
320	.46	1.64	.55	1.46	1.19	1.82	1.91	.55	-	-	9.58
330	.18	.82	.27	.46	.46	1.19	.55	.82	-	-	4.75
340	.46	.91	.46	1.09	.64	.82	.36	.27	-	-	5.01
350	.36	-	.18	.09	-	-	.18	.09	-	-	.90
360	.82	.46	.18	.36	.18	.18	.09	-	-	-	2.27
TOTAL	12.26	25.85	21.55	13.49	10.29	7.83	6.64	2.09	-	-	

TABLE C-31

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 BU Date: 12 Jan 78 - 31 Jan 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-
30	-	.11	.11	.67	-	-	-	-	-	-	.89
40	-	.34	.45	.45	-	-	-	-	-	-	1.24
50	-	1.23	2.36	.78	.11	.22	.22	-	-	-	4.92
60	.11	1.68	3.25	2.01	1.68	1.01	.67	-	-	-	10.41
70	-	1.45	3.36	2.69	3.70	3.48	1.01	-	-	-	15.69
80	-	.56	1.90	.89	.78	2.47	.34	-	-	-	6.94
90	-	.67	1.34	.67	1.12	1.01	.45	-	-	-	5.26
100	-	.45	1.01	.45	.56	1.01	.45	-	-	-	3.93
110	.11	.22	.78	.67	.56	.56	.11	-	-	-	3.01
120	-	-	.45	.56	.34	.11	-	-	-	-	1.46
130	.56	.22	.11	.34	.22	.11	.11	-	-	-	1.67
140	-	.34	.78	1.01	.34	-	.11	-	-	-	2.58
150	.34	.34	.45	.11	.34	-	-	-	-	-	1.58
160	-	-	.78	.11	-	.11	-	-	-	-	1.00
170	-	-	.45	.22	.22	.22	-	-	-	-	1.11
180	.11	-	.34	.34	-	-	-	-	-	-	.79
190	-	.45	.34	.22	.22	-	-	-	-	-	1.23
200	.22	.67	.22	.22	.45	-	-	-	-	-	1.78
210	.11	.22	.34	.45	.34	-	-	-	-	-	1.46
220	.22	.11	.22	.22	.34	-	-	-	-	-	1.11
230	.11	.11	.22	.22	.22	-	-	-	-	-	.88
240	.11	.11	.11	.34	.22	.11	-	-	-	-	1.00
250	.67	.56	.11	.67	.11	-	-	-	-	-	2.12
260	.67	.45	.34	.11	.89	.11	-	-	-	-	2.57
270	1.01	.45	.45	.11	.34	.22	.11	-	-	-	2.69
280	.22	.56	.22	.11	.22	.67	.34	.11	-	-	2.45
290	.67	.78	.45	.11	.34	.67	.22	.56	-	-	3.80
300	.11	.78	.22	.11	.45	1.23	.45	.45	-	-	3.80
310	1.01	1.12	1.45	.45	.22	-	-	-	-	-	4.25
320	.34	.89	.34	.11	.78	1.01	.45	.34	-	-	4.26
330	.22	.34	.11	-	.56	1.34	.11	-	-	-	2.68
340	-	.22	.78	-	.11	.22	-	-	-	-	1.33
350	-	-	-	-	-	-	-	-	-	-	-
360	-	-	-	-	-	-	-	-	-	-	-
TOTAL	6.92	15.43	23.84	15.42	15.78	15.89	5.15	1.46	-	-	

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TABLE C-32

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 BL Date: 12 Jan 78 - 4 Feb 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	1.09	.36	-	.09	-	-	-	-	-	-	1.54
20	2.35	1.27	.45	-	-	-	-	-	-	-	4.07
30	3.27	6.15	2.35	1.54	.18	-	-	-	-	-	13.49
40	1.54	3.17	2.08	1.18	.18	.09	-	-	-	-	8.24
50	2.53	4.53	3.35	3.80	1.37	.45	.36	-	-	-	16.39
60	1.18	1.27	1.09	1.72	1.54	1.09	.18	-	-	-	8.07
70	1.18	.36	.81	1.99	2.26	.36	.18	-	-	-	7.14
80	.63	.09	.18	1.54	1.09	.36	-	-	-	-	3.89
90	.27	.27	.09	1.00	.18	-	-	-	-	-	2.90
100	.54	.18	.09	.54	.18	-	-	-	-	-	1.53
110	.81	-	.09	.63	.27	-	-	-	-	-	1.80
120	.36	.18	.09	.27	-	-	-	-	-	-	.90
130	.18	.09	.18	.09	-	-	-	-	-	-	.54
140	.18	.09	-	-	.09	-	-	-	-	-	.36
150	.09	-	-	-	-	-	-	-	-	-	.09
160	-	-	-	-	-	-	-	-	-	-	-
170	-	-	-	-	-	-	-	-	-	-	-
180	.09	-	-	-	-	-	-	-	-	-	.09
190	.09	-	-	-	-	-	-	-	-	-	.09
200	.09	-	-	-	-	-	-	-	-	-	.09
210	.09	.18	-	-	-	-	-	-	-	-	.27
220	-	.36	-	-	-	-	-	-	-	-	.36
230	-	-	-	-	-	-	-	-	-	-	-
240	-	-	-	-	-	-	-	-	-	-	-
250	-	-	-	-	-	-	-	-	-	-	-
260	-	-	-	-	-	-	-	-	-	-	-
270	-	-	-	-	-	-	-	-	-	-	-
280	-	.18	-	-	-	-	-	-	-	-	.18
290	-	.09	-	-	-	-	-	-	-	-	.09
300	-	.09	.45	-	-	-	-	-	-	-	.54
310	-	.63	.81	-	-	-	-	-	-	-	1.44
320	.09	.18	.45	.36	.09	.09	-	-	-	-	1.26
330	-	.45	.72	.81	.36	.27	-	-	-	-	2.61
340	.36	2.53	1.37	1.45	.91	.45	.27	-	-	-	7.34
350	.09	.18	1.54	1.81	1.54	-	.09	-	-	-	5.25
360	.09	2.26	3.90	1.37	.45	-	-	-	-	-	8.07
TOTAL	17.19	25.14	20.09	20.28	11.51	3.34	1.08	-	-	-	

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TABLE C-33

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 AU Date: 4 Feb 78 - 15 Feb 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	-	-	-	-	-	.18	-	-	-	.18
20	-	-	-	-	-	-	-	-	-	-	-
30	.36	-	.18	-	-	.18	.18	-	-	-	.90
40	.18	.54	-	-	-	-	.18	-	-	-	.90
50	-	-	-	.18	.18	.54	.72	.54	-	-	2.16
60	-	.72	.90	.54	.72	.54	1.08	1.08	.18	-	5.76
70	-	.54	1.27	.36	.90	.72	1.99	1.80	.36	-	7.94
80	.36	.36	1.44	1.80	.36	1.27	3.06	1.62	1.80	.54	12.61
90	.18	-	.54	.72	-	.72	2.34	4.33	.54	.18	9.55
100	-	-	.54	.18	-	.72	1.80	1.27	1.62	.18	6.31
110	-	-	-	-	-	.36	1.27	1.44	.36	.18	3.61
120	-	-	.36	-	-	-	.36	.54	.18	-	1.44
130	-	-	-	-	-	-	.36	.18	-	-	.54
140	-	.18	-	-	-	-	-	-	-	-	.18
150	-	-	-	-	-	-	.36	-	.18	-	.54
160	-	-	-	-	-	-	-	.18	-	-	.18
170	-	-	-	-	.18	-	-	-	-	-	.18
180	-	.18	-	-	-	-	-	-	-	-	.18
190	-	.36	-	-	-	-	-	-	-	-	.36
200	-	.36	-	-	-	-	-	-	-	-	.36
210	.18	.18	-	-	-	-	-	-	-	-	.36
220	.54	.54	-	-	-	-	-	-	-	-	1.08
230	.36	.90	.18	-	-	-	-	-	-	-	1.44
240	.36	.72	.54	.18	-	-	-	-	-	-	1.80
250	.18	2.16	1.99	.54	.18	.36	-	-	-	-	5.41
260	.36	2.16	4.33	1.80	1.80	2.52	.36	-	-	-	13.33
270	.18	1.80	2.71	2.16	3.61	2.52	-	-	-	-	12.98
280	.18	.72	2.16	.54	.54	1.08	-	-	-	-	5.22
290	-	-	.36	.36	-	.18	-	-	-	-	.90
300	.36	.18	-	-	-	-	-	-	-	-	.54
310	-	.18	-	-	-	-	-	-	-	-	.18
320	-	.18	-	-	-	-	-	-	-	-	.18
330	.18	.18	-	-	-	-	-	-	-	-	.36
340	.18	-	-	-	-	-	-	-	-	-	.18
350	-	.18	-	-	-	-	-	-	-	-	.18
360	-	.18	-	-	-	-	-	-	-	-	.18
TOTAL	7.14	13.50	17.50	9.36	8.47	11.71	14.24	12.98	5.22	1.08	

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TABLE C-34

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 AL Date: 4 Feb 78 - 11 Feb 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-
30	-	-	.28	.28	.28	.28	.55	-	-	-	1.67
40	-	.55	.28	.55	1.93	1.92	.28	-	-	-	5.51
50	-	-	1.64	2.76	5.23	3.30	2.47	.28	.55	-	16.23
60	-	.54	1.10	2.76	7.98	3.58	1.64	.55	.28	-	18.43
70	-	.28	.55	2.20	4.95	4.67	1.38	1.09	.28	-	15.40
80	.28	.83	.28	1.64	1.09	.55	1.10	.28	-	-	6.05
90	-	-	-	.55	-	-	-	-	-	-	.55
100	-	.55	-	-	.55	.55	.28	-	-	-	1.93
110	-	-	-	-	-	-	-	-	-	-	-
120	-	-	-	-	-	-	-	-	-	-	-
130	-	.28	-	-	.28	-	-	-	-	-	.56
140	-	-	-	-	-	-	-	-	-	-	-
150	-	-	-	-	-	-	-	-	-	-	-
160	-	-	-	-	-	.28	-	-	-	-	.28
170	-	.28	-	-	-	-	-	-	-	-	.28
180	.28	-	-	-	-	-	-	-	-	-	.28
190	-	.28	-	-	-	-	-	-	-	-	.28
200	-	-	-	-	-	-	-	-	-	-	-
210	-	.55	.55	-	-	-	-	-	-	-	1.10
220	-	.28	.28	.28	-	-	-	-	-	-	.84
230	-	.28	1.93	2.47	-	-	-	-	-	-	4.68
240	-	.28	2.75	2.75	3.85	.83	-	-	-	-	10.46
250	-	.28	2.47	3.85	.55	.55	-	-	-	-	7.70
260	-	-	.55	1.10	.28	.55	-	-	-	-	2.48
270	-	.28	.55	-	-	-	-	-	-	-	.83
280	-	.28	-	-	-	-	-	-	-	-	.28
290	-	.28	.28	-	-	-	-	-	-	-	.56
300	-	-	.28	-	-	-	-	-	-	-	.28
310	-	-	-	-	-	-	.28	-	-	-	.28
320	-	.28	-	-	-	-	.28	.28	.28	-	1.12
330	-	-	-	-	-	-	-	.55	-	-	.55
340	-	-	-	-	.28	-	-	.28	-	-	.56
350	-	-	-	-	.28	-	-	-	-	-	.28
360	-	-	-	-	-	-	-	-	-	-	-
TOTAL	.56	6.38	13.77	21.19	27.53	17.06	8.26	3.31	1.39	-	

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TABLE C-35

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 AU Date: 16 Feb 78 to 25 Feb 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-
30	.22	.88	-	-	-	-	-	-	-	-	1.10
40	.66	.66	-	-	-	-	-	-	-	-	1.32
50	.66	1.54	-	-	-	-	-	.22	-	-	2.42
60	.88	2.20	.88	-	.44	.44	.22	.66	-	-	5.72
70	.88	4.18	3.30	1.32	4.83	5.71	1.32	.88	.66	-	23.08
80	.66	1.10	2.64	5.93	6.81	6.15	1.98	.66	-	-	25.93
90	1.32	1.75	3.30	1.32	.66	.44	-	-	.22	-	9.01
100	.22	-	.22	.44	-	-	-	-	-	-	.88
110	.22	-	-	-	-	-	.22	-	-	-	.44
120	-	-	-	-	-	-	-	-	-	-	-
130	-	-	-	-	-	-	-	-	-	-	-
140	-	-	-	-	-	-	-	-	-	-	-
150	-	-	-	-	-	-	-	-	-	-	-
160	.22	-	-	-	-	-	-	-	-	-	.22
170	.44	-	-	-	-	-	-	-	-	-	.44
180	.22	-	-	-	-	-	-	-	-	-	.22
190	.44	-	-	-	-	-	-	-	-	-	.44
200	.22	-	-	-	-	-	-	-	-	-	.22
210	.22	-	-	-	-	-	-	-	-	-	.22
220	-	.22	-	-	-	-	-	-	-	-	.22
230	-	.44	-	-	-	-	-	-	-	-	.44
240	-	-	.44	.22	.22	-	-	-	-	-	.88
250	.44	.44	3.73	.66	-	.22	-	-	-	-	5.49
260	.66	.44	5.49	3.51	-	-	-	-	-	-	10.10
270	.22	.22	2.85	.66	-	-	-	-	-	-	3.95
280	.22	.22	.44	.22	.22	-	-	-	-	-	1.32
290	.22	.22	.44	.22	-	-	-	-	-	-	1.10
300	.44	-	-	-	-	-	-	-	-	-	.44
310	.44	-	-	-	-	-	-	-	-	-	.44
320	.44	-	-	-	-	-	-	-	-	-	.44
330	.66	-	-	-	-	-	-	-	-	-	.66
340	1.10	-	-	-	-	-	-	-	-	-	1.10
350	.88	.44	.22	-	-	-	-	-	-	-	1.54
360	-	-	-	-	-	-	-	-	-	-	-
TOTAL	13.20	14.95	23.95	14.50	13.18	12.96	3.74	2.42	.88	-	

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TABLE C-36

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 AU Date: 1 Mar 78 - 15 Mar 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	.14	-	-	-	.14
40	.69	.28	-	.56	-	-	-	-	-	-	1.53
50	1.25	1.53	3.74	2.50	1.11	2.78	1.25	1.11	-	-	15.27
60	.42	1.11	4.99	4.03	1.39	3.47	2.08	.97	-	-	18.46
70	1.67	1.67	.42	.14	-	-	-	-	-	-	3.90
80	.28	.14	.42	-	-	-	-	-	-	-	.84
90	.14	.14	.14	-	-	-	-	-	-	-	.42
100	.28	-	-	-	-	-	-	-	-	-	.28
110	.14	-	-	-	-	-	-	-	-	-	.14
120	.28	.14	-	-	-	-	-	-	-	-	.42
130	.56	-	-	-	-	-	-	-	-	-	.56
140	.56	-	-	-	-	-	-	-	-	-	.56
150	.28	-	-	-	-	-	-	-	-	-	.28
160	.83	.28	-	-	-	-	-	-	-	-	1.11
170	.42	.14	-	-	-	-	-	-	-	-	.56
180	.56	.14	-	-	-	-	-	-	-	-	.70
190	.42	.42	-	-	-	-	-	-	-	-	.84
200	.28	.28	-	-	-	-	-	-	-	-	.56
210	.69	.28	.14	-	-	-	-	-	-	-	1.11
220	1.25	.97	-	-	-	-	-	-	-	-	2.22
230	1.25	2.92	.28	-	-	-	-	-	-	-	4.45
240	1.53	5.27	1.11	-	-	-	-	-	-	-	7.91
250	1.53	4.99	2.08	-	-	-	-	-	-	-	8.60
260	1.81	7.35	3.33	.28	-	-	-	-	-	-	12.77
270	2.35	3.89	2.22	.14	-	-	-	-	-	-	8.60
280	1.38	3.19	.69	-	-	-	-	-	-	-	5.26
290	.56	1.11	-	-	-	-	-	-	-	-	1.67
300	.14	.28	-	-	-	-	-	-	-	-	.42
310	-	.14	-	-	-	-	-	-	-	-	.14
320	-	.14	-	-	-	-	-	-	-	-	.14
330	-	-	-	-	-	-	-	-	-	-	-
340	-	-	-	-	-	-	-	-	-	-	-
350	-	-	-	-	-	-	-	-	-	-	-
360	-	-	-	-	-	-	-	-	-	-	-
TOTAL	21.55	36.80	19.56	7.65	2.50	6.25	3.33	2.22	-	-	

TABLE C-37

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 AU Date: 16 Mar 78 - 31 Mar 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-25	36-40	41-45	46-50	Total
10	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-
30	.52	1.04	.39	-	-	-	-	-	-	-	1.95
40	.39	1.04	.39	.13	-	-	-	-	-	-	1.95
50	1.95	6.13	3.79	3.00	.91	-	-	-	-	-	15.78
60	.78	4.70	3.65	6.00	4.43	2.47	1.17	.26	-	-	23.46
70	.78	3.00	2.61	3.65	1.95	1.17	.91	-	-	-	14.07
80	.26	1.17	.91	.13	-	.13	-	-	-	-	2.60
90	.65	1.04	.39	-	-	-	-	-	-	-	2.08
100	.52	.78	-	.13	-	-	-	-	-	-	1.43
110	.52	.26	-	-	-	-	-	-	-	-	.78
120	.39	.26	-	-	-	-	-	-	-	-	.65
130	.26	-	-	-	-	-	-	-	-	-	.26
140	.26	.39	-	-	-	-	-	-	-	-	.65
150	-	.39	-	-	-	-	-	-	-	-	.39
160	.39	.26	-	-	-	-	-	-	-	-	.65
170	.13	.13	-	-	-	-	-	-	-	-	.26
180	.91	.65	-	-	-	-	-	-	-	-	1.56
190	.52	.26	-	-	-	-	-	-	-	-	.78
200	.13	.26	-	-	-	-	-	-	-	-	.39
210	.13	-	-	-	-	-	-	-	-	-	.13
220	.13	.13	-	-	-	-	-	-	-	-	.26
230	.65	1.95	.39	.52	.26	-	-	-	-	-	3.77
240	1.04	1.43	2.21	6.00	1.30	-	-	-	-	-	11.98
250	.91	.65	.39	.65	-	-	-	-	-	-	2.60
260	1.04	.65	.78	-	-	-	-	-	-	-	2.47
270	.39	.65	.13	-	-	-	-	-	-	-	1.17
280	1.04	.52	.13	-	-	-	-	-	-	-	1.69
290	.65	.52	-	.13	-	-	-	-	-	-	1.30
300	.78	.26	-	-	-	-	-	-	-	-	1.04
310	.65	-	-	-	-	-	-	-	-	-	.65
320	.26	-	-	-	-	-	-	-	-	-	.26
330	.52	-	-	-	-	-	-	-	-	-	.52
340	.13	-	-	-	-	-	-	-	-	-	.13
350	-	-	-	-	-	-	-	-	-	-	-
360	-	-	-	-	-	-	-	-	-	-	-
TOTAL	17.68	28.52	16.16	20.34	8.85	3.77	2.08	.26	-	-	

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TABLE C-38

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 AL Date: 16 Mar 78 - 31 Mar 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	.14	-	-	-	-	-	-	-	-	.14
20	.67	.40	-	-	-	-	-	-	-	-	1.07
30	.14	.81	.14	-	-	-	-	-	-	-	1.09
40	.95	5.26	2.02	1.35	.27	-	-	-	-	-	9.85
50	2.02	6.21	3.91	3.10	1.48	.14	-	-	-	-	16.86
60	.67	2.83	2.83	1.75	.54	.95	-	-	-	-	9.57
70	.27	1.75	2.97	.67	.54	.67	.67	-	-	-	7.54
80	.95	.68	.95	.40	.40	.40	-	-	-	-	3.78
90	.27	.40	-	-	-	-	-	-	-	-	.67
100	.40	.14	-	-	-	.14	-	-	-	-	.68
110	.54	-	-	-	-	-	-	-	-	-	.54
120	.27	.14	-	-	-	-	-	-	-	-	.41
130	.14	.14	-	-	-	-	-	-	-	-	.28
140	.40	-	-	-	-	-	-	-	-	-	.40
150	-	.14	-	-	-	-	-	-	-	-	.14
160	.40	.40	-	-	-	-	-	-	-	-	.80
170	.40	-	-	-	-	-	-	-	-	-	.40
180	.14	.27	-	-	-	-	-	-	-	-	.41
190	.14	-	-	-	-	-	-	-	-	-	.14
200	.40	.40	-	-	-	-	-	-	-	-	.80
210	.95	.54	-	-	-	-	-	-	-	-	1.49
220	.14	.40	.27	.14	-	-	-	-	-	-	.95
230	.14	.54	1.62	.27	-	-	-	-	-	-	2.57
240	1.48	.95	1.22	2.96	.14	-	-	-	-	-	6.75
250	.95	.40	.27	4.18	.95	-	-	-	-	-	6.75
260	.81	.40	-	.81	.54	-	-	-	-	-	2.56
270	4.86	1.22	-	-	-	-	-	-	-	-	6.08
2 0	.81	-	.14	-	-	-	-	-	-	-	.95
290	.54	.27	.27	-	-	-	-	-	-	-	1.08
300	.40	.54	-	-	-	-	-	-	-	-	.94
310	.67	.54	-	-	-	-	-	-	-	-	1.21
320	.54	.54	-	-	-	-	-	-	-	-	1.08
330	.14	.14	-	-	-	-	-	-	-	-	.28
340	-	.27	-	-	-	-	-	-	-	-	.27
350	4.32	1.48	-	-	-	-	-	-	-	-	5.80
360	2.16	1.08	-	-	-	-	-	-	-	-	3.24
TOTAL	28.08	29.42	16.61	15.63	4.86	2.30	.67	-	-	-	

