Environmental Quality of Israel's Mediterranean Coastal Waters in 2004

Israel Oceanographic & Limnological Research
IOLR Report H34/2005a

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Annual Report of the National Marine Environmental Monitoring Program

Executive Summary

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IOLR Report H34/2005a

The National Marine Environmental Monitoring Program is funded by
The Ministry of the Environment
The Ministry of National Infrastructures

Monitoring activities in ports and marinas are funded by
The Ministry of Defense

September 2005

Executive Summary[1]

Introduction

This report presents information on the environmental quality of Israel's Mediterranean coastal waters in the year 2004, based on the **National Marine Environmental Monitoring Program (NMEMP)** and related activities carried out by the National Institute of Oceanography of Israel Oceanographic and Limnological Research (IOLR). The report also presents trends of environmental changes based on analysis of long-term monitoring data.

The NMEMP is guided by the Marine and Coastal Environment Division of the Ministry of Environment. The aim of the program is to provide a scientific basis for decision making with regard to protection of the marine environment, including enforcement of the provisions of national legislation and international conventions.

The NMEMP includes five components:

- Monitoring of heavy metals in the coastal waters (carried out since 1978);
- Monitoring of the introduction of nutrients and particulate metals into the coastal waters through coastal rivers (since 1990);
- Monitoring of the atmospheric fluxes of nutrients and heavy metals into the coastal waters (since 1996);
- Monitoring of nutrient levels and algal populations in the coastal waters (since 2000);
- Estimation of the overall pollution load introduced into the coastal waters derived from a database on point sources of pollution (as of 2002).

The NMEMP has been updated over the years in accordance with the available information on pollution sources. Fig. 1 shows the main sources of pollution along the coastline. Fig. 2 presents the NMEMP sampling stations. Location of the sampling stations and the parameters measured at each station are listed in Table 1.

All the data collected within the framework of the NMMP is archived at the **Israel Marine Data Center (ISRAMAR)**, IOLR. The evaluation of temporal trends in the environmental quality of the coastal waters is based on analysis of all relevant ISRAMAR databases.

[1] The original full report submitted to the Government is written in *Hebrew* (available at the IOLR web site, *Hebrew Version* - www.ocean.org.il). This executive summary presents the main findings of the report and the figures included therein.

Monitoring Activities in the Year 2004

- **Heavy metals in sediments:** 14 sampling stations in Haifa Bay; 10 stations on the continental shelf along the coast (~5 m depth); 31 stations at the lower reaches and outlets of the coastal rivers.
- **Heavy metals and organic pollutants in ports and marinas:** Sampling stations (water and sediments) in Haifa, Qishon and Ashdod ports and in Akko, Atlit, Hadera, Michmoret, Hertzelia, Tel-Aviv, Ashdod and Ashquelon marinas.
- **Heavy metals in suspended particulate matter:** 9 sampling stations along the coast between Ashdod and Haifa; 10 stations in Haifa Bay; 31 stations at the lower reach of the coastal rivers.
- **Heavy metals in benthic organisms:** 173 specimens of bivalves, 408 specimens of gastropods and 10 specimens of Hermit crab from Haifa Bay and other areas along the coast.
- **Heavy metals in fish:** 182 specimens of 10 species of inshore fish and 157 specimens of 4 species of trawl fish caught in Haifa Bay and in other areas along the coast.
- **Pesticide residues in fish** (preliminary screening): 11 specimens of 3 species of inshore fish.
- **Heavy metals in atmospheric dust:** 43 samples from Haifa area and 47 samples from Maagan Michael.
- **Nutrients in rainwater:** 36 samples from Haifa area.
- **Nutrients in the coastal rivers:** 31 sampling stations at the lower reaches and outlets of the rivers sampled twice (winter and fall).
- **Nutrients, chlorophyll and algae in coastal waters:** Sampling during several cruises along the coastline including Haifa Bay.

Appendix 1 presents the total number of heavy metal analyses carried out since the beginning of the monitoring program.

Main Findings

The findings of the monitoring activities carried out in 2004 reveal that in general, the level of pollution of Israel's Mediterranean coastal waters is not high relative to international marine environmental quality guidelines and criteria. Trends of decreasing pollution identified in previous years continued in 2004. However, the situation is not yet satisfactory. Significant quantities of anthropogenic materials are introduced into the coastal waters both from point sources (marine outfalls and coastal rivers) and from diffuse sources (runoff waters and atmospheric deposition). As a result, a number of local pollution problems exist along the coastline.