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TABLE C-39

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 1 AU Date: 8 Apr 78 - 15 Apr 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	-	-	-	-	-	-	-	-	-	-
20	0.28	-	-	-	-	-	-	-	-	-	0.28
30	-	0.84	0.84	0.28	-	-	-	-	-	-	1.96
40	1.12	1.12	3.92	0.56	-	-	-	-	-	-	6.72
50	1.96	2.52	2.80	0.28	-	-	-	-	-	-	7.56
60	1.68	2.52	5.05	-	-	-	-	-	-	-	9.25
70	1.96	4.20	-	-	-	-	-	-	-	-	6.16
80	1.12	2.52	0.56	-	-	-	-	-	-	-	4.20
90	1.96	1.40	0.28	-	-	-	-	-	-	-	3.64
100	0.84	0.28	0.56	-	-	-	-	-	-	-	1.68
110	1.12	0.84	-	-	-	-	-	-	-	-	1.96
120	0.84	-	-	-	-	-	-	-	-	-	0.84
130	0.84	-	-	-	-	-	-	-	-	-	0.84
140	0.84	0.28	-	-	-	-	-	-	-	-	1.12
150	0.28	-	-	-	-	-	-	-	-	-	0.28
160	-	-	-	-	-	-	-	-	-	-	-
170	0.56	-	-	-	-	-	-	-	-	-	0.56
180	0.56	2.24	-	-	-	-	-	-	-	-	2.80
190	-	1.68	0.28	-	-	-	-	-	-	-	1.96
200	0.28	1.12	0.84	-	-	-	-	-	-	-	2.24
210	0.84	2.80	0.84	0.28	-	-	-	-	-	-	4.76
220	-	3.08	4.21	1.40	-	-	-	-	-	-	8.69
230	-	3.08	1.96	4.49	-	-	-	-	-	-	9.53
240	0.28	2.80	4.77	3.08	0.28	-	-	-	-	-	11.21
250	0.28	0.56	0.84	1.12	-	-	-	-	-	-	2.80
260	0.28	0.84	-	-	0.28	-	-	-	-	-	1.40
270	-	0.28	-	-	-	-	-	-	-	-	0.28
280	1.12	-	-	-	-	-	-	-	-	-	1.12
290	0.28	-	-	-	-	-	-	-	-	-	0.28
300	0.84	-	-	-	-	-	-	-	-	-	0.84
310	0.84	-	-	-	-	-	-	-	-	-	0.84
320	0.28	0.84	0.56	-	-	-	-	-	-	-	1.68
330	0.28	-	0.28	-	-	-	-	-	-	-	0.56
340	0.56	0.28	-	-	-	-	-	-	-	-	0.84
350	0.28	-	-	-	-	-	-	-	-	-	0.28
360	-	-	-	-	-	-	-	-	-	-	-
TOTAL	22.40	36.12	28.59	11.49	0.56	-	-	-	-	-	100.00

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TABLE C-40

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 1 AL Date: 8 Apr 78 - 15 Apr 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	-	-	-	-	-	-	-	-	-	-
20	-	-	.84	.28	-	-	-	-	-	-	1.12
30	-	1.40	4.20	.56	-	-	-	-	-	-	6.16
40	-	1.96	2.24	.28	-	-	-	-	-	-	4.48
50	.84	4.76	.28	-	-	-	-	-	-	-	5.88
60	3.37	3.64	.84	-	-	-	-	-	-	-	7.85
70	.56	.84	.28	-	-	-	-	-	-	-	1.68
80	1.68	.28	-	-	-	-	-	-	-	-	1.96
90	1.40	.28	.28	-	-	-	-	-	-	-	1.96
100	1.68	-	-	-	-	-	-	-	-	-	1.68
110	.28	.28	-	-	-	-	-	-	-	-	.56
120	.84	-	-	-	-	-	-	-	-	-	.84
130	.56	-	-	-	-	-	-	-	-	-	.56
140	1.12	-	-	-	-	-	-	-	-	-	1.12
150	.84	-	-	-	-	-	-	-	-	-	.84
160	1.12	-	-	-	-	-	-	-	-	-	1.12
170	1.12	-	-	-	-	-	-	-	-	-	1.12
180	1.40	-	-	-	-	-	-	-	-	-	1.40
190	1.96	.56	-	-	-	-	-	-	-	-	2.52
200	2.80	5.61	-	-	-	-	-	-	-	-	8.41
210	2.80	7.85	2.80	.28	-	-	-	-	-	-	13.73
220	1.96	4.48	4.21	1.12	-	-	-	-	-	-	11.77
230	-	2.24	3.08	1.12	-	-	-	-	-	-	6.44
240	.28	1.68	2.52	.56	-	-	-	-	-	-	5.04
250	1.40	1.12	1.40	-	-	-	-	-	-	-	3.92
260	1.40	.28	.56	-	-	-	-	-	-	-	2.24
270	.28	-	-	-	-	-	-	-	-	-	.28
280	-	-	-	-	-	-	-	-	-	-	-
290	.28	-	-	-	-	-	-	-	-	-	.28
300	-	-	-	-	-	-	-	-	-	-	-
310	.28	-	-	-	-	-	-	-	-	-	.28
320	-	-	-	-	-	-	-	-	-	-	-
330	.28	-	-	-	-	-	-	-	-	-	.28
340	.28	.56	-	-	-	-	-	-	-	-	.84
350	-	1.40	.28	-	-	-	-	-	-	-	1.68
360	-	.28	.84	-	-	-	-	-	-	-	1.12
TOTAL	30.81	39.50	24.65	4.20	-	-	-	-	-	-	

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TABLE C-41

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 AU Date: 1 Apr 78 - 15 Apr 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-
30	.14	.14	-	-	-	-	-	-	-	-	.28
40	.97	1.67	.28	-	-	-	-	-	-	-	2.92
50	2.36	6.37	1.39	.97	.42	-	-	-	-	-	11.51
60	2.78	5.55	8.04	2.50	.83	-	-	-	-	-	19.70
70	1.25	2.21	4.57	.69	.56	.14	-	-	-	-	9.42
80	1.67	1.67	1.67	.42	-	-	-	-	-	-	5.43
90	1.53	.14	.28	-	-	-	-	-	-	-	1.95
100	.83	-	-	-	-	-	-	-	-	-	.83
110	1.53	.14	-	-	-	-	-	-	-	-	1.67
120	1.67	-	-	-	-	-	-	-	-	-	1.67
130	.69	.14	-	-	-	-	-	-	-	-	.83
140	.28	-	-	-	-	-	-	-	-	-	.28
150	.83	-	-	-	-	-	-	-	-	-	.83
160	.56	-	-	-	-	-	-	-	-	-	.56
170	.56	-	-	-	-	-	-	-	-	-	.56
180	.28	-	-	-	-	-	-	-	-	-	.28
190	.42	.42	-	-	-	-	-	-	-	-	.84
200	.42	.14	.14	-	-	-	-	-	-	-	.70
210	.83	.14	-	-	-	-	-	-	-	-	.97
220	1.53	.56	-	-	-	-	-	-	-	-	2.09
230	1.81	5.26	1.25	.28	-	-	-	-	-	-	8.60
240	1.25	3.47	1.53	.14	-	-	-	-	-	-	6.95
250	.83	2.50	1.11	.42	-	-	-	-	-	-	4.86
260	.56	3.05	2.92	.97	-	-	-	-	-	-	7.50
270	.83	.42	.28	-	-	-	-	-	-	-	1.53
280	.28	.42	-	-	-	-	-	-	-	-	.70
290	1.25	.14	-	-	-	-	-	-	-	-	1.39
300	.14	.14	-	-	-	-	-	-	-	-	.28
310	.56	-	-	-	-	-	-	-	-	-	.56
320	.28	.14	-	-	-	-	-	-	-	-	.42
330	.14	-	-	-	-	-	-	-	-	-	.14
340	.14	-	-	-	-	-	-	-	-	-	.14
350	-	-	-	-	-	-	-	-	-	-	-
360	-	-	-	-	-	-	-	-	-	-	-
TOTAL	29.20	34.83	23.46	6.81	1.95	.14	-	-	-	-	

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TABLE C-42

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 AL Date: 1 Apr 78 - 15 Apr 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	0.14	-	-	-	-	-	-	-	-	0.14
20	0.14	0.14	-	-	-	-	-	-	-	-	0.28
30	0.42	0.28	0.55	-	-	-	-	-	-	-	1.25
40	0.83	0.42	0.83	-	-	-	-	-	-	-	2.08
50	2.91	1.93	1.94	-	-	-	-	-	-	-	6.78
60	4.82	1.80	1.80	0.69	-	-	-	-	-	-	9.11
70	4.68	0.69	1.52	1.66	0.28	-	-	-	-	-	8.83
80	3.87	0.14	0.14	0.14	-	-	-	-	-	-	4.29
90	3.46	0.69	-	-	-	-	-	-	-	-	4.15
100	2.77	-	-	-	-	-	-	-	-	-	2.77
110	1.25	-	0.28	-	-	-	-	-	-	-	1.53
120	1.52	0.14	-	-	-	-	-	-	-	-	1.66
130	0.69	-	-	-	-	-	-	-	-	-	0.69
140	0.69	-	-	-	-	-	-	-	-	-	0.69
150	1.38	-	-	-	-	-	-	-	-	-	1.38
160	0.55	-	-	-	-	-	-	-	-	-	0.55
170	1.11	-	-	-	-	-	-	-	-	-	1.11
180	0.42	-	-	-	-	-	-	-	-	-	0.42
190	4.56	-	-	-	-	-	-	-	-	-	4.56
200	7.03	1.52	-	-	-	-	-	-	-	-	8.55
210	1.66	0.55	0.28	-	-	-	-	-	-	-	2.49
220	1.66	0.55	0.42	0.42	-	-	-	-	-	-	3.05
230	1.38	1.66	0.69	0.69	0.14	-	-	-	-	-	4.56
240	2.49	0.55	0.69	0.83	0.14	-	-	-	-	-	4.70
250	2.21	-	0.28	0.69	-	-	-	-	-	-	3.18
260	0.42	0.14	-	-	-	-	-	-	-	-	0.56
270	0.14	0.42	-	-	-	-	-	-	-	-	0.56
280	0.69	0.55	-	-	-	-	-	-	-	-	1.24
290	1.11	0.42	-	-	-	-	-	-	-	-	1.53
300	0.14	0.28	-	-	-	-	-	-	-	-	0.42
310	0.14	-	-	-	-	-	-	-	-	-	0.14
320	-	-	-	-	-	-	-	-	-	-	-
330	-	-	-	-	-	-	-	-	-	-	-
340	-	0.14	-	-	-	-	-	-	-	-	0.14
350	1.11	0.55	-	-	-	-	-	-	-	-	1.66
360	0.97	0.42	-	-	-	-	-	-	-	-	1.39
TOTAL	57.22	14.12	9.42	5.12	0.56	-	-	-	-	-	100.00

TABLE C-43

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 1 AU Date: 16 Apr 78 - 30 Apr 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	0.14	0.42	-	-	-	-	-	-	-	-	0.56
20	0.42	0.42	-	-	-	-	-	-	-	-	0.84
30	1.11	3.19	0.28	-	-	-	-	-	-	-	4.58
40	0.97	3.88	1.53	0.14	-	-	-	-	-	-	6.52
50	2.07	7.63	2.22	-	-	-	-	-	-	-	11.92
60	1.39	4.30	4.03	0.14	-	-	-	-	-	-	9.86
70	1.66	3.61	3.47	0.14	-	-	-	-	-	-	8.88
80	1.66	3.19	1.39	-	-	-	-	-	-	-	6.24
90	1.25	1.81	0.42	-	-	-	-	-	-	-	3.48
100	0.83	1.11	-	-	-	-	-	-	-	-	1.94
110	0.83	0.28	0.14	-	-	-	-	-	-	-	1.25
120	1.66	0.14	-	-	-	-	-	-	-	-	1.80
130	0.56	-	-	-	-	-	-	-	-	-	0.56
140	0.42	0.14	-	-	-	-	-	-	-	-	0.56
150	0.42	-	-	-	-	-	-	-	-	-	0.42
160	0.14	0.14	-	-	-	-	-	-	-	-	0.28
170	0.28	0.42	-	-	-	-	-	-	-	-	0.70
180	-	0.69	-	-	-	-	-	-	-	-	0.69
190	0.42	0.42	-	-	-	-	-	-	-	-	0.84
200	0.28	2.22	0.28	-	-	-	-	-	-	-	2.78
210	0.28	0.97	0.28	-	-	-	-	-	-	-	1.53
220	0.28	0.56	0.69	0.14	0.28	-	-	-	-	-	1.95
230	0.69	0.97	0.97	0.69	-	-	-	-	-	-	3.32
240	-	1.25	1.39	1.25	-	-	-	-	-	-	3.89
250	0.14	0.56	0.69	0.28	-	-	-	-	-	-	1.67
260	0.56	0.97	0.97	0.69	-	-	-	-	-	-	3.19
270	0.42	0.97	0.42	0.83	-	-	-	-	-	-	2.64
280	0.28	1.25	0.42	0.14	-	-	-	-	-	-	2.09
290	0.56	1.11	0.28	-	-	-	-	-	-	-	1.95
300	1.11	1.39	-	-	-	-	-	-	-	-	2.50
310	0.28	0.28	-	-	-	-	-	-	-	-	0.56
320	0.56	1.39	-	-	-	-	-	-	-	-	1.95
330	0.28	0.56	-	-	-	-	-	-	-	-	0.84
340	1.39	1.39	0.14	-	-	-	-	-	-	-	2.92
350	0.83	1.25	0.14	-	-	-	-	-	-	-	2.22
360	0.69	0.42	-	-	-	-	-	-	-	-	1.11
TOTAL	24.86	49.30	20.15	4.44	0.28	-	-	-	-	-	100.00

TABLE C-44

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 1 AL Date: 16 Apr 78 - 23 Apr 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	-	-	-	-	-	-	-	-	-	-
20	-	0.55	0.27	-	-	-	-	-	-	-	0.82
30	-	1.64	1.64	0.27	-	-	-	-	-	-	3.55
40	0.55	2.19	-	0.55	0.55	-	-	-	-	-	3.84
50	1.64	6.01	0.27	0.82	0.55	-	-	-	-	-	9.29
60	0.82	4.92	0.55	0.55	-	-	-	-	-	-	6.84
70	1.09	2.46	0.27	1.09	-	-	-	-	-	-	4.91
80	0.55	0.55	0.82	1.09	-	-	-	-	-	-	3.01
90	1.09	2.19	0.82	-	0.27	-	-	-	-	-	4.37
100	1.09	3.83	0.27	0.27	-	-	-	-	-	-	5.46
110	0.27	2.19	0.27	-	-	-	-	-	-	-	2.73
120	0.55	0.27	0.55	-	-	-	-	-	-	-	1.37
130	-	0.55	-	-	-	-	-	-	-	-	0.55
140	-	-	0.27	-	-	-	-	-	-	-	0.27
150	0.82	0.27	-	-	-	-	-	-	-	-	1.09
160	1.37	0.27	0.27	-	-	-	-	-	-	-	1.91
170	1.09	-	0.55	-	-	-	-	-	-	-	1.64
180	2.19	-	-	0.55	-	-	-	-	-	-	2.74
190	0.27	-	0.55	-	-	-	-	-	-	-	0.82
200	-	-	0.55	0.55	-	-	-	-	-	-	1.10
210	-	-	1.09	0.55	-	-	-	-	-	-	1.64
220	0.82	-	1.09	0.27	-	-	-	-	-	-	2.18
230	1.64	0.82	0.55	0.27	-	-	-	-	-	-	3.28
240	2.46	2.19	1.09	-	-	-	-	-	-	-	5.74
250	2.73	1.37	0.27	-	-	-	-	-	-	-	4.37
260	10.11	5.46	0.27	-	-	-	-	-	-	-	15.84
270	0.55	0.27	-	-	-	-	-	-	-	-	0.82
280	0.27	-	-	-	-	-	-	-	-	-	0.27
290	0.27	-	0.27	-	-	-	-	-	-	-	0.54
300	0.55	-	0.27	-	-	-	-	-	-	-	0.82
310	-	-	-	-	-	-	-	-	-	-	-
320	0.55	-	0.27	-	-	-	-	-	-	-	0.82
330	0.27	0.27	-	-	-	-	-	-	-	-	0.54
340	0.55	1.09	-	-	-	-	-	-	-	-	1.64
350	0.27	1.09	1.37	-	-	-	-	-	-	-	2.73
360	-	0.55	-	1.09	-	-	-	-	-	-	1.64
TOTAL	34.43	41.00	14.46	7.92	1.37	-	-	-	-	-	100.00

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TABLE C-45

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 AU Date: 16 Apr 78 - 30 Apr 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	-	-	-	-	-	-	-	-	-	-
20	0.83	0.97	-	-	-	-	-	-	-	-	1.80
30	0.69	0.97	0.14	0.14	-	-	-	-	-	-	1.94
40	1.80	3.04	1.52	0.28	-	-	-	-	-	-	6.64
50	1.80	7.45	5.74	2.63	0.28	0.41	-	-	-	-	8.31
60	2.07	4.69	3.86	2.77	0.83	0.14	-	-	-	-	14.36
70	1.24	2.35	3.04	2.35	0.69	-	-	-	-	-	9.67
80	1.52	2.07	0.69	0.14	0.28	0.14	-	-	-	-	4.84
90	1.94	2.63	0.14	-	-	-	-	-	-	-	4.71
100	0.69	0.14	-	-	-	-	-	-	-	-	0.83
110	0.41	-	-	-	-	-	-	-	-	-	0.41
120	0.41	-	-	-	-	-	-	-	-	-	0.41
130	0.69	-	-	-	-	-	-	-	-	-	0.69
140	0.55	0.14	-	-	-	-	-	-	-	-	0.69
150	0.28	-	-	-	-	-	-	-	-	-	0.28
160	0.41	0.14	-	-	-	-	-	-	-	-	0.55
170	0.69	-	-	-	-	-	-	-	-	-	0.69
180	0.83	0.14	-	-	-	-	-	-	-	-	0.97
190	0.97	0.14	-	-	-	-	-	-	-	-	1.11
200	0.69	0.83	-	-	-	-	-	-	-	-	1.52
210	0.97	0.69	-	-	-	-	-	-	-	-	1.66
220	0.28	0.41	-	-	-	-	-	-	-	-	0.69
230	0.55	0.83	-	0.28	-	-	-	-	-	-	1.66
240	-	0.69	0.69	1.11	0.28	-	-	-	-	-	2.77
250	0.55	0.28	1.24	0.28	0.14	-	-	-	-	-	2.49
260	1.24	0.41	0.83	0.14	-	-	-	-	-	-	2.62
270	-	0.55	0.14	-	-	-	-	-	-	-	0.69
280	1.38	0.41	0.28	-	-	-	-	-	-	-	2.07
290	1.66	2.07	0.14	-	-	-	-	-	-	-	3.87
300	1.11	1.52	-	-	-	-	-	-	-	-	2.63
310	1.24	0.69	-	-	-	-	-	-	-	-	1.93
320	1.52	0.69	-	-	-	-	-	-	-	-	2.21
330	0.97	-	-	-	-	-	-	-	-	-	0.97
340	0.55	0.69	-	-	-	-	-	-	-	-	1.24
350	0.14	0.28	-	-	-	-	-	-	-	-	0.42
360	-	0.14	-	-	-	-	-	-	-	-	0.14
TOTAL	30.67	36.05	18.45	10.12	2.50	0.69	-	-	-	-	100.00

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TABLE C-46

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 AL Date: 16 Apr 78 - 30 Apr 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	0.14	-	-	-	-	-	-	-	-	-	0.14
20	0.41	0.28	0.14	-	-	-	-	-	-	-	0.83
30	1.80	0.69	-	0.14	-	-	-	-	-	-	2.63
40	2.21	1.66	0.41	-	0.14	-	-	-	-	-	4.42
50	6.21	5.79	3.04	1.80	0.69	-	-	-	-	-	17.53
60	2.90	4.83	2.62	0.41	-	-	-	-	-	-	10.76
70	4.97	4.42	2.07	0.41	0.41	-	-	-	-	-	12.28
80	4.70	1.52	0.14	-	-	-	-	-	-	-	6.36
90	2.21	0.83	-	-	-	-	-	-	-	-	3.04
100	1.38	0.28	-	-	-	-	-	-	-	-	1.66
110	0.97	-	-	-	-	-	-	-	-	-	0.97
120	1.24	0.28	-	-	-	-	-	-	-	-	1.25
130	2.35	0.14	0.14	-	-	-	-	-	-	-	2.63
140	0.83	-	-	-	-	-	-	-	-	-	0.83
150	0.28	-	-	-	-	-	-	-	-	-	0.28
160	0.55	-	-	-	-	-	-	-	-	-	0.55
170	0.69	-	-	-	-	-	-	-	-	-	0.69
180	0.41	0.14	-	-	-	-	-	-	-	-	0.55
190	1.10	0.69	0.14	-	-	-	-	-	-	-	1.93
200	1.80	1.38	0.28	-	-	-	-	-	-	-	3.46
210	1.10	1.38	0.28	-	-	-	-	-	-	-	2.76
220	2.07	0.83	0.28	0.97	-	-	-	-	-	-	4.15
230	1.10	-	-	0.41	-	-	-	-	-	-	1.51
240	0.69	-	-	-	-	-	-	-	-	-	0.69
250	0.69	-	-	-	-	-	-	-	-	-	0.69
260	1.80	-	-	-	-	-	-	-	-	-	1.80
270	1.38	-	-	-	-	-	-	-	-	-	1.38
280	0.97	-	-	-	-	-	-	-	-	-	0.97
290	0.69	-	-	-	-	-	-	-	-	-	0.69
300	-	-	-	-	-	-	-	-	-	-	-
310	0.41	0.14	-	-	-	-	-	-	-	-	0.55
320	0.41	0.28	0.14	-	-	-	-	-	-	-	0.83
330	0.28	0.14	-	-	-	-	-	-	-	-	0.42
340	0.55	-	-	-	-	-	-	-	-	-	0.55
350	0.14	-	-	-	-	-	-	-	-	-	0.14
360	-	-	-	-	-	-	-	-	-	-	-
TOTAL	49.43	25.70	9.68	4.14	1.24	-	-	-	-	-	100.00

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TABLE C-47

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 1 AU Date : 1 May 78 - 15 May 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	-	-	-	-	-	-	-	-	-	-
20	0.42	-	-	-	-	-	-	-	-	-	0.42
30	0.14	0.56	0.69	0.56	-	-	-	-	-	-	1.95
40	0.56	0.97	1.25	0.83	-	-	-	-	-	-	3.61
50	0.42	2.36	3.04	1.81	0.56	-	-	-	-	-	8.19
60	0.28	1.94	2.91	1.53	1.39	0.14	-	-	-	-	8.19
70	0.42	0.56	1.38	1.11	0.28	-	-	-	-	-	3.75
80	-	0.42	0.96	0.28	0.42	-	-	-	-	-	2.08
90	0.97	1.25	0.28	0.42	0.14	-	-	-	-	-	3.06
100	4.17	2.91	0.42	0.28	-	-	-	-	-	-	7.78
110	1.39	0.42	-	-	-	-	-	-	-	-	1.81
120	1.39	0.14	-	-	-	-	-	-	-	-	1.53
130	0.83	-	-	-	-	-	-	-	-	-	0.83
140	0.28	0.69	0.14	-	-	-	-	-	-	-	1.11
150	1.52	0.56	-	-	-	-	-	-	-	-	2.08
160	1.25	0.56	-	-	-	-	-	-	-	-	1.81
170	1.39	0.28	-	-	-	-	-	-	-	-	1.67
180	0.97	0.42	-	-	-	-	-	-	-	-	1.39
190	0.56	0.69	-	-	-	-	-	-	-	-	1.25
200	1.94	1.81	0.28	-	-	-	-	-	-	-	4.03
210	2.36	1.25	-	-	-	-	-	-	-	-	3.61
220	2.92	1.39	-	-	-	-	-	-	-	-	4.31
230	5.83	1.67	-	-	-	-	-	-	-	-	7.50
240	5.83	0.83	0.83	-	-	-	-	-	-	-	7.50
250	2.77	0.42	-	-	-	-	-	-	-	-	3.19
260	0.97	0.28	0.83	0.14	-	-	-	-	-	-	2.22
270	0.97	1.25	-	-	-	-	-	-	-	-	2.22
280	0.56	1.53	0.14	-	-	-	-	-	-	-	2.22
290	0.56	1.25	-	-	-	-	-	-	-	-	1.81
300	0.83	0.28	-	-	-	-	-	-	-	-	1.11
310	0.97	0.42	-	-	-	-	-	-	-	-	1.39
320	1.11	0.56	-	-	-	-	-	-	-	-	1.67
330	0.69	-	-	-	-	-	-	-	-	-	0.69
340	1.11	0.28	-	-	-	-	-	-	-	-	1.39
350	0.83	0.14	-	-	-	-	-	-	-	-	0.97
360	0.69	-	-	-	-	-	-	-	-	-	0.69
TOTAL	47.90	28.09	13.15	6.96	2.79	0.14	-	-	-	-	100.00

TABLE C-48

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 1 AL Date: 7 May 78 - 9 May 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	-	-	-	-
40	1.20	32.54	3.61	-	-	-	-	-	-	-	37.35
50	9.64	25.30	3.61	-	-	-	-	-	-	-	38.55
60	-	-	-	-	-	-	-	-	-	-	-
70	-	-	-	-	-	-	-	-	-	-	-
80	-	-	-	2.41	-	-	-	-	-	-	2.41
90	-	-	-	2.41	-	-	-	-	-	-	2.41
100	4.82	4.82	-	2.41	-	-	-	-	-	-	12.05
110	2.41	2.41	2.41	-	-	-	-	-	-	-	7.23
120	-	-	-	-	-	-	-	-	-	-	-
130	-	-	-	-	-	-	-	-	-	-	-
140	-	-	-	-	-	-	-	-	-	-	-
150	-	-	-	-	-	-	-	-	-	-	-
160	-	-	-	-	-	-	-	-	-	-	-
170	-	-	-	-	-	-	-	-	-	-	-
180	-	-	-	-	-	-	-	-	-	-	-
190	-	-	-	-	-	-	-	-	-	-	-
200	-	-	-	-	-	-	-	-	-	-	-
210	-	-	-	-	-	-	-	-	-	-	-
220	-	-	-	-	-	-	-	-	-	-	-
230	-	-	-	-	-	-	-	-	-	-	-
240	-	-	-	-	-	-	-	-	-	-	-
250	-	-	-	-	-	-	-	-	-	-	-
260	-	-	-	-	-	-	-	-	-	-	-
270	-	-	-	-	-	-	-	-	-	-	-
280	-	-	-	-	-	-	-	-	-	-	-
290	-	-	-	-	-	-	-	-	-	-	-
300	-	-	-	-	-	-	-	-	-	-	-
310	-	-	-	-	-	-	-	-	-	-	-
320	-	-	-	-	-	-	-	-	-	-	-
330	-	-	-	-	-	-	-	-	-	-	-
340	-	-	-	-	-	-	-	-	-	-	-
350	-	-	-	-	-	-	-	-	-	-	-
360	-	-	-	-	-	-	-	-	-	-	-
TOTAL	18.07	65.07	9.63	7.23	-	-	-	-	-	-	100.00

TABLE C-49

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 AU Date: 1 May 78 - 15 May 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	-	-	-	-	-	-	-	-	-	-
20	0.14	0.14	-	-	-	-	-	-	-	-	0.28
30	0.42	0.83	0.28	0.14	-	-	-	-	-	-	1.67
40	0.69	1.67	1.39	-	-	-	-	-	-	-	3.75
50	0.83	3.06	2.64	2.64	1.39	-	-	-	-	-	10.56
60	1.53	2.92	4.72	4.17	3.19	-	-	-	-	-	16.53
70	0.97	2.08	1.53	2.36	1.67	-	-	-	-	-	8.61
80	1.53	0.97	0.69	-	-	-	-	-	-	-	3.19
90	2.07	0.14	-	-	-	-	-	-	-	-	2.21
100	2.49	0.14	-	-	-	-	-	-	-	-	2.63
110	0.56	0.28	-	-	-	-	-	-	-	-	0.84
120	0.56	-	-	-	-	-	-	-	-	-	0.56
130	0.14	-	-	-	-	-	-	-	-	-	0.14
140	0.28	-	-	-	-	-	-	-	-	-	0.28
150	0.28	-	-	-	-	-	-	-	-	-	0.28
160	0.42	-	-	-	-	-	-	-	-	-	0.42
170	0.28	-	-	-	-	-	-	-	-	-	0.28
180	0.14	-	-	-	-	-	-	-	-	-	0.14
190	-	0.14	-	-	-	-	-	-	-	-	0.14
200	0.56	-	-	-	-	-	-	-	-	-	0.56
210	0.14	0.97	-	-	-	-	-	-	-	-	1.11
220	0.56	0.69	0.42	-	-	-	-	-	-	-	1.67
230	0.83	0.83	1.94	0.14	-	-	-	-	-	-	3.74
240	1.53	4.31	0.69	0.69	-	-	-	-	-	-	7.22
250	1.67	5.00	1.53	0.14	-	-	-	-	-	-	8.34
260	1.39	3.61	1.39	-	-	-	-	-	-	-	6.39
270	1.81	0.97	0.14	-	-	-	-	-	-	-	2.92
280	1.39	0.97	-	-	-	-	-	-	-	-	2.36
290	0.69	0.83	-	-	-	-	-	-	-	-	1.52
300	2.07	0.42	-	-	-	-	-	-	-	-	2.49
310	0.69	0.14	-	-	-	-	-	-	-	-	0.83
320	1.80	0.28	-	-	-	-	-	-	-	-	2.08
330	0.97	0.28	-	-	-	-	-	-	-	-	1.25
340	1.11	1.53	-	-	-	-	-	-	-	-	2.64
350	0.56	0.14	-	-	-	-	-	-	-	-	0.70
360	0.28	-	-	-	-	-	-	-	-	-	0.28
TOTAL	31.39	33.34	17.36	10.28	6.25	-	-	-	-	-	100.00

TABLE C-50

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 AL Date: 1 May 78 - 15 May 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	0.28	-	-	-	-	-	-	-	-	-	0.28
20	4.02	0.14	-	-	-	-	-	-	-	-	4.16
30	1.53	0.42	0.28	-	-	-	-	-	-	-	2.23
40	0.97	0.83	1.11	-	-	-	-	-	-	-	2.91
50	1.39	4.03	2.08	0.14	-	-	-	-	-	-	7.64
60	2.78	6.10	4.43	0.83	-	-	-	-	-	-	14.14
70	1.67	1.25	0.97	0.56	-	-	-	-	-	-	4.45
80	1.25	0.69	1.39	0.14	-	-	-	-	-	-	3.47
90	0.97	0.83	0.83	-	-	-	-	-	-	-	2.63
100	3.06	0.28	0.97	-	-	-	-	-	-	-	4.31
110	1.94	1.94	-	-	-	-	-	-	-	-	3.88
120	2.78	0.42	-	-	-	-	-	-	-	-	3.20
130	2.36	0.28	-	-	-	-	-	-	-	-	2.64
140	0.42	-	-	-	-	-	-	-	-	-	0.42
150	0.42	-	-	-	-	-	-	-	-	-	0.42
160	-	-	-	-	-	-	-	-	-	-	-
170	1.11	-	-	-	-	-	-	-	-	-	1.11
180	0.69	0.14	-	-	-	-	-	-	-	-	0.83
190	1.53	0.97	-	-	-	-	-	-	-	-	2.50
200	3.89	1.81	-	-	-	-	-	-	-	-	5.70
210	2.50	4.44	0.14	-	-	-	-	-	-	-	7.08
220	1.39	4.17	0.28	0.14	-	-	-	-	-	-	5.98
230	2.89	2.22	0.42	-	-	-	-	-	-	-	6.53
240	1.25	0.69	0.28	-	-	-	-	-	-	-	2.22
250	0.28	0.14	-	-	-	-	-	-	-	-	0.42
260	0.42	-	-	-	-	-	-	-	-	-	0.42
270	-	-	-	-	-	-	-	-	-	-	-
280	-	-	-	-	-	-	-	-	-	-	-
290	0.56	-	-	-	-	-	-	-	-	-	0.56
300	0.42	-	-	-	-	-	-	-	-	-	0.42
310	0.42	-	-	-	-	-	-	-	-	-	0.42
320	0.69	-	-	-	-	-	-	-	-	-	0.69
330	0.28	-	-	-	-	-	-	-	-	-	0.28
340	15.3	-	-	-	-	-	-	-	-	-	15.3
350	2.73	-	-	-	-	-	-	-	-	-	2.78
360	0.56	-	-	-	-	-	-	-	-	-	0.56
TOTAL	50.03	31.79	13.19	1.81	-	-	-	-	-	-	100.00

433

TABLE C-51

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 BU Date: 9 May 78 - 15 May 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-
30	-	1.25	0.31	-	-	-	-	-	-	-	1.56
40	-	0.31	1.56	-	-	-	-	-	-	-	1.87
50	0.63	2.81	0.94	-	-	-	-	-	-	-	4.38
60	0.94	4.06	2.19	-	-	-	-	-	-	-	7.19
70	17.19	6.56	0.94	-	-	-	-	-	-	-	24.69
80	3.13	1.56	0.31	-	-	-	-	-	-	-	5.00
90	-	0.94	0.94	-	-	-	-	-	-	-	1.88
100	-	0.31	0.63	-	-	-	-	-	-	-	0.94
110	-	-	-	-	-	-	-	-	-	-	-
120	-	0.31	-	-	-	-	-	-	-	-	0.31
130	-	0.31	-	-	-	-	-	-	-	-	0.31
140	-	1.25	-	-	-	-	-	-	-	-	1.25
150	-	-	-	-	-	-	-	-	-	-	-
160	-	-	-	-	-	-	-	-	-	-	-
170	-	-	-	-	-	-	-	-	-	-	-
180	-	-	-	-	-	-	-	-	-	-	-
190	-	-	-	-	-	-	-	-	-	-	-
200	-	-	-	-	-	-	-	-	-	-	-
210	-	-	-	-	-	-	-	-	-	-	-
220	-	-	-	-	-	-	-	-	-	-	-
230	-	-	-	-	-	-	-	-	-	-	-
240	-	-	-	-	-	-	-	-	-	-	-
250	-	-	-	-	-	-	-	-	-	-	-
260	-	-	-	-	-	-	-	-	-	-	-
270	0.31	0.63	-	-	-	-	-	-	-	-	0.94
280	10.63	4.06	-	-	-	-	-	-	-	-	14.69
290	9.07	6.56	0.31	0.31	-	-	-	-	-	-	16.25
300	8.75	3.13	-	-	-	-	-	-	-	-	11.88
310	1.56	1.88	-	-	-	-	-	-	-	-	3.44
320	-	0.31	0.31	-	-	-	-	-	-	-	0.62
330	-	-	0.31	-	-	-	-	-	-	-	0.31
340	-	0.31	0.31	-	-	-	-	-	-	-	0.62
350	-	-	-	-	-	-	-	-	-	-	-
360	-	0.31	0.31	-	-	-	-	-	-	-	0.62
TOTAL	52.21	36.86	9.37	0.31	-	-	-	-	-	-	100.00

TABLE C-52

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 BL Date: 9 May 78 - 15 May 78

Speed (m/sec x 10^{-2})

Direction	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	-	-	-	-	-	-	-	-	-	-
20	0.32	0.32	-	-	-	-	-	-	-	-	0.64
30	0.32	0.96	-	-	-	-	-	-	-	-	1.28
40	0.96	1.28	0.64	-	-	-	-	-	-	-	2.88
50	0.64	0.64	1.28	-	-	-	-	-	-	-	2.56
60	6.64	1.92	1.28	-	-	-	-	-	-	-	3.84
70	-	1.92	0.96	-	-	-	-	-	-	-	2.88
80	0.64	4.17	0.96	-	-	-	-	-	-	-	5.77
90	0.96	4.18	-	-	-	-	-	-	-	-	5.14
100	0.96	4.81	-	-	-	-	-	-	-	-	5.77
110	0.96	1.92	0.32	-	-	-	-	-	-	-	3.20
120	0.32	1.28	0.32	-	-	-	-	-	-	-	1.92
130	0.64	0.64	0.32	-	-	-	-	-	-	-	1.60
140	0.64	1.60	-	-	-	-	-	-	-	-	2.24
150	0.64	-	-	-	-	-	-	-	-	-	0.64
160	0.96	0.64	-	-	-	-	-	-	-	-	1.60
170	1.60	0.64	-	-	-	-	-	-	-	-	2.24
180	7.05	2.24	0.64	-	-	-	-	-	-	-	9.93
190	-	0.64	-	-	-	-	-	-	-	-	0.64
200	2.24	2.56	0.32	-	-	-	-	-	-	-	5.12
210	1.28	0.64	0.32	-	-	-	-	-	-	-	2.24
220	2.56	1.60	1.28	-	-	-	-	-	-	-	5.44
230	0.32	1.28	0.64	0.32	-	-	-	-	-	-	2.56
240	0.96	0.64	1.28	-	-	-	-	-	-	-	2.88
250	-	3.21	1.28	-	-	-	-	-	-	-	4.49
260	2.24	1.28	0.32	-	-	-	-	-	-	-	3.84
270	2.88	3.53	-	-	-	-	-	-	-	-	6.41
280	1.92	1.60	0.32	-	-	-	-	-	-	-	3.84
290	0.96	0.96	-	-	-	-	-	-	-	-	1.92
300	0.64	0.64	-	-	-	-	-	-	-	-	1.28
310	0.96	0.32	-	-	-	-	-	-	-	-	1.28
320	1.28	0.32	-	-	-	-	-	-	-	-	1.60
330	0.32	-	-	-	-	-	-	-	-	-	0.32
340	0.32	-	-	-	-	-	-	-	-	-	0.32
350	-	0.32	-	-	-	-	-	-	-	-	0.32
360	-	0.32	-	-	-	-	-	-	-	-	0.32
TOTAL	37.13	49.11	12.48	0.32	-	-	-	-	-	-	100.00

TABLE C-53

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 1 AU Date: 16 May 78 - 7 Jun 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10		-	-	-	-	-	-	-	-	-	-
20	-	0.46	0.46	0.09	-	-	-	-	-	-	1.01
30	0.28	2.13	1.93	0.46	-	-	-	-	-	-	4.80
40	0.09	2.03	3.50	1.01	0.18	-	-	-	-	-	6.81
50	2.58	3.13	6.63	3.22	0.37	0.18	-	-	-	-	16.11
60	1.66	6.49	3.97	3.41	1.57	1.57	1.75	0.09	-	-	20.51
70	-	1.29	1.93	3.32	1.10	0.92	-	-	-	-	8.56
80	0.55	1.47	1.29	0.18	0.18	0.37	0.09	-	-	-	4.13
90	0.18	0.64	0.09	0.09	-	-	-	-	-	-	1.00
100	0.64	0.55	0.18	-	-	-	-	-	-	-	1.37
110	0.74	1.57	0.28	-	-	-	-	-	-	-	2.59
120	2.49	1.20	0.37	-	-	-	-	-	-	-	4.06
130	0.09	0.09	-	-	-	-	-	-	-	-	0.18
140	0.28	-	-	-	-	-	-	-	-	-	0.28
150	0.09	-	-	-	-	-	-	-	-	-	0.09
160	0.09	-	-	-	-	-	-	-	-	-	0.09
170	0.09	-	-	-	-	-	-	-	-	-	0.09
180	4.14	1.75	0.09	-	-	-	-	-	-	-	5.98
190	8.20	2.30	0.09	-	-	-	-	-	-	-	10.59
200	0.09	-	-	-	-	-	-	-	-	-	0.09
210	0.09	-	-	-	-	-	-	-	-	-	0.09
220	0.09	-	-	-	-	-	-	-	-	-	0.09
230	0.18	-	-	-	-	-	-	-	-	-	0.18
240	0.18	-	-	-	-	-	-	-	-	-	0.18
250	-	-	-	-	-	-	-	-	-	-	-
260	0.28	-	-	-	-	-	-	-	-	-	0.28
270	0.09	-	-	-	-	-	-	-	-	-	0.09
280	3.78	2.67	0.09	-	-	-	-	-	-	-	6.54
290	0.83	0.18	0.09	-	-	-	-	-	-	-	1.10
300	-	-	-	-	-	-	-	-	-	-	-
310	0.28	-	-	-	-	-	-	-	-	-	0.28
320	0.18	0.64	0.09	-	-	-	-	-	-	-	0.91
330	0.18	-	-	-	-	-	-	-	-	-	0.18
340	-	0.18	0.09	-	-	-	-	-	-	-	0.27
350	0.37	-	0.37	-	-	-	-	-	-	-	0.74
360	0.09	0.46	0.18	-	-	-	-	-	-	-	0.73
TOTAL	28.90	29.23	21.72	11.78	3.40	3.04	1.84	0.09	-	-	

TABLE C-54

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 1 AL Date: 23 May 78 - 5 Jun 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-
30	0.16	0.79	1.74	0.47	-	-	-	-	-	-	3.16
40	-	1.10	5.04	1.26	0.16	0.16	-	-	-	-	7.72
50	-	1.42	5.84	3.93	2.21	0.79	0.47	-	-	-	14.66
60	0.16	1.88	4.89	3.47	5.35	0.79	0.32	-	-	-	16.86
70	-	1.57	2.21	1.10	0.79	0.95	-	-	-	-	6.62
80	0.16	1.42	0.94	1.42	-	-	-	-	-	-	3.94
90	1.10	0.79	0.16	-	-	-	-	-	-	-	2.05
100	1.26	2.37	-	-	-	-	-	-	-	-	3.63
110	-	-	-	-	-	-	-	-	-	-	-
120	-	-	-	-	-	-	-	-	-	-	-
130	-	-	-	-	-	-	-	-	-	-	-
140	17.67	3.47	-	-	-	-	-	-	-	-	21.14
150	0.32	0.16	0.16	-	-	-	-	-	-	-	0.64
160	-	-	-	-	-	-	-	-	-	-	-
170	0.16	-	0.16	-	-	-	-	-	-	-	0.32
180	-	-	-	-	-	-	-	-	-	-	-
190	-	0.47	-	-	-	-	-	-	-	-	0.47
200	0.16	0.16	0.32	-	-	-	-	-	-	-	0.64
210	-	-	-	-	-	-	-	-	-	-	-
220	-	-	-	-	-	-	-	-	-	-	-
230	-	-	-	-	-	-	-	-	-	-	-
240	-	-	-	-	-	-	-	-	-	-	-
250	-	-	-	-	-	-	-	-	-	-	-
260	-	-	-	-	-	-	-	-	-	-	-
270	-	-	-	-	-	-	-	-	-	-	-
280	0.16	-	-	-	-	-	-	-	-	-	0.16
290	-	-	-	-	-	-	-	-	-	-	-
300	-	-	-	-	-	-	-	-	-	-	-
310	-	-	-	-	-	-	-	-	-	-	-
320	-	-	-	-	-	-	-	-	-	-	-
330	-	0.16	-	-	-	-	-	-	-	-	0.16
340	0.16	-	-	-	-	-	-	-	-	-	0.16
350	12.78	4.67	-	-	-	-	-	-	-	-	17.35
360	0.32	-	-	-	-	-	-	-	-	-	0.32
TOTAL	34.57	20.33	21.46	11.65	8.51	2.69	0.79	-	-	-	

401

TABLE C-55

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 AU Date: 16 May 78 - 6 Jun 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	0.10	-	-	-	-	-	-	-	-	-	0.10
20	0.19	0.29	-	-	-	-	-	-	-	-	0.48
30	0.77	1.34	1.05	1.05	0.19	-	-	-	-	-	4.40
40	5.16	6.41	2.49	0.48	0.38	0.10	-	-	-	-	15.02
50	3.54	4.12	5.66	11.58	2.97	0.57	0.10	-	-	-	28.53
60	4.50	1.44	2.97	2.78	3.83	1.15	0.29	-	-	-	16.96
70	3.45	1.44	1.72	1.15	1.25	0.10	-	0.10	-	-	9.21
80	0.29	0.29	0.19	0.96	0.19	-	-	-	-	-	1.92
90	0.57	-	-	0.10	-	-	-	-	-	-	0.67
100	0.19	0.10	-	-	-	-	-	-	-	-	0.29
110	0.19	-	-	-	-	-	-	-	-	-	0.19
120	-	-	-	-	-	-	-	-	-	-	-
130	0.10	-	-	-	-	-	-	-	-	-	0.10
140	0.10	-	-	-	-	-	-	-	-	-	0.10
150	0.10	-	-	-	-	-	-	-	-	-	0.10
160	-	-	-	-	-	-	-	-	-	-	-
170	-	-	-	-	-	-	-	-	-	-	-
180	0.10	0.10	-	-	-	-	-	-	-	-	0.20
190	-	-	-	-	-	-	-	-	-	-	-
200	0.86	-	-	-	-	-	-	-	-	-	0.86
210	0.10	0.10	-	-	-	-	-	-	-	-	0.20
220	0.38	0.19	-	-	-	-	-	-	-	-	0.57
230	0.67	0.19	-	-	-	-	-	-	-	-	0.86
240	2.20	0.77	-	-	-	-	-	-	-	-	2.97
250	1.34	0.48	-	-	-	-	-	-	-	-	1.82
260	0.67	0.10	0.10	-	-	-	-	-	-	-	0.87
270	0.48	0.38	-	-	-	-	-	-	-	-	0.86
280	0.38	0.29	0.19	-	-	-	-	-	-	-	0.86
290	0.29	0.19	0.10	-	-	-	-	-	-	-	0.58
300	0.38	0.38	-	-	-	-	-	-	-	-	0.76
310	0.19	0.57	-	-	-	-	-	-	-	-	0.76
320	0.86	0.67	-	-	-	-	-	-	-	-	1.53
330	0.86	0.48	-	-	-	-	-	-	-	-	1.34
340	2.68	0.86	0.29	-	-	-	-	-	-	-	3.83
350	1.15	0.38	0.19	-	-	-	-	-	-	-	1.72
360	0.38	0.86	0.10	-	-	-	-	-	-	-	1.34
TOTAL	33.22	22.42	15.04	18.10	8.81	1.92	0.39	0.10	-	-	

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TABLE C-56

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 AL Date: 16 May 78 - 6 Jun 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	0.19	0.19	-	-	-	-	-	-	-	-	0.38
20	0.10	0.59	0.97	0.10	0.19	-	-	-	-	-	1.95
30	0.77	1.65	2.19	0.87	0.49	0.10	-	-	-	-	6.07
40	2.12	3.37	2.22	0.67	0.29	0.19	-	-	-	-	8.86
50	7.41	6.75	4.92	2.04	-	0.38	-	-	-	-	21.50
60	4.52	1.84	2.03	0.67	0.10	-	-	-	-	-	9.16
70	1.26	1.26	0.30	-	-	-	-	-	-	-	2.82
80	12.99	2.19	-	-	-	-	-	-	-	-	15.18
90	4.04	1.25	0.19	-	-	-	-	-	-	-	5.48
100	0.10	-	-	-	-	-	-	-	-	-	0.10
110	-	-	-	-	-	-	-	-	-	-	-
120	-	-	-	-	-	-	-	-	-	-	-
130	4.15	-	-	-	-	-	-	-	-	-	4.15
140	3.56	-	-	-	-	-	-	-	-	-	3.56
150	0.58	-	-	-	-	-	-	-	-	-	0.58
160	7.51	0.67	0.10	-	-	-	-	-	-	-	8.28
170	0.38	-	-	-	-	-	-	-	-	-	0.38
180	0.29	-	-	-	-	-	-	-	-	-	0.29
190	0.19	-	-	-	-	-	-	-	-	-	0.19
200	0.19	-	-	-	-	-	-	-	-	-	0.19
210	-	-	-	-	-	-	-	-	-	-	-
220	-	-	-	-	-	-	-	-	-	-	-
230	-	-	-	-	-	-	-	-	-	-	-
240	0.10	-	-	-	-	-	-	-	-	-	0.10
250	-	-	-	-	-	-	-	-	-	-	-
260	-	-	-	-	-	-	-	-	-	-	-
270	-	-	-	-	-	-	-	-	-	-	-
280	-	-	-	-	-	-	-	-	-	-	-
290	0.10	-	-	-	-	-	-	-	-	-	0.10
300	-	-	-	-	-	-	-	-	-	-	-
310	-	-	-	-	-	-	-	-	-	-	-
320	0.19	0.19	-	-	-	-	-	-	-	-	0.38
330	-	0.19	0.10	-	-	-	-	-	-	-	0.29
340	0.19	0.19	0.10	-	-	-	-	-	-	-	0.48
350	0.19	0.58	0.67	0.10	-	-	-	-	-	-	1.54
360	-	1.15	3.56	3.18	0.10	-	-	-	-	-	7.99
TOTAL	51.12	22.06	17.35	7.63	1.17	0.67	-	-	-	-	

TABLE C-57

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 BU Date: 16 May 78 - 6 Jun 78

Direction	Speed (m/sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	Total
10	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-	-
30	0.10	0.29	0.10	0.96	1.25	0.38	0.10	-	-	-	-	3.18
40	0.10	0.50	1.25	2.59	1.82	0.50	0.10	-	-	-	-	6.86
50	0.38	2.79	4.60	3.54	3.36	5.56	1.05	0.10	-	-	-	21.38
60	0.10	2.68	3.06	2.49	4.03	6.23	4.41	3.45	2.21	1.15	0.10	29.91
70	0.29	0.58	3.26	2.30	1.92	1.92	0.58	0.96	0.96	0.29	0.10	13.16
80	0.19	2.21	1.63	0.58	0.50	-	-	-	-	-	-	5.11
90	-	0.29	0.29	0.10	-	-	-	-	-	-	-	0.68
100	-	0.50	0.38	-	-	-	-	-	-	-	-	0.88
110	0.19	0.50	0.29	-	-	-	-	-	-	-	-	0.98
120	1.73	1.34	0.19	-	-	-	-	-	-	-	-	3.26
130	0.19	0.77	-	-	-	-	-	-	-	-	-	0.96
140	5.66	5.94	-	0.10	-	-	-	-	-	-	-	11.60
150	0.29	-	-	-	-	-	-	-	-	-	-	0.29
160	-	-	-	-	-	-	-	-	-	-	-	-
170	-	-	-	-	-	-	-	-	-	-	-	-
180	0.10	-	-	-	-	-	-	-	-	-	-	0.10
190	-	-	-	-	-	-	-	-	-	-	-	-
200	0.10	-	-	-	-	-	-	-	-	-	-	0.10
210	-	-	-	-	-	-	-	-	-	-	-	-
220	-	-	-	-	-	-	-	-	-	-	-	-
230	-	-	-	-	-	-	-	-	-	-	-	-
240	-	-	-	-	-	-	-	-	-	-	-	-
250	-	-	-	-	-	-	-	-	-	-	-	-
260	-	-	-	-	-	-	-	-	-	-	-	-
270	-	-	-	-	-	-	-	-	-	-	-	-
280	0.10	-	-	-	-	-	-	-	-	-	-	0.10
290	0.19	0.29	0.10	-	-	-	-	-	-	-	-	0.58
300	0.19	-	-	-	-	-	-	-	-	-	-	0.19
310	0.10	0.10	-	-	-	-	-	-	-	-	-	0.20
320	0.38	-	-	-	-	-	-	-	-	-	-	0.38
330	-	-	-	-	-	-	-	-	-	-	-	-
340	0.10	-	-	-	-	-	-	-	-		-	0.10
350	-	-	-	-	-	-	-	-	-	-	-	-
360	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	10.48	18.78	15.15	12.56	12.88	14.59	6.24	4.51	3.17	1.44	0.20	

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TABLE C-58

FREQUENCY DISTRIBUTION OF CURRENT SPEED AND DIRECTION

Meter: 2 BL Date: 16 May 78 - 31 May 78

Direction	Speed (m /sec x 10^{-2}) 0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
10	-	-	-	-	-	-	-	-	-	-	-
20	-	-	0.13	0.13	-	-	-	-	-	-	0.26
30	-	0.66	-	-	-	-	-	-	-	-	0.66
40	-	0.93	0.80	1.34	0.40	-	-	-	-	-	3.47
50	-	0.80	1.07	0.80	0.40	-	-	-	-	-	3.07
60	-	0.93	2.66	0.93	0.66	0.40	22.6	1.46	0.40	-	9.70
70	1.33	4.41	4.26	1.46	0.53	-	2.39	0.93	0.53	-	15.84
80	2.80	7.71	6.53	2.26	0.13	-	-	-	-	-	19.43
90	3.46	9.57	5.99	1.34	0.40	-	-	-	-	-	20.76
100	0.66	1.60	0.40	0.13	-	-	-	-	-	-	2.79
110	0.13	0.13	-	-	-	-	-	-	-	-	0.26
120	0.13	0.27	-	-	-	-	-	-	-	-	0.40
130	0.40	0.27	-	-	-	-	-	-	-	-	0.67
140	0.66	1.33	0.53	-	-	-	-	-	-	-	2.52
150	0.27	-	-	-	-	-	-	-	-	-	0.27
160	-	0.13	-	-	-	-	-	-	-	-	0.13
170	-	-	-	-	-	-	-	-	-	-	-
180	0.40	0.27	-	-	-	-	-	-	-	-	0.67
190	0.13	0.13	0.13	-	0.13	-	-	-	-	-	0.52
200	0.13	1.20	0.27	0.53	0.13	-	-	-	-	-	2.26
210	0.40	1.46	0.27	-	-	-	-	-	-	-	2.13
220	1.46	2.79	0.66	0.13	0.13	-	-	-	-	-	5.17
230	1.06	0.53	-	-	-	-	-	-	-	-	1.59
240	0.27	-	0.13	-	0.13	-	-	-	-	-	0.53
250	0.40	0.53	-	0.27	0.13	-	-	-	-	-	1.33
260	1.60	1.74	0.13	0.27	-	-	-	-	-	-	3.74
270	-	0.27	0.13	-	-	-	-	-	-	-	0.40
280	-	0.13	-	-	-	-	-	-	-	-	0.13
290	-	-	-	0.13	0.13	-	-	-	-	-	0.26
300	-	0.13	-	0.13	-	-	-	-	-	-	0.26
310	-	-	-	-	-	-	-	-	-	-	-
320	0.13	-	0.13	-	-	-	-	-	-	-	0.26
330	-	-	-	-	-	-	-	-	-	-	-
340	-	0.13	0.13	-	-	-	-	-	-	-	0.26
350	-	0.13	-	-	-	-	-	-	-	-	0.13
360	-	0.13	-	-	-	-	-	-	-	-	0.13
TOTAL	15.82	38.31	24.35	9.85	3.30	0.40	4.65	2.39	0.93	-	

441

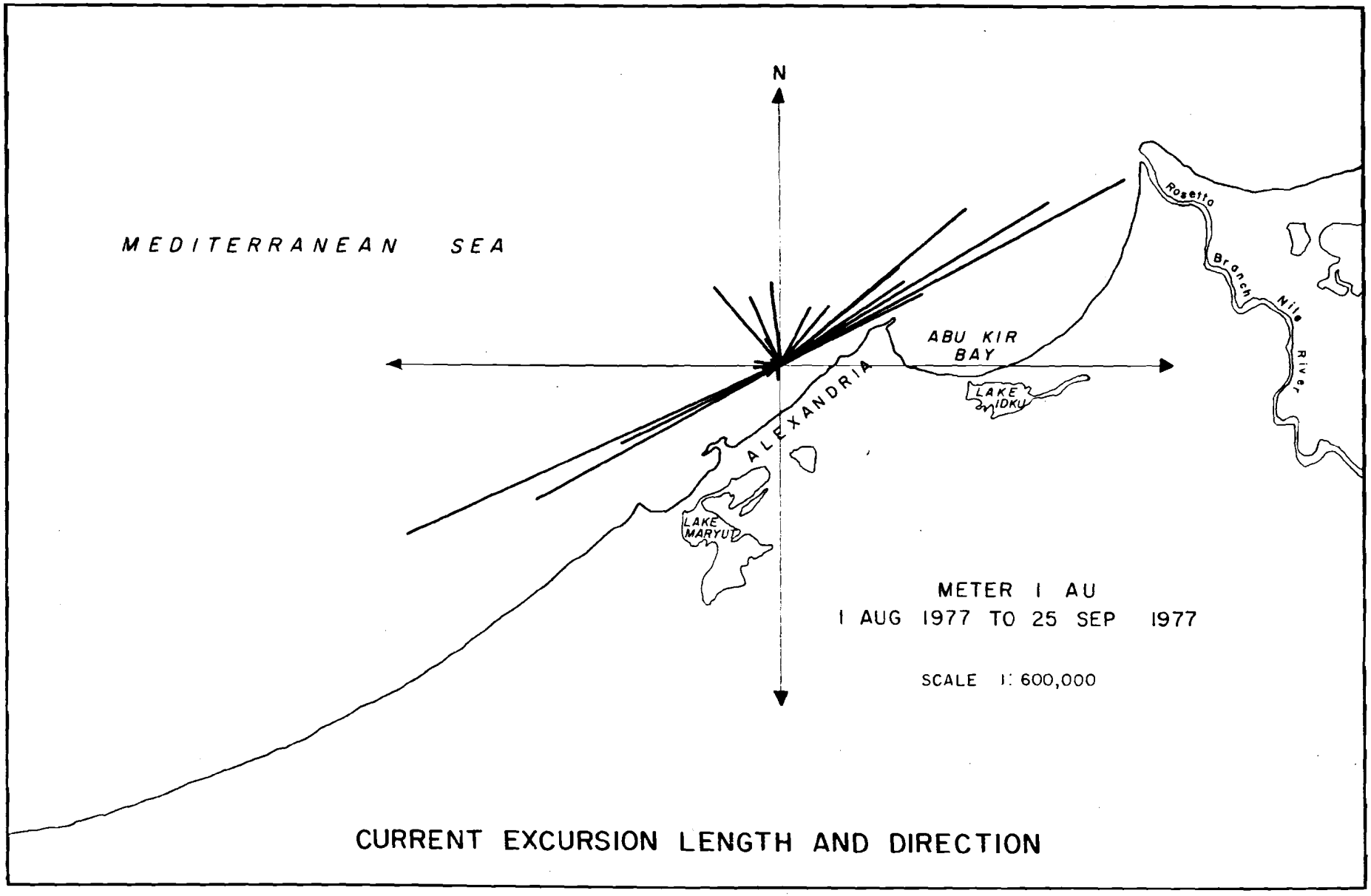


FIGURE C-1

CURRENT EXCURSION LENGTH AND DIRECTION

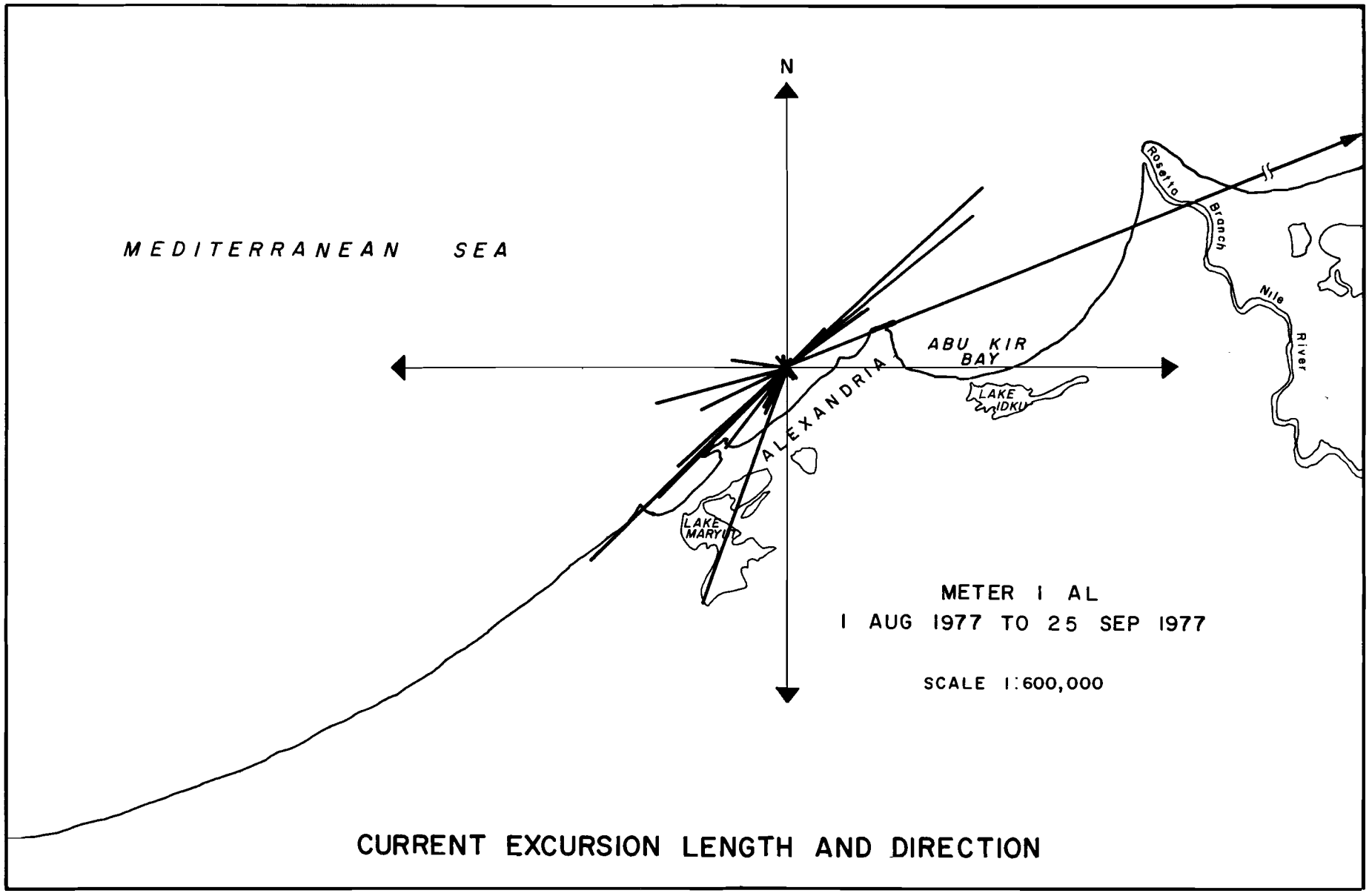


FIGURE C-2

CURRENT EXCURSION LENGTH AND DIRECTION

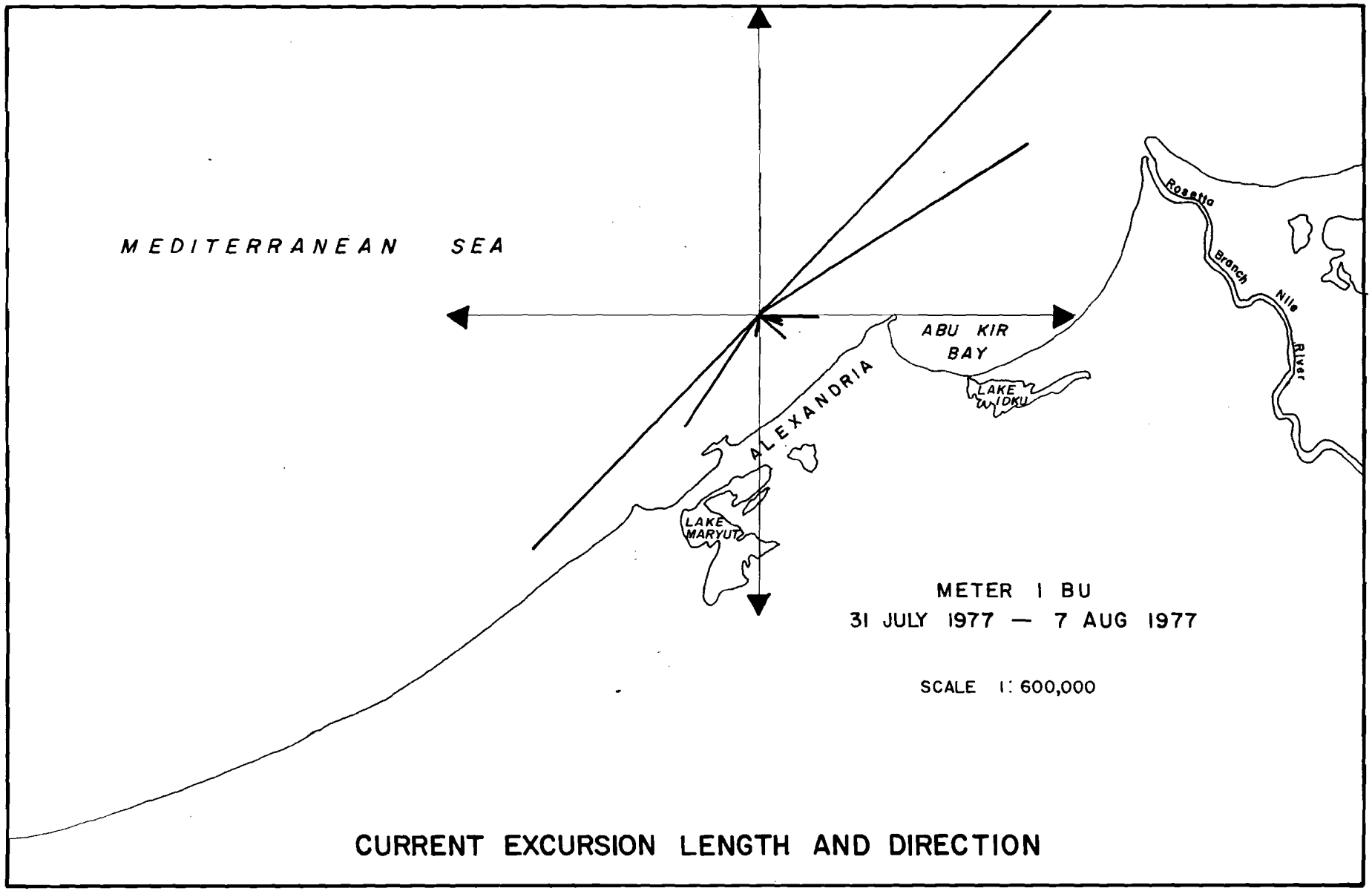
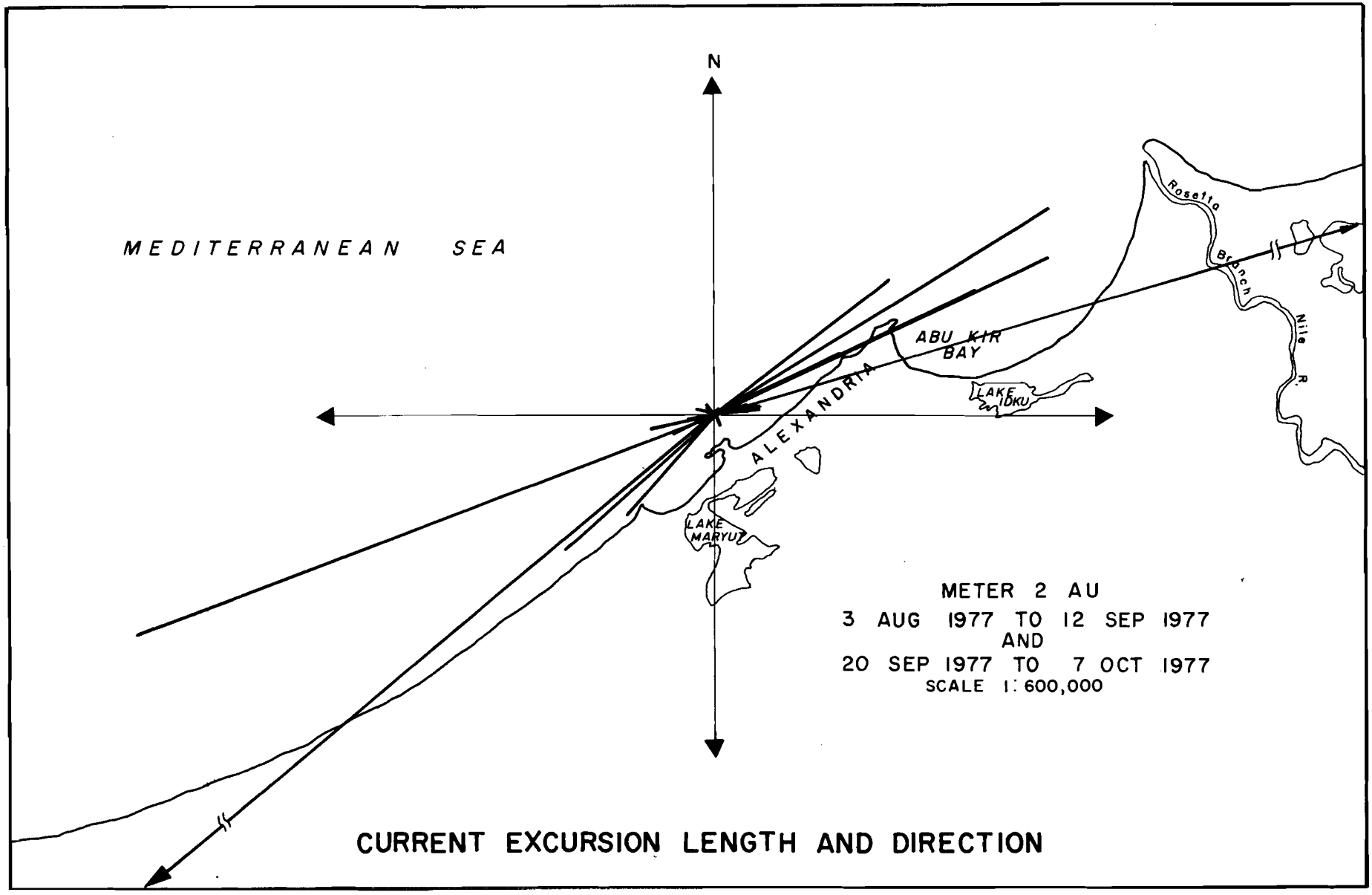


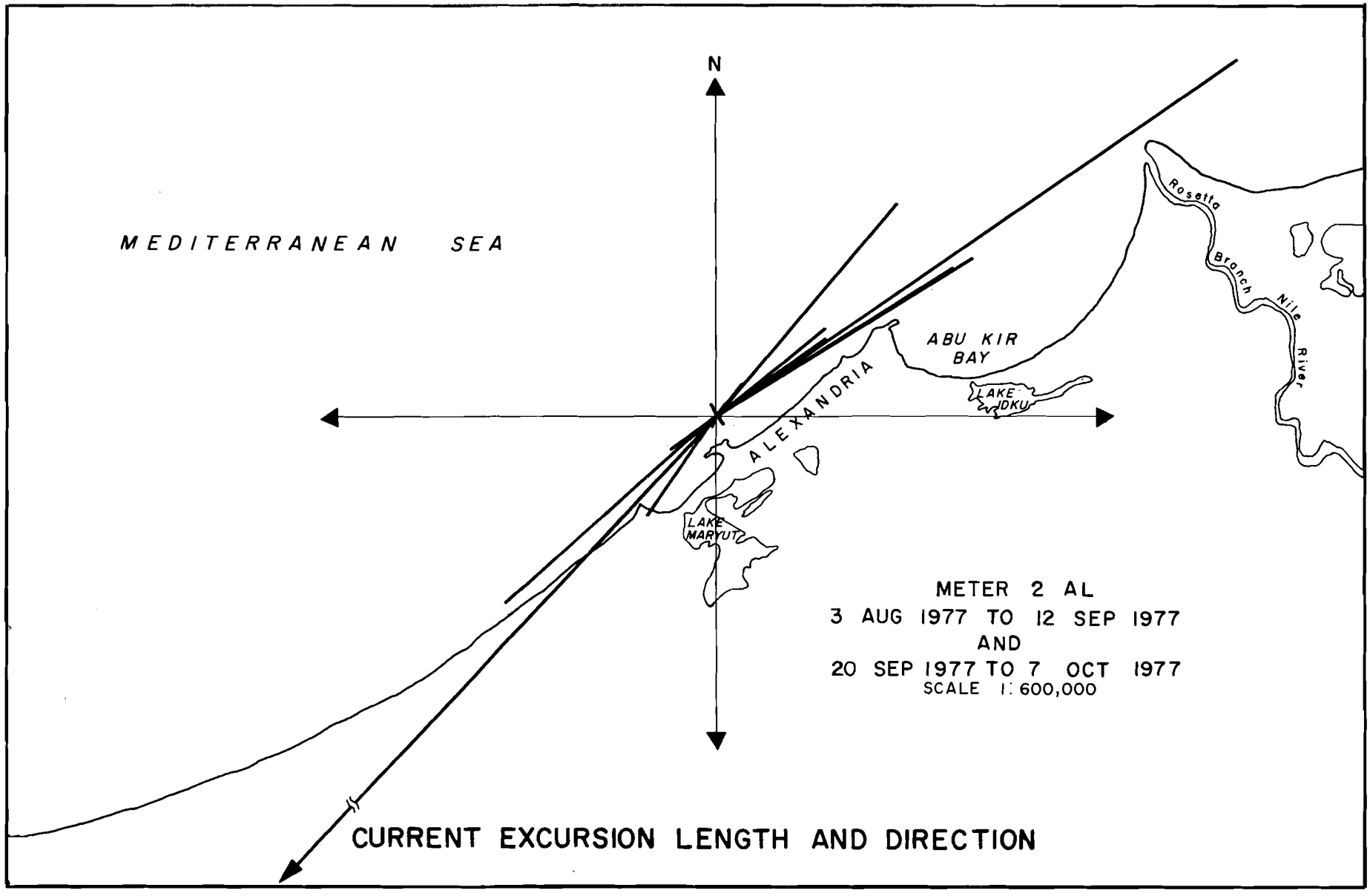
FIGURE C - 3

CURRENT EXCURSION LENGTH AND DIRECTION



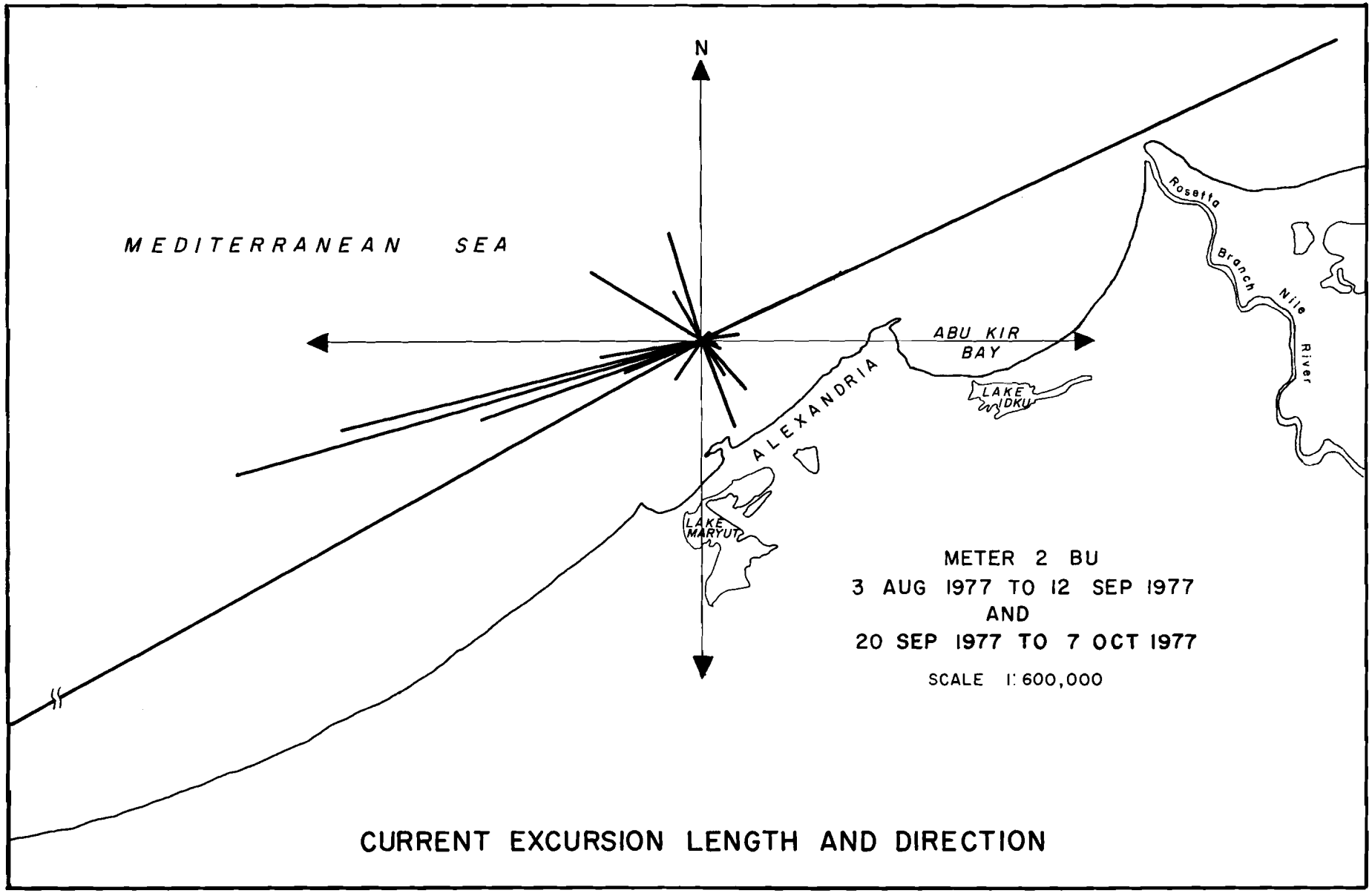
CURRENT EXCURSION LENGTH AND DIRECTION

FIGURE C-4



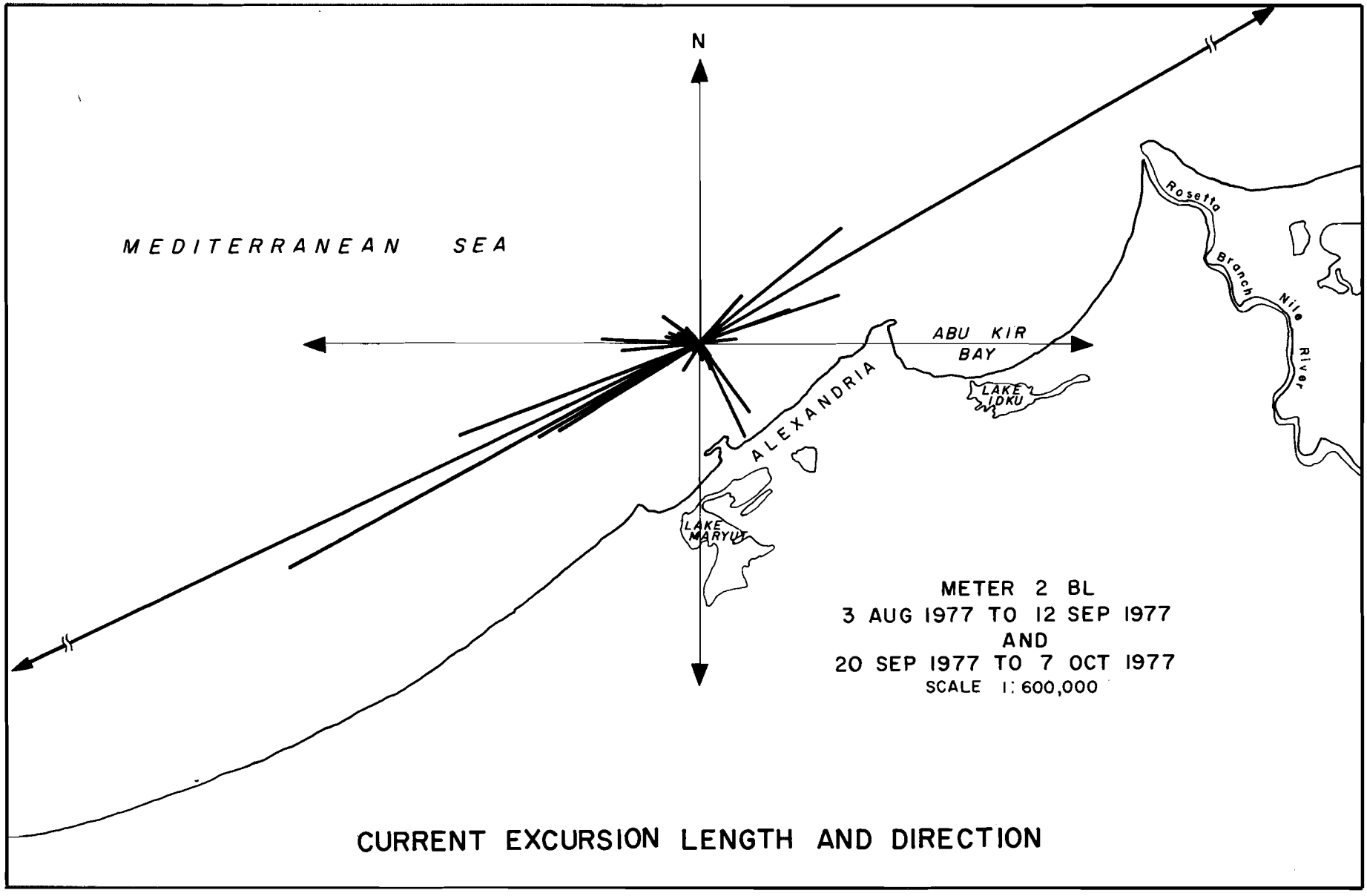
CURRENT EXCURSION LENGTH AND DIRECTION

FIGURE C-5



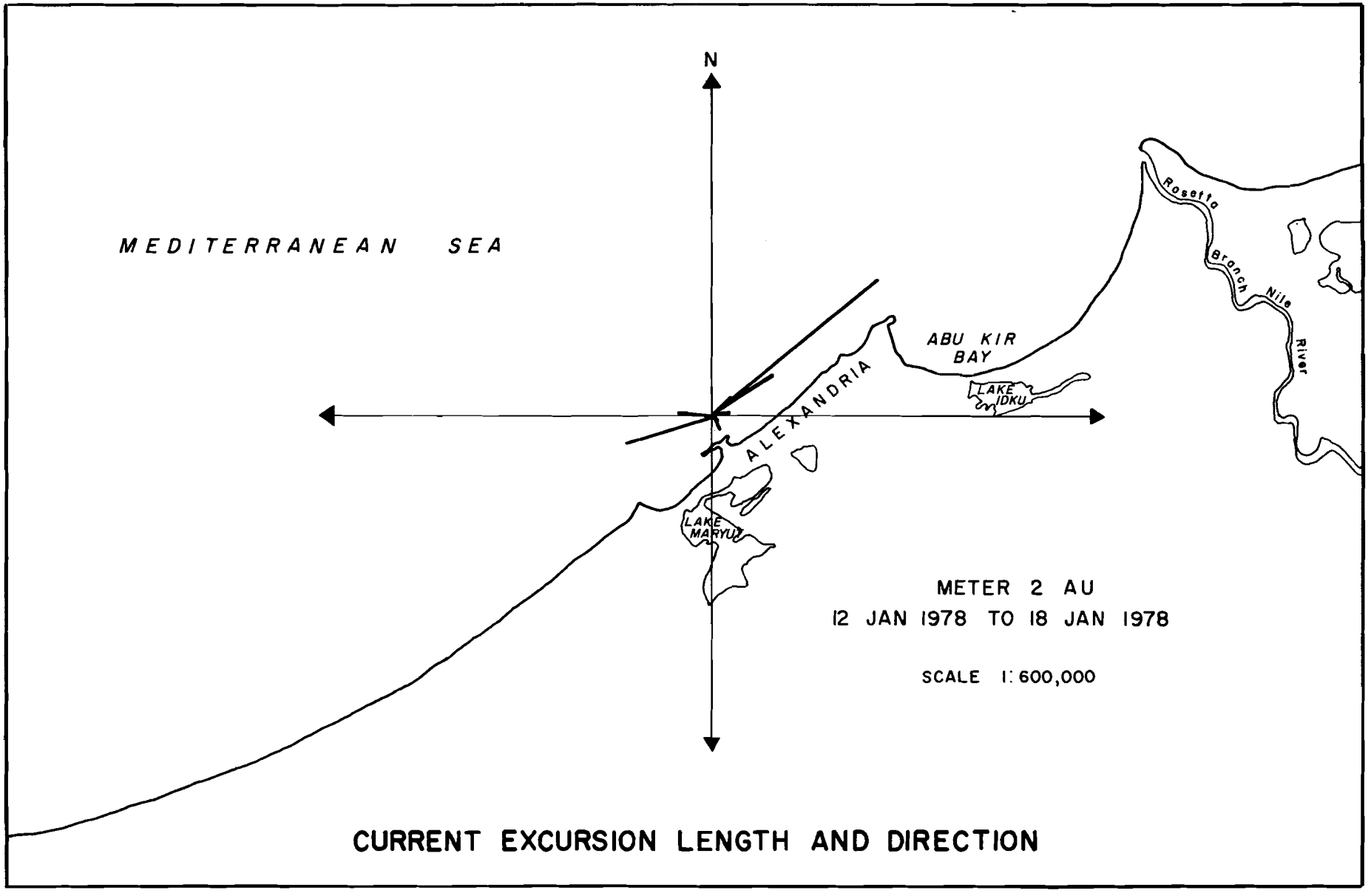
CURRENT EXCURSION LENGTH AND DIRECTION

FIGURE C-6



CURRENT EXCURSION LENGTH AND DIRECTION

FIGURE C-7



CURRENT EXCURSION LENGTH AND DIRECTION

FIGURE C-8

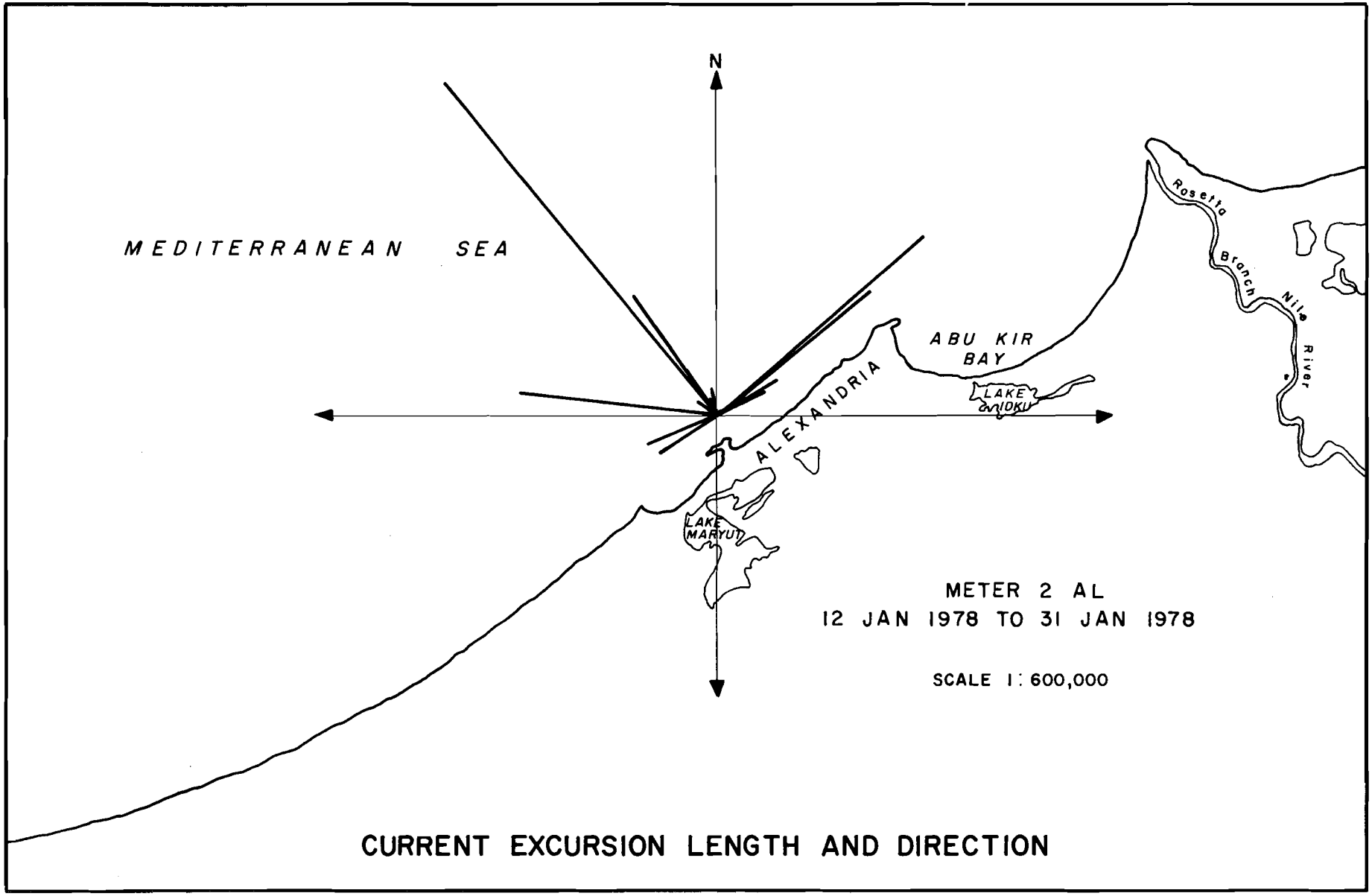
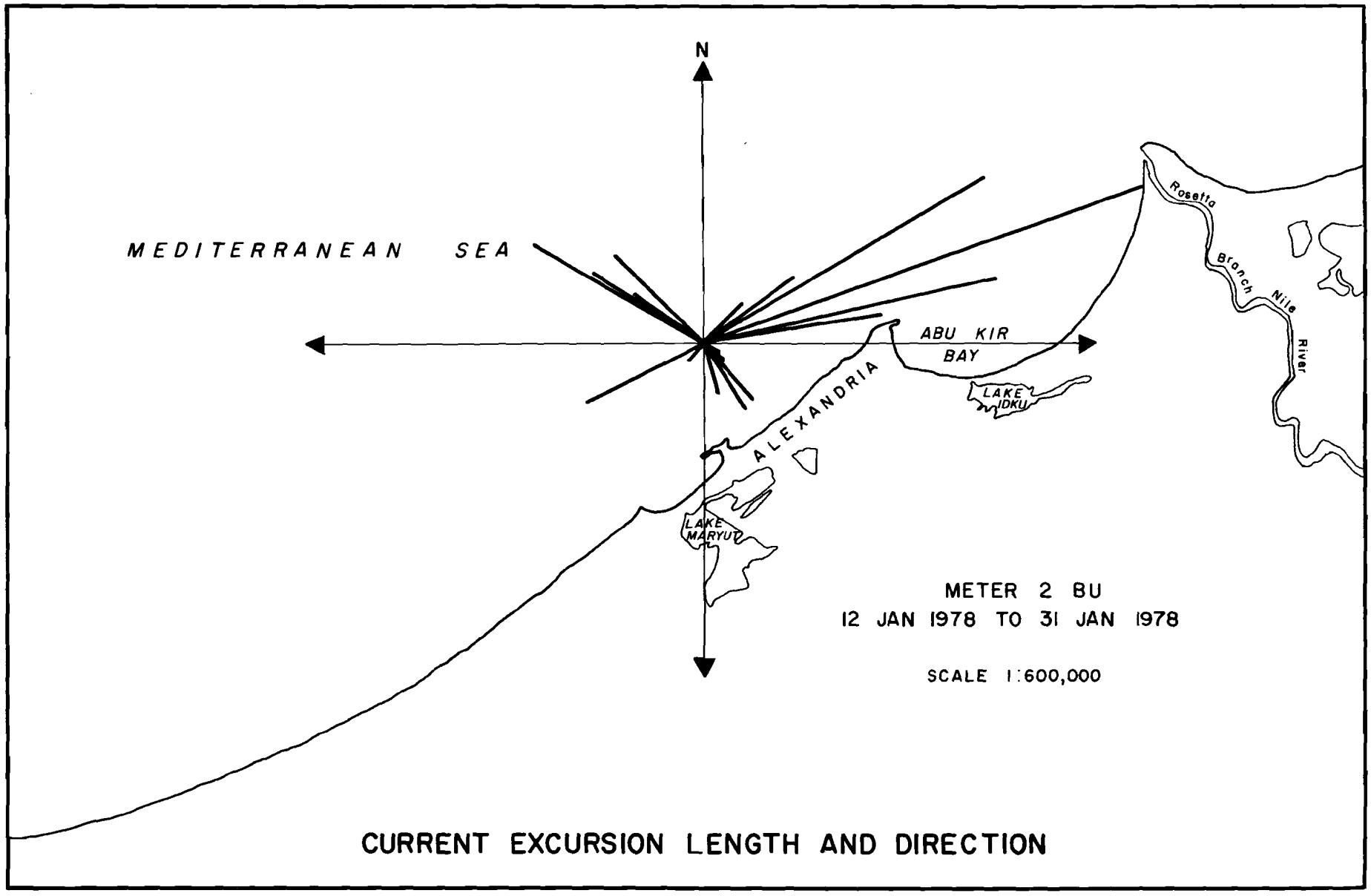


FIGURE C-9

CURRENT EXCURSION LENGTH AND DIRECTION



CURRENT EXCURSION LENGTH AND DIRECTION

FIGURE C-10

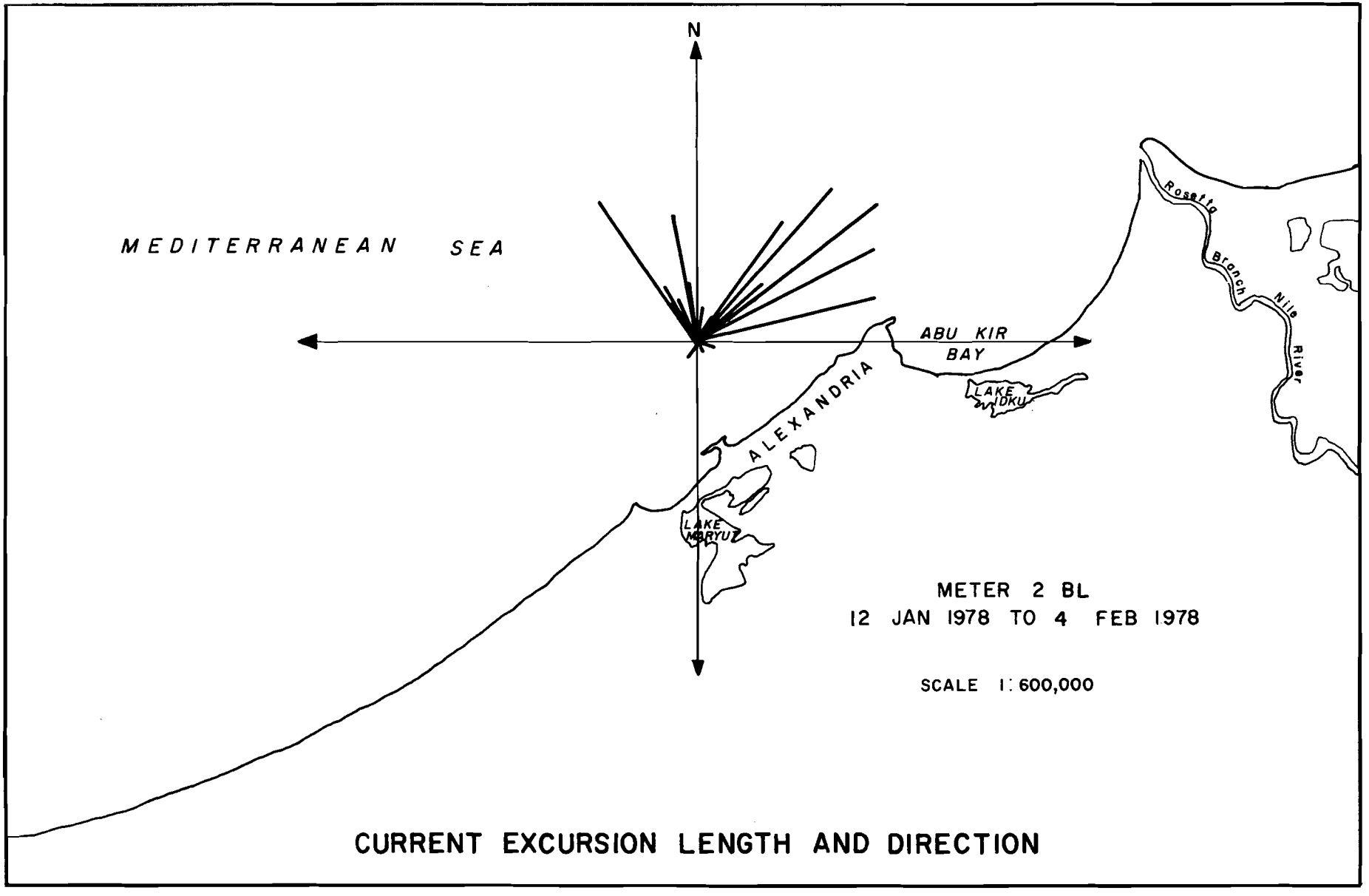
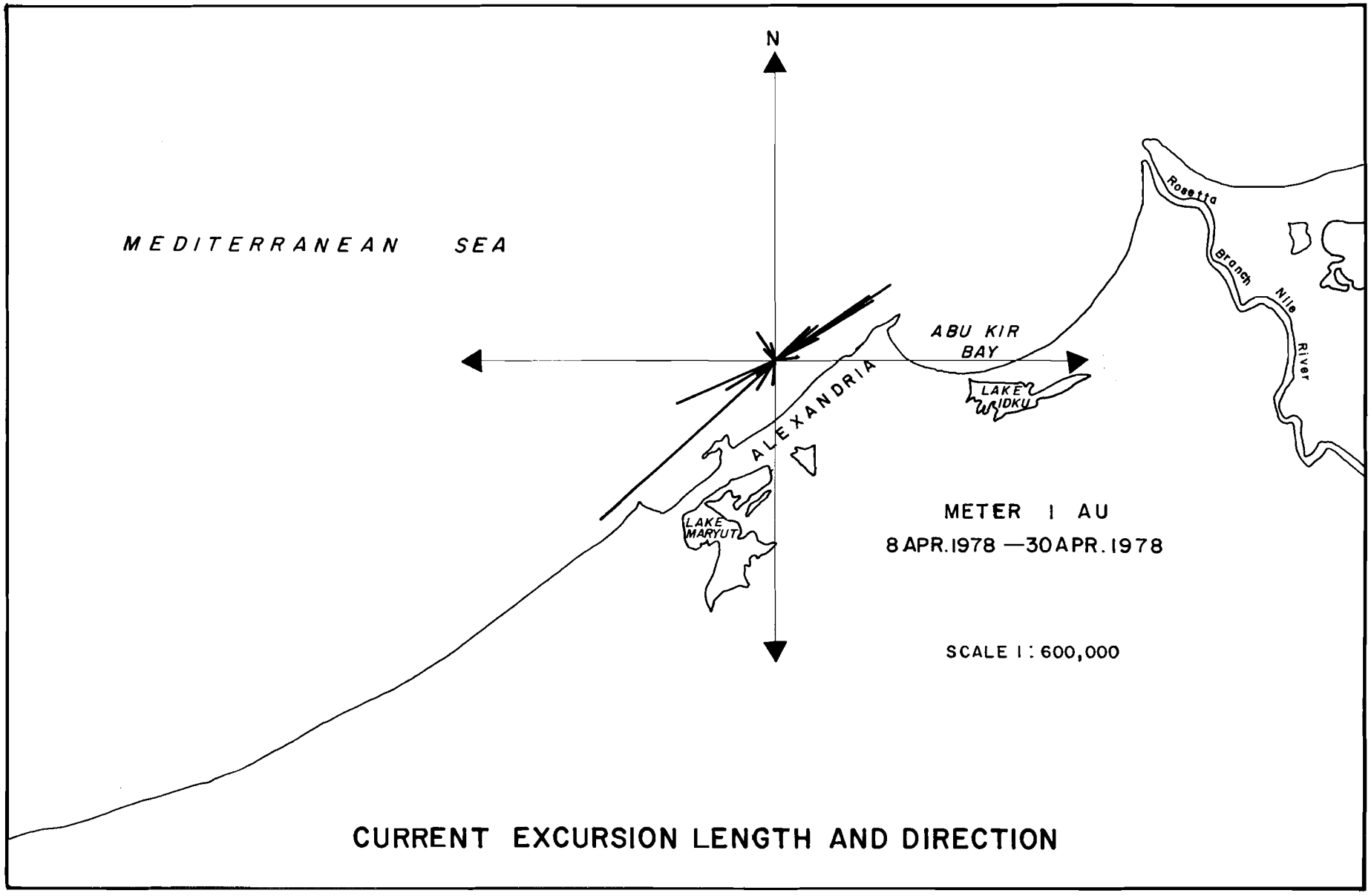


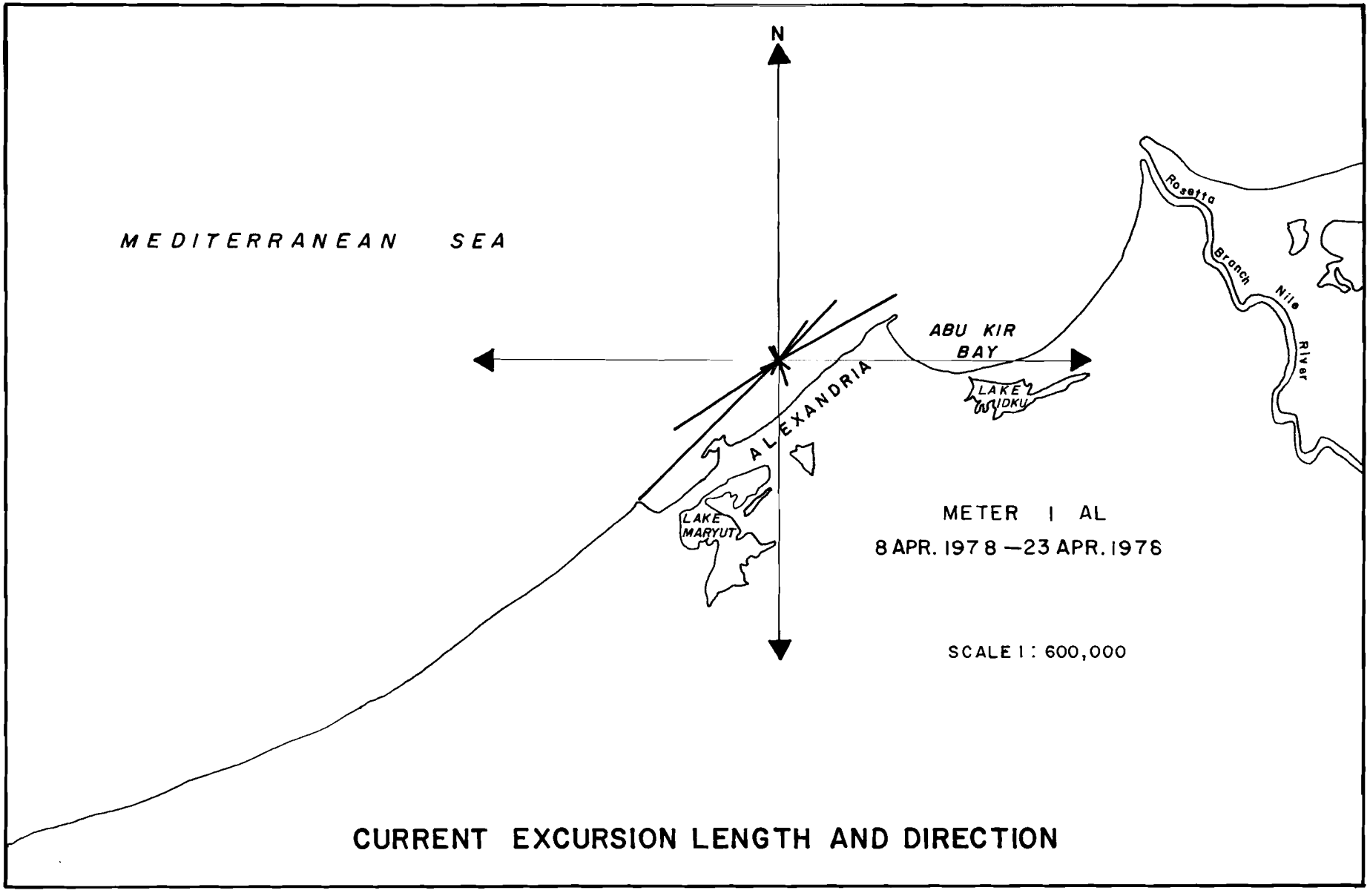
FIGURE C-11

CURRENT EXCURSION LENGTH AND DIRECTION



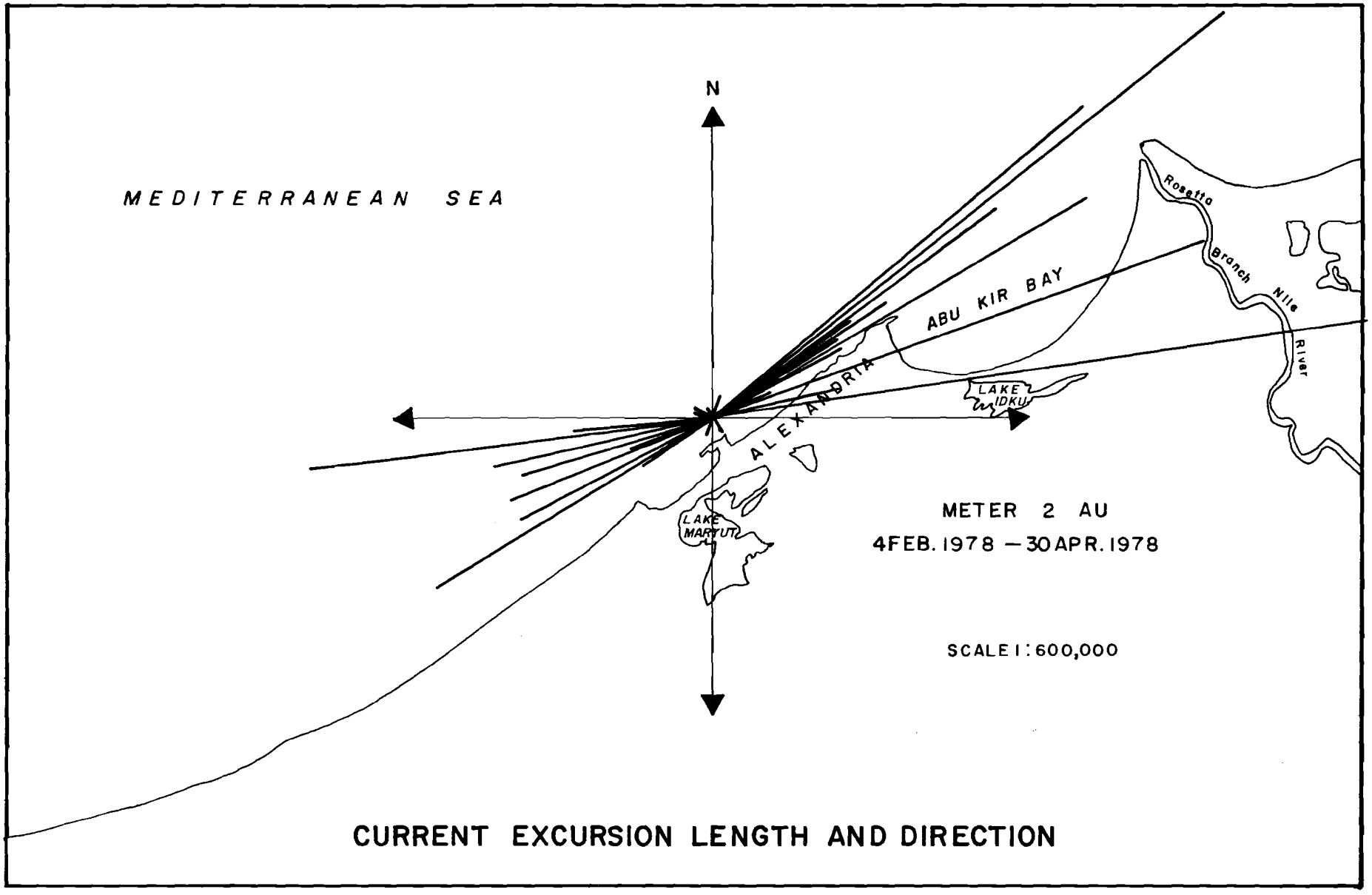
CURRENT EXCURSION LENGTH AND DIRECTION

FIGURE C-12



CURRENT EXCURSION LENGTH AND DIRECTION

FIGURE C-13



CURRENT EXCURSION LENGTH AND DIRECTION

FIGURE C-14

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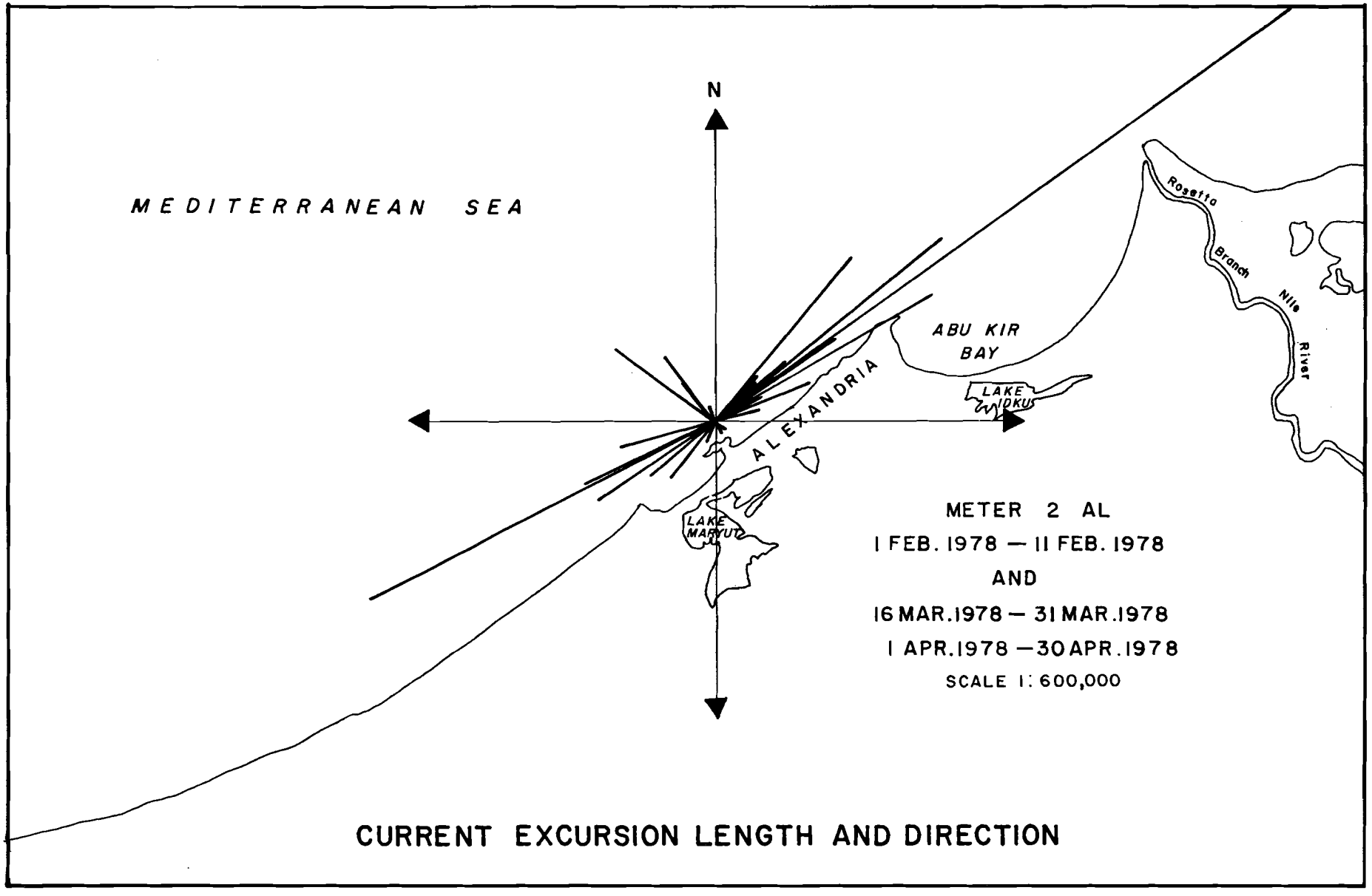
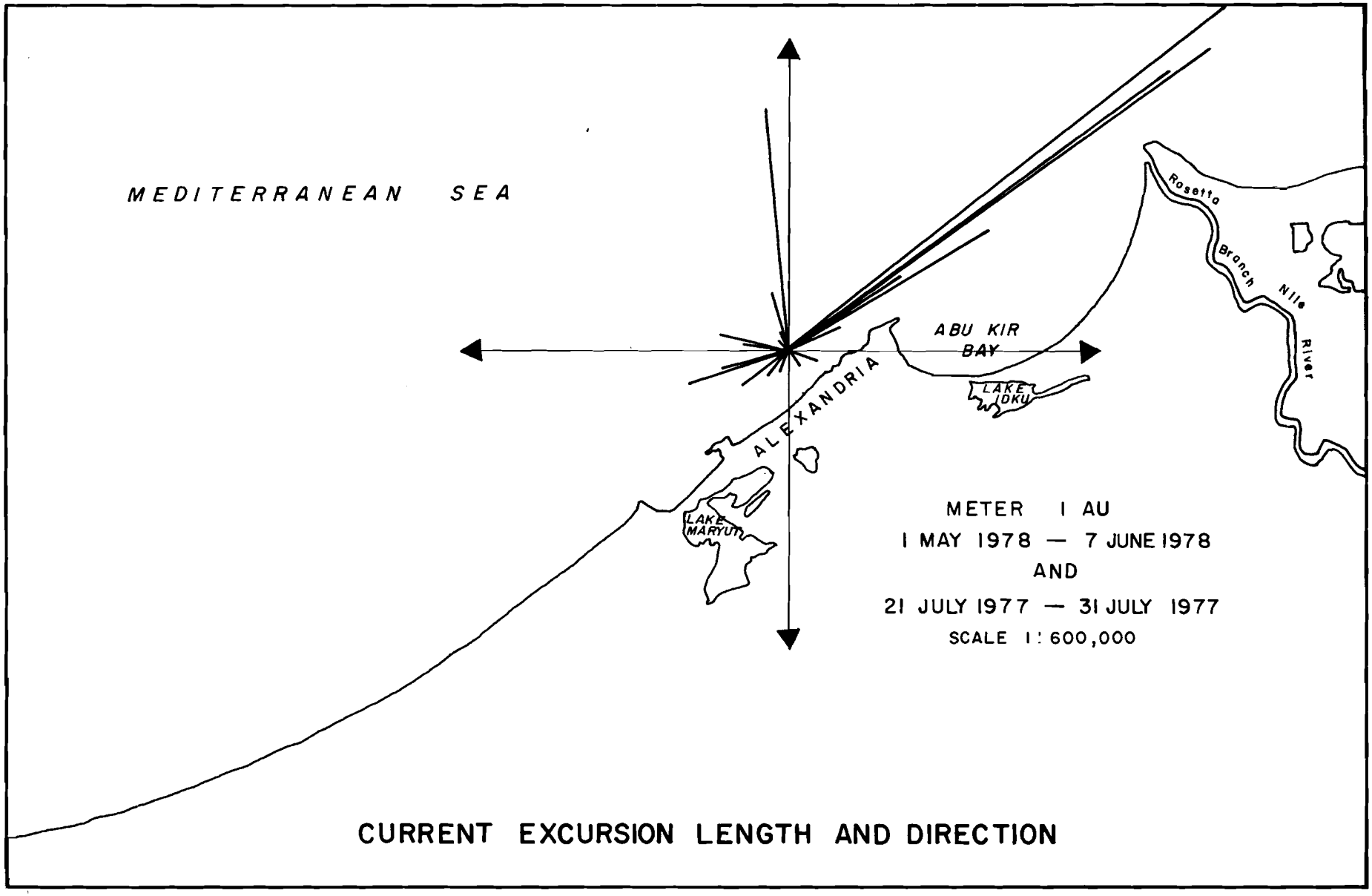


CURRENT EXCURSION LENGTH AND DIRECTION

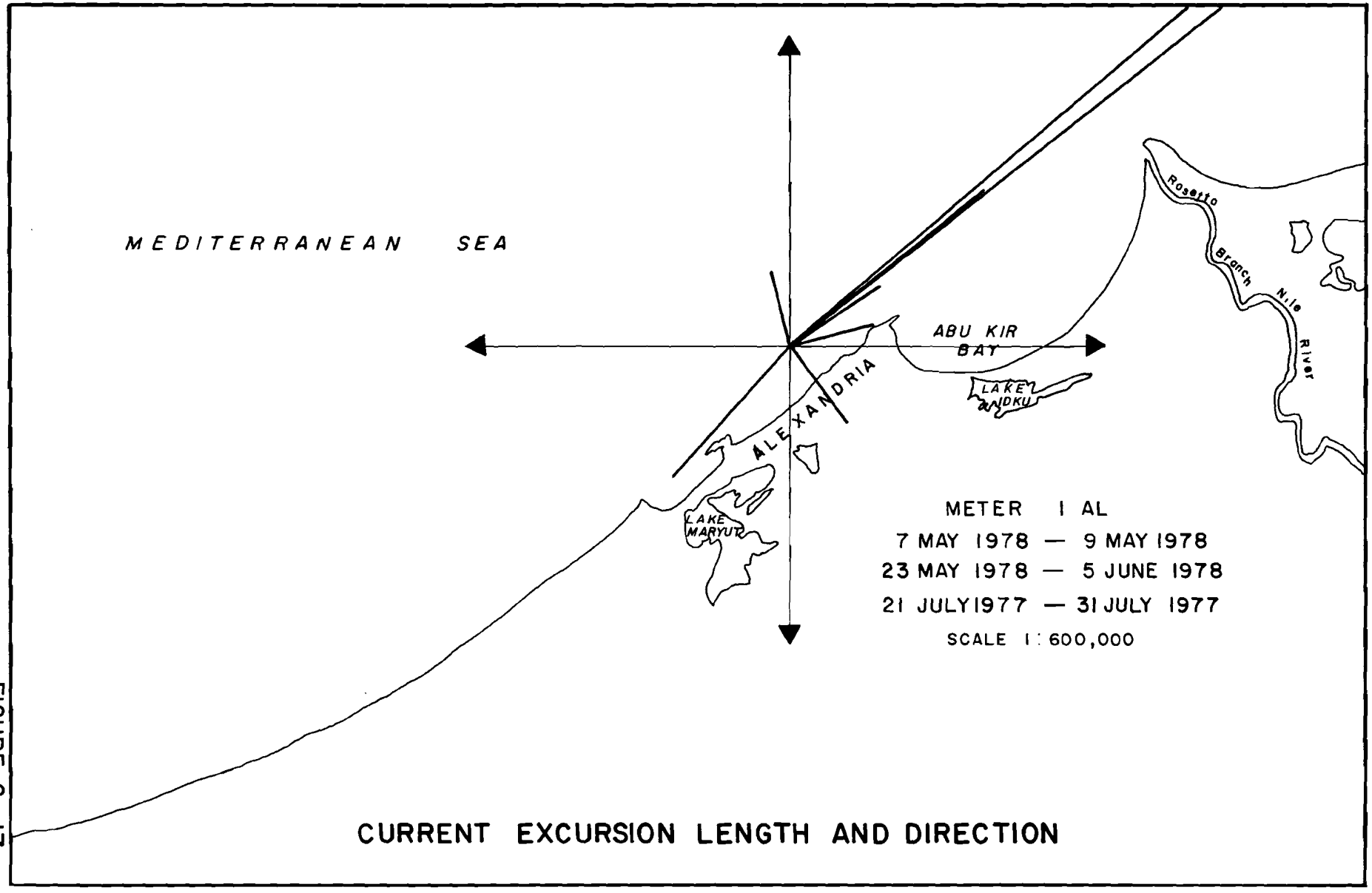
FIGURE C-15

436



CURRENT EXCURSION LENGTH AND DIRECTION

FIGURE C-16



CURRENT EXCURSION LENGTH AND DIRECTION

FIGURE C-17

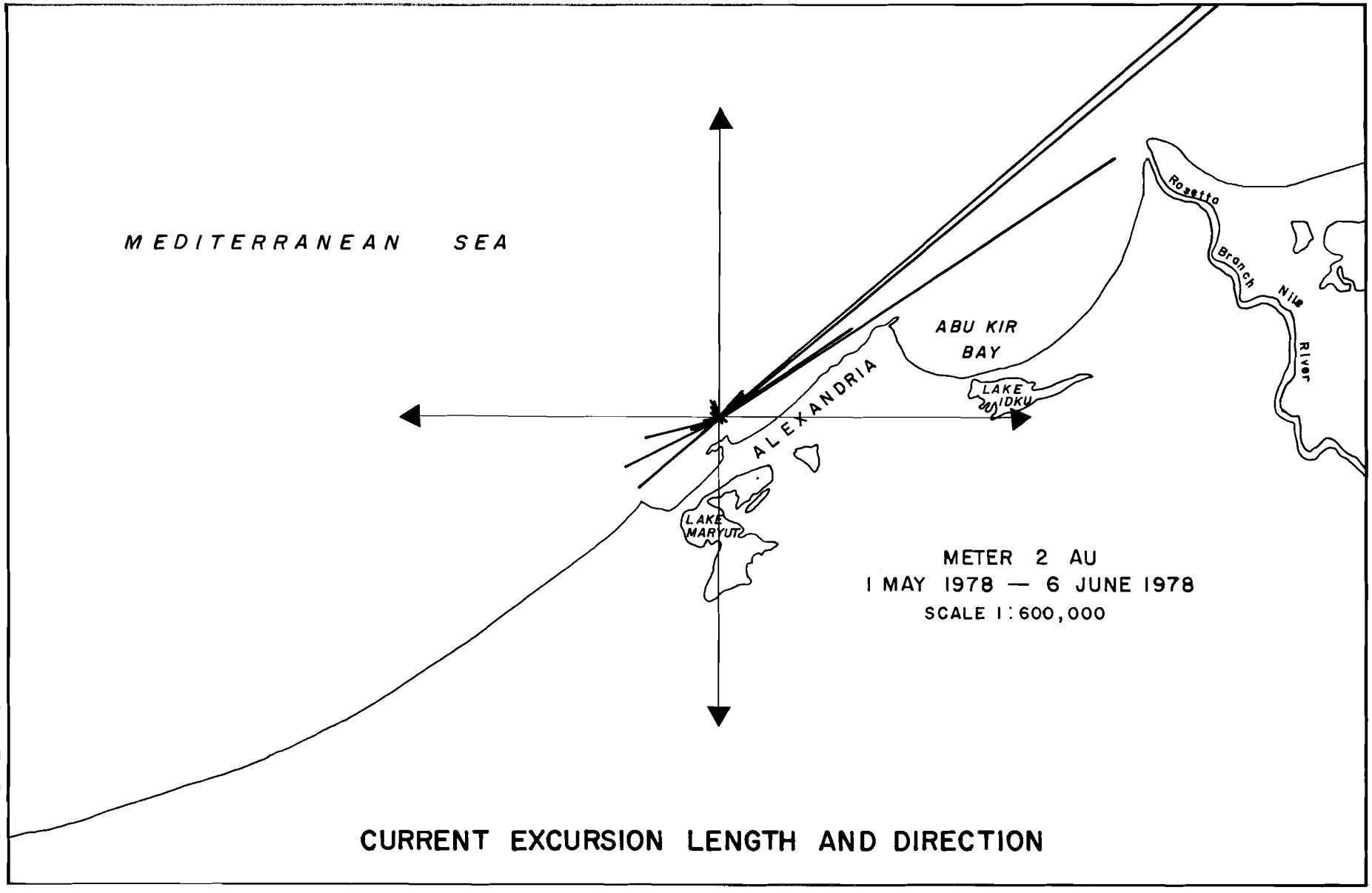
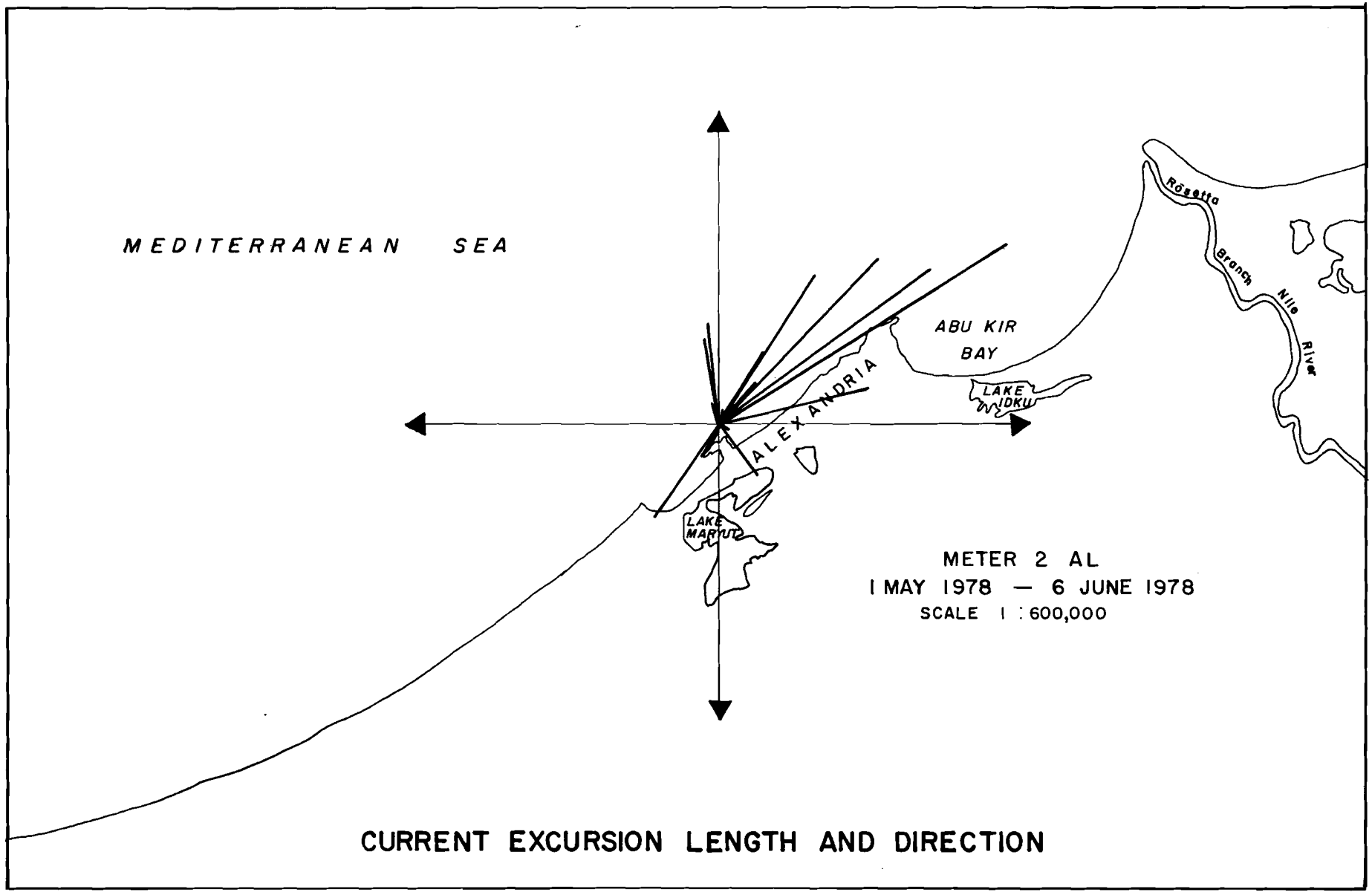


FIGURE C-18

CURRENT EXCURSION LENGTH AND DIRECTION



CURRENT EXCURSION LENGTH AND DIRECTION

FIGURE C-19

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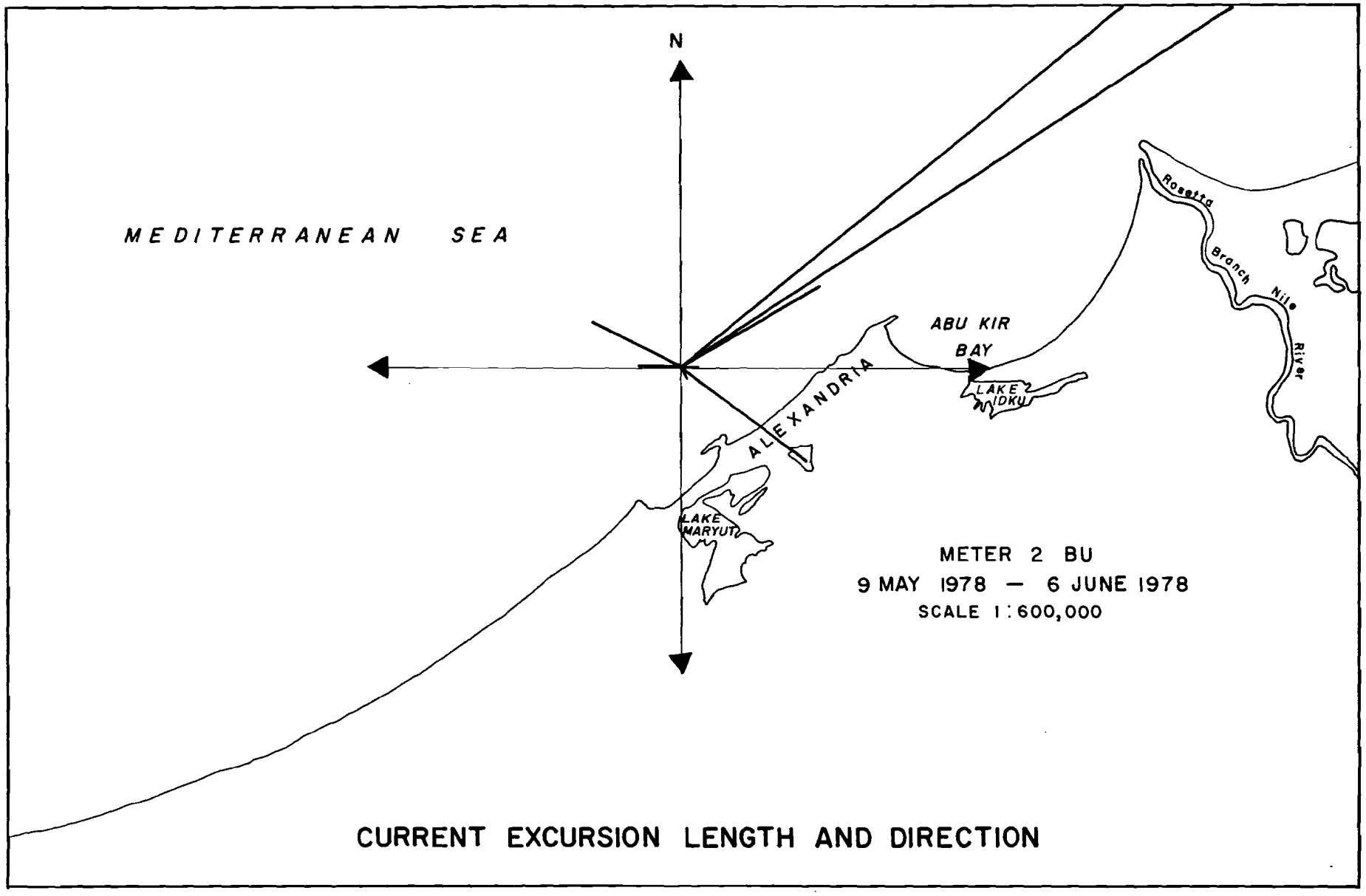

CURRENT EXCURSION LENGTH AND DIRECTION

FIGURE C-20

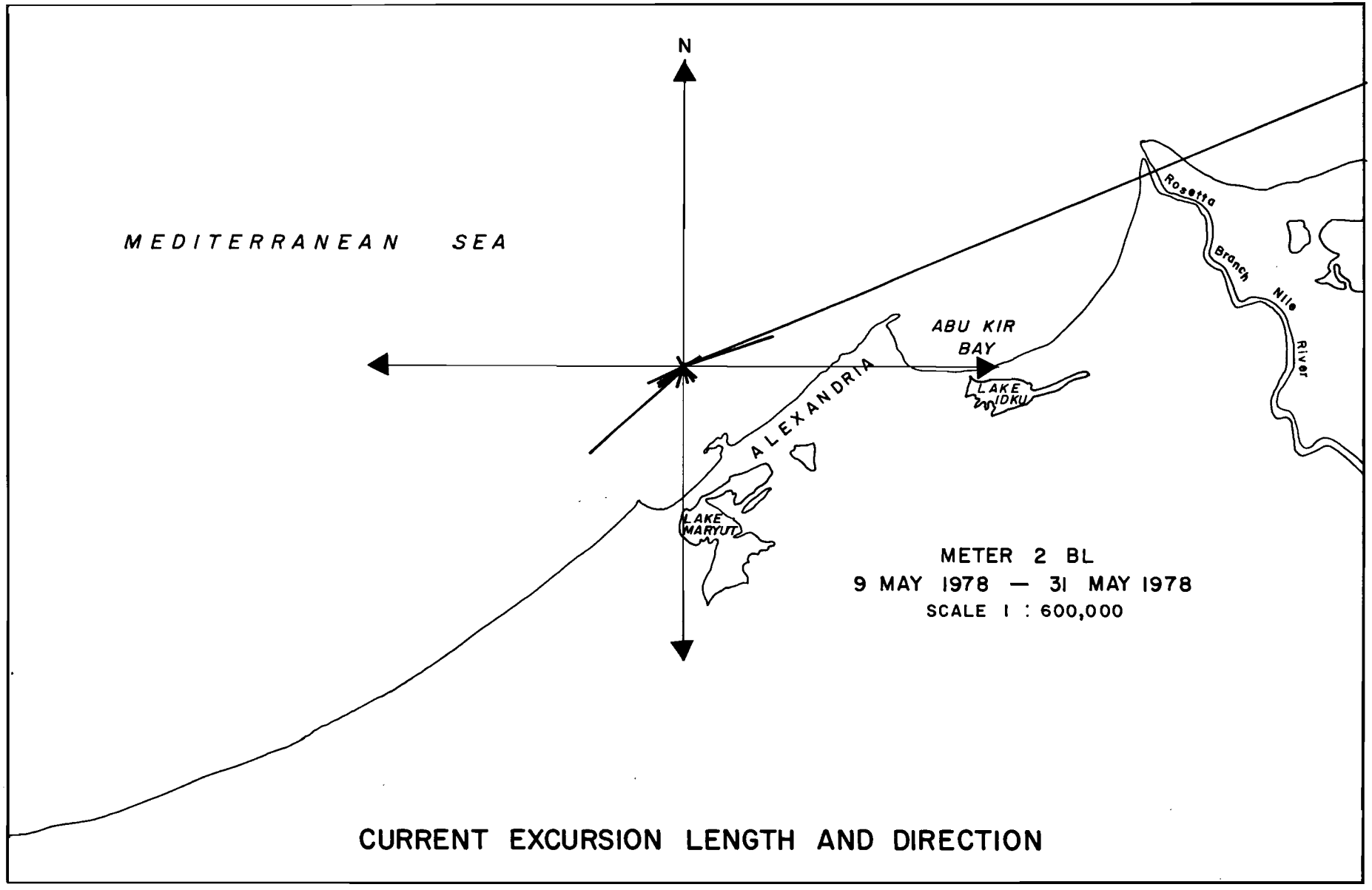

FIGURE C-21

CURRENT EXCURSION LENGTH AND DIRECTION

APPENDIX D

A NOTE ON THE RATE OF REOXYGENATION BY DOWNWARD DIFFUSION

APPENDIX D

A NOTE ON THE RATE OF REOXYGENATION BY DOWNWARD DIFFUSION

A primary measure of the assimilative capacity of the ocean is the rate at which oxygen can be transferred downward from the atmosphere to the oxygen-demanding constituents in the wastewater. To be conservative, the rate of downward diffusion through the pycnocline should be considered; for although the pycnocline is not strong enough nor persistent enough to be counted upon to keep the effluent plume submerged, it will doubtless submerge the plume part of the time.

The downward diffusion of oxygen through the pycnocline may be estimated as follows: The diffusive flux, F, may be assumed to be given by $F = -K dc/dy$, where K is the vertical diffusion coefficient and dc/dy is the vertical gradient of dissolved oxygen concentration. While in general K is a function of vertical gradients in ambient velocity as well as density gradients, Koh and Fan[1] have shown that, as a rough approximation in the ocean, K can be related to the vertical density gradient alone:

$$K = 10^{-4}/e$$

where $e = (1/\rho)(d\rho/dy)$ is the vertical relative density gradient expressed in m^{-1}; and K is expressed in cm^2/sec; and where $4 \times 10^{-7} m^{-1} \leq e \leq 10^{-2} m^{-1}$.

The vertical flux is then:

$$F = \frac{-10^{-4}}{\frac{1}{\rho}\frac{d\rho}{dy}} \frac{dc}{dy} \cong \frac{10^{-4}\,\rho\, dc \;\; cm^2\text{-}mg}{d\rho \;\; m\text{-}sec\text{-}L}$$

From Chapter 4, the allowable far-field oxygen deficit, 1.4 mg/L, may be adopted for dc. From Figure 5-5, the density difference between the surface and 40 m depth may be seen to be as much as 1.3 sigma-t units. The density of seawater may be assumed to be 1029 sigma-t units. Applying these values and converting some units gives

$$F = 9.5 \text{ kg/ha/day.}$$

By comparison, the projected COD load of 1109 thousand kg/day from marine discharges in the year 2000 (Table 2-4), distributed over a patch of ocean measuring roughly 10 km, by 40 km, will impose an oxygen demand of 27 kg/ha/day, or three times the rate available by downward diffusion under the stratified conditions considered. Sufficient dilution of the effluent with ambient oxyen-rich seawater must therefore be provided.

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[1] Koh, R.C.Y., and Loh-Nien Fan, "Mathematical Models for the Prediction of Temperature Distributions Resulting from the Discharge of Heated Water into Large Bodies of Water," USEPA Water Quality Office Contract No. 14-12-570, U.S. Government Printing Office, October, 1970.

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APPENDIX E

DISCUSSION OF VIRAL AND BACTERIAL CRITERIA

APPENDIX E

DISCUSSION OF VIRAL AND BACTERIAL CRITERIA

Recent Research: Viruses

Estimates vary as to the concentrations of pathogenic organisms in wastewater but one study by Geldreich and Clarke[1] has estimated a value for enteric viruses of 500 units/100 mL of sewage. Based on these estimates of coliform density in sewage they found a virus-to-coliform ratio of 1:92,000. Petrilli et al.[2] found ratios of enteroviruses to E. Coli of 1:2000 minimum to 1:400,000 maximum in moderately and highly polluted waters, respectively, with the ratios decreasing in time due to the more rapid die-off of E. Coli organisms away from the initial discharge point. The variability of the ratios over such a large range can be due to the fact that the excretion of enteroviruses like that of pathogenic enterobacteria is occasional and quantitatively inconsistent, being influenced not only by infection rates in the community at any given time, but also by the hour of the day, the season of the year, the ratio of industrial to domestic waste and the extent of sewage dilution from seepage or surface run-off into the sewer system. Nevertheless, large numbers of viruses may be present in wastewater, e.g., poliovirus, hepatitis and adenovirus, which present a wide range of symptoms and diseases.

Despite much study, the exact health risk of viral pathogens cannot be quantified. Research by Plotkin and Katz[3] has shown that infective doses may be as small as one or two plaque forming units (PFU) for such viruses as poliovirus types 1 and 3. But, Petrilli[2] points out that inapparent infection rather than overt illness may develop from low concentrations of pathogens.

Attempts to define the specific factors which lead to the destruction of viruses in the marine environment have not been very successful and are often contradictory. In general, observations have pointed out that most enteric viruses are more resistent than indicator bacteria to inactivation by water disinfectants.[4]

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[1] Geldreich and Clarke, "The Coliform Test: A Criterion for the Viral Safety of Water," Proceedings of the 13th Water Quality Conference, University of Illinois, 1971.

[2] Petrilli, DeFlora and Lemori, "Pollution of Coastal Waters in Italy -- Bacteriological and Virological Research," Marine Pollution and Marine Waste Disposal, Pergamon Press, 1975.

[3] Plotkin and Katz, "Minimal Infective Doses of Viruses for Man by the Oral Route," Transmission of Viruses by the Water Route (ed. G. Berg), Wiley-Interscience, 1967.

[4] Mitchell and Chamberlain, "Factors Influencing the Survival of Enteric Microorganisms in the Sea: An Overview," Discharge of Sewage from Sea Outfalls, Pergamon Press, 1975.

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Literature reports summarized by Petrilli[1] show that enteroviruses survive in seawater for longer periods than coliform indicator organisms. For the majority of viruses tested it took from 3 to 21 days to achieve a three order of magnitude decrease in concentration at 25° C. At 4°-6° C the viruses persisted for even longer times. For coliform organisms, by comparison, with a T_{90} of 3 hours, a three order of magnitude decrease in concentration can be achieved in 9 hours.

Shuval et al.[2] reported findings of survival times for polioviruses suspended in water of the eastern Mediterranean and the Red Sea. Three log cycles of concentration were lost in 9 days in normal seawater at 15° C. They also reported that the MAVA (marine anti-viral activity) required either the presence of bacteria in high numbers or was associated with a very short-lived agent produced by the bacteria. Mitchell[3] has also observed that the presence of indigenous marine micro-organisms enhances the inactivation of the bacteriophage (virus) -174 in seawater collected off the New England (USA) coast. He reported that the chemical component, presumably the heavy metals, of seawater also exerted a detrimental effect on the phage. Matossian and Garabedian[4] attempted to identify the factors in natural Mediterranean water (near Beirut) which inactivate poliovirus 1. They found that three log cycles of virus infectivity were lost in 6-7 days in both untreated and filtered seawater at 25° C. From other tests they concluded that the virucidal property of seawater was due to the combined effect of its chemical composition and to an unknown heat-labile inhibitory substance. Tests by others concerning the effect of salinity as a virucidal agent have been inconclusive.[5]

To complicate the matter of determining die-off rates of enteroviruses, it has been found by Berg[6] that the cell-culture systems used for detecting enteric viruses are sensitive to less than 50 percent of the viruses excreted by man, and there are probably viruses in sewage that have not yet been detected and identified. Thus, the number of viruses detected can be well below the quantities actually present.

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[1] Petrilli, DeFlora and Lemori, "Pollution of Coastal Waters in Italy -- Bacteriological and Virological Research," Marine Pollution and Marine Waste Disposal, Pergamon Press, 1975.

[2] Shuval et al., Developments in Water Quality Research, Ann Arbor-Humphrey Science Publishers, 1970.

[3] Mitchell, "Destruction of Bacteria and Viruses in Sea Water," Journal Sanitary Engineering Division, American Society of Civil Engineers, 1971.

[4] Matossian and Garabedian, "Virucidal Action of Sea Water," American Journal of Epidemiology, 1967.

[5] Akin, Hill and Clarke, "Mortality of Enteric Viruses in Marine and Other Waters," Discharge of Sewage from Sea Outfalls, Pergamon Press, 1975.

[6] Berg, "Methods for Detecting Viruses in Environmental Waters -- a Status Report," Proceedings 1st Microbiol. Seminar of Methods, U.S. EPA, 1973.

Recent Research: Bacteria

Besides viruses, large numbers of bacterial pathogens such as Salmonella, Shigella and Vibrio Cholera may be present in wastewater. From contact with these bacteria, symptoms can range from serious diseases to ear infections and sore throats.

For bacterial pathogens, like viruses, wide ranges of infective doses have been reported. The classical studies by Kehr and Butterfield[1] conclude that 1 percent of the individuals ingesting a single typhoid bacterium became infected. McCullough and Eisele[2] showed that for Salmonella Typhi and Vibrio Cholera quite small doses are infectious (3-5 organisms) whereas other Salmonella types and enteropathogenic E. Coli require considerably larger doses.

Studies of bacterial die-off in the marine environment have shown that many bacterial pathogens have the ability to survive longer than coliform indicator organisms. Some may even multiply in the sea environment. Disappearance studies have shown that there are a number of factors which contribute to bacterial removal from the sea; these are:

- Sedimentation
- Solar Radiation
- Predation
- Bacteriophages
- Nutrient Deficiencies
- Algal Toxins
- Bacterial Toxins
- Physical-Chemical Factors

Physical-chemical factors may include osmotic effects, pH effects and specific ion toxicity. Solar radiation has been shown to substantially affect bacterial die-off rates. Research by Bellair et al.[3] has shown large diurnal variations in T_{90} values for fecal coliforms in the sea. However, the magnitude of diurnal variation varies from location to location, with die-off from solar radiation being affected by such factors as surface roughness, amount of incident light received and concentration of suspended particulate matter in the sea.

Research Summary

In summary, the factors which contribute to the disappearance of viral and bacterial pathogens are numerous and at this time too complex to permit a prediction of pathogen die-off by measuring the contributing factors in the marine environment.

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[1] Kehr and Butterfield, "Notes on the Relationship between Coliform and Enteric Pathogens," Public Health Report, Washington, 1943.

[2] McCullough and Eisele, "Experimental Human Salmonellosis," Journal of Infectious Diseases, 1951.

[3] Bellair, Parr-Smith and Wallis, "Significance of Diurnal Variations in Fecal Coliform Die-Off Rates in the Design of Ocean Outfalls," Journal Water Pollution Control Federation, September, 1977.

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Indicator Organisms

Ideally, an indicator organism should be present when pathogenic organisms are present and in large enough quantities that there is a high probability of detection even after high dilution. This is one reason that coliform organisms are widely used as indicators of pollution, despite the sometimes ambiguous conclusions that might be drawn from their measurement. As mentioned previously, coliforms suffer a rather rapid die-off in the sea while certain pathogens do not.

A review of the literature on the use of indicator organisms in the marine environment has pointed out the deficiencies of the commonly used indicators. Total coliform counts include the more useful fecal coliforms but may be misleading since they are not specifically linked to the intestines of warm-blooded animals (including man); and major sources of coliforms in the coastal region may come from rivers, soil run-off and certain types of industrial discharges. Since coliforms suffer a rapid die-off in the marine environment, this factor may lead to an over-estimate of the protection achieved against the more long-lived pathogens.

Fecal coliforms are more specific indicators of recent fecal pollution and are discharged from the intestines of warm-blooded animals (including man). Escherichia coli, in particular, meet many of the requirements of a good indicator but also have a relatively short survival time in seawater.

Fecal streptococci are sometimes found in human and animal wastes but may also come from certain industrial processes. The ratio of fecal coliform to fecal strep is frequently used[1] to help identify the source of pollution in a receiving water but this ratio must be applied with caution.

Fecal Coliform Organisms

Despite the problems mentioned, there is some merit in using the bacterial indicator organisms such as fecal coliform and specifically E. Coli for monitoring pollution:

1. These organisms are always associated with fecal pollution and, if they are detected in large concentrations, it is a serious matter regardless of the source or time of travel from the source.

2. These organisms can be detected more easily and at less cost than the pathogens themselves.

3. There is a greater chance of finding fecal coliforms if present even after high dilution because of the abundance of these organisms.

4. There are some pathogenic bacteria which follow a die-off rate similar to fecal coliforms and it is useful for design purposes

[1] Coordinated Mediterranean Pollution Monitoring and Research Programme, Guidelines for Health Related Monitoring of Coastal Water Quality, World Health Organization, 1977.

to at least be assured of adequate protection from these types of bacteria.

5. Most of the available research on marine pollution has utilized fecal coliforms or total coliforms as indicator organisms and standards have been set based on such concentrations that have been felt to give adequate protection for the intended use of the waters.

In field studies, near outfalls, conducted by Petrilli[1] in coastal Italy, it was found that virological tests were positive only when the MPN of E. Coli were greater than 1000/100 mL. The corresponding total coliform counts ranged from 5-10,000/100 mL. Shuval[2] also found in sampling near outfalls in the Mediterranean near Israel that no viruses were recovered when fecal coliform counts were less than 1000/100 mL. A study by Bonde[3] utilizing data from Lund, Shuval et al., and Taylor found that the probability of recovering viruses was 53 percent for samples in which the E. Coli count exceeded 1000 per 100 mL and 18 percent from those of lower E. Coli counts. Similarly Bonde found from data by Grunnet et al. taken in estuarine waters that a count of 1000 fecal coliforms/100 mL corresponds to a 50 percent probability of demonstrating the pathogenic bacterium Salmonella. Additionally, Cabelli[4] in his epidemiological studies of gastroenteric illness found the highest correlations between incidence of disease and bathing water quality occurred when E. Coli were used as the bacteriological indicator. Fecal coliforms were the next best indicator.

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[1] Petrilli, DeFlora and Lemori, "Pollution of Coastal Waters in Italy -- Bacteriological and Virological Research," Marine Pollution and Marine Waste Disposal, Pergamon Press, 1975.

[2] Shuval, Developments in Water Quality Research, Ann Arbor-Humphrey Science Publishers, 1970.

[3] Bonde, "Bacterial Indicators of Sewage Pollution," Discharge of Sewage from Sea Outfalls, Pergamon Press, 1975.

[4] Cabelli, Dufour, Levin and McCabe, Relationship of Microbial Indicators to Health Effects at Marine Bathing Beaches, U.S. Environmental Protection Agency and Paul W. Haberman Center for Policy Research, 1975.

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APPENDIX F

PROCEDURES ADOPTED ON EVALUATING THE MPN OF THE COLIFORM AND ENTEROCOCCAN GROUPS IN SEAWATER SAMPLES

APPENDIX F

PROCEDURES ADOPTED ON EVALUATING THE MPN OF THE COLIFORM & ENTEROCOCCAL GROUPS IN SEAWATER SAMPLES

Tests for the Coliform Group

Both the presumptive as well as the confirmed tests of this group were carried out. Decimal dilutions of each sample were prepared. From the appropriate dilutions a series of fermentation tubes was inoculated.

Presumptive Test. From each dilution three fermentation tubes were inoculated with 1 mL each. The medium used for this test was Mac-Conkey broth. The inoculated tubes were incubated at 35.5°C for 24 hours. The presence or absence of gas was noted for each tube. The tubes showing doubtful results were reincubated for another 24 hours. The most probable numbers (MPN) of bacteria were computed according to the tables of MPN for various combinations of the positive results using three tubes.

Confirmed Test. All positive tubes, i.e., those showing gas in the presumptive test, were subjected to the confirmed test. Two loopfuls from each positive tube were inoculated in a tube containing Eijkman's medium. The inoculated tubes were transferred to a water bath and incubated at 44.5°C for 24 hours. All tubes showing gas were recorded as positive confirmatory tests for the presence of fecal coliforms. However, in most cases, streaks from the positive presumptive or confirmed tests mentioned above were carried out on EMB Agar plates and at 35.5°C for 24 hours. Plates showing button-like colonies with metallic sheen (or sometimes dark pink) were recorded as confirmed tests for the presence of fecal coliforms.

Tests for the Enterococci

Presumptive Test. From the same dilutions prepared for testing the presence of coliforms, 1 mL volumes were inoculated in a series of test tubes each containing 5 mL of *enterococci* azide dextrose broth. The inoculated tubes were incubated for 24 hours at 35.5°C. Tubes showing typical growth of the *enterococci* were recorded positive. The MPN of the enterococcal group was computed from the tables of the MPN.

Confirmed Test. Three loopfuls of each positive growth were transferred to a test tube provided with 5 mL of *enterococci* confirmed broth. The inoculated tubes were incubated at 45.5°C for 24 hours. Tubes showing growth accompanied by a distinct yellow colour were recorded as positive confirmed tests for the presence of fecal *enterococci* and their MPN were computed from the MPN tables.

ACKNOWLEDGEMENTS

ACKNOWLEDGMENTS

Many individuals and organizations contributed to the successful execution of this year-long program of marine studies. The officers and engineers of the Ministry of Housing and Reconstruction, the Advisory Committee on Reconstruction, the General Organization for Sewerage and Sanitary Drainage, and the United States Agency for International Development, as named in the preface to Volume I of this Master Plan Report series, are to be acknowledged for approving and funding the program. CDM engineers who participated in the planning and execution of field studies and in data analysis are Dr. Jonathan French, and Messrs. David Wakefield, Ellis Turner, and Bruce Conklin. On the ATECO staff, Mr. Eid Said El Bamby and Miss Maysa Omar undertook much of the burden of data reduction. Mr. Louis Marcello provided valuable computer programming assistance. The ATECO and CDM secretarial and drafting personnel are to be commended for their contributions.

The Ocean Surveys, Inc., team included, at various times, Messrs. Alan Bieber, Stephen Bartlett, Donald Hanberg, George Reynolds, Paul Kronfield, Donald McNair, Roger Zaunere, David Kline, and David Robinson. Without exception, these men are to be commended for working long, hard hours under conditions that were at times difficult, to say the least.

From the Department of Oceanography, Faculty of Science, University of Alexandria, Prof. Sayed Sharaf El-Din contributed a very large and invaluable amount of technical and logistical support. The contributions of Dr. Mohsen Osman and Messrs. Fahmy Eid and Ahmed Fuad, at sea and ashore, are acknowledged. Prof. Altaf Ezzat directed the whole biological section of the program. Mrs. Manal Atta supervised plankton sampling and undertook the very lengthy task of plankton identification. Dr. Abd El Fattah and Mrs. Hafez conducted the fish market surveys. Messrs. Eid Berzan and Hesham Nabih lent valuable assistance at sea and ashore.

From the Institute of Oceanography and Fisheries, Alexandria, Dr. Sherif Ramadan undertook the field sampling and laboratory identification of benthos and fouling organisms, and supervised plankton sampling. Mr. Abd El Atty was often of great manual assistance at sea.

The laboratory staff of the High Institute of Public Health undertook the analyses for water quality and bacterial concentration. Dr. Fahmy El Sharkawy coordinated this work, and kept the CDM staff informed about concurrent developments in the MED POL program, in the epidemiological studies underway on Alexandria beaches, and in studies of the water quality of Lake Maryut. His assistance to the program is greatly appreciated.

Soils analyses were conducted by the Consultative Bureau for Civil Constructions, Alexandria.

The day-to-day assistance of the security liaison officer, Gen. Sayed El Alfi, was of inestimable value. The Mohamed Abdel Aziz Mohamed General Services Co. provided the project with capable and reliable vessels and crews. Frequently, the OSI divers chose to augment their team with the exceptionally capable Mr. Nadar of The Seamen Diving Co., Alexandria.

To the men of the Egyptian Navy and the fisherman of Abu Kir who at various times found and returned valuable metering equipment, CDM extends its very great gratitude.

Finally, thanks are due to all others not mentioned above or cited in the report who contributed to this project.