The findings and conclusions of the report are summarized below in two ways. First, in a table of **environmental indicators** (e.g. heavy metals in sediments, heavy metals in fish etc.). The table presents the status of the coastal waters in 2004 and trends in the last decade. Second, in maps presenting the status of different areas along the coastline relative to four **environmental criteria**: (1) status of the shallow water area based on the values of the "Diversity Index"[2] of the microalgae populations – four levels; (2) status of the lower reaches/outlet areas of the coastal rivers based on chlorophyll concentrations – three levels[3]; (3) status of the coastal sediments based on the concentrations of heavy metals, pesticide residues (DDT) and PCB's – two levels[4]; (4) status of the coastal sediments based on tributyl-tin (TBT) concentrations – two levels[5].

Environmental Indicators - Status and Trends [6]

Environmental Indicator	Status in 2004	Trends in Last Decade
Heavy metals in sediments	**Haifa Bay:** Medium level of mercury pollution in the northern part of the Bay and the Qishon estuary. No change in mercury levels compared to 2003. Low concentrations of other heavy metals. Lead and zinc enrichment relative to other areas. **Coastal rivers :** High level of pollution by mercury, zinc, cadmium, nickel and medium level of pollution by copper, lead and chromium in the lower reach of the Qishon River. Medium level of pollution by some metals in the Betzet, Naaman, Hadera, Taninim and Alexander rivers.	Mercury pollution decreased. Lead concentrations decreased. Pollution in the Qishon estuary decreased. No clear trend of change in other rivers.

[2] Number of species divided by the aquare root of the algal biomass (decreasing values indicate a trend towards eutrophication).

[3] Based on the Sediment Quality Guidelines developed by US National Oceanic and Atmospheric Administration (NOAA) for the National Status and Trends Program. The two levels used are pollutant concentrations smaller and greater than *ERM* values (concentration of pollutant above which biological effects frequently occur). An area/site is marked as "polluted" when the concentration of one of the metals/organic compounds considered exceeded ERM.

[4] *Low*, *Medium* and *High* levels of nutrient pollution based on chlorophyll concentration data, according to NOAA's estuarine trophic state classification.

[5] Less than and more than 100 microgr./Kg.

[6] Pollution levels in the table (*high, medium and low*) are relative to water and sediment quality guidelines and criteria commonly used by US Government agencies for environmental assessment purposes and to the Israeli standeards for marine water quality.

Environmental Indicator	Status in 2004	Trends in Last Decade
	Along the coast: In general, the concentrations of all metals in shallow areas are smaller than harmful levels. Several local pollution problems:	
	Medium level of pollution by mercury and cadmium in TAS area.	No clear trend in TAS (*Tel-Aviv Region Sewage Treatment Plant*) area (seasonal changes in the level of pollution).
	Chromium enrichment along the coast south of Palmachim and in the area of the "*Agan Chemicals/Ashdod Refineries*" outfall (off Ashdod).	
	Ports and Marinas: High level of pollution by mercury and zinc in Haifa Port. Medium level of pollution by several metals in the ports of Haifa, Qishon and Ashdod and the marinas of Akko and Ashdod.	Similar and even higher levels of pollution found previously in Haifa and Qishon ports.

Environmental Indicator	Status in 2004	Trends in Last Decade
Heavy metals in suspended particulate matter	**Haifa Bay:** Concentrations in southern Haifa Bay, near the Qishon estuary, higher than those recorded outside the bay.	No change in mercury levels. Cadmium levels in the southern part of the bay decreased as of July 2000.
	Coastal rivers: High concentrations of mercury, cadmium and copper in several rivers.	No significant trend
	Along the coast: Much lower concentrations than in the outlets of the coastal rivers. Mercury enrichment opposite the outlets of Yarkon and Soreq rivers.	No significant trend.
Dissolved heavy metals in seawater	Concentrations in Haifa Bay higher than in other areas but generally lower than the Israeli water quality standard.	
Heavy metals in fish	Fish fit for consumption with respect to national safety limit.	Mercury concentrations stabilized at a lower level than in previous decade.
	Mercury enrichment in inshore fish from Haifa Bay relative to fish from other areas.	
	Mercury enrichment in some trawl fish from the northern part of the coastline relative to fish from the south. .	No change.
Heavy metals in benthic organisms	**Haifa Bay and Akko:** Mercury enrichment in bivalves and gastropods relative to other areas.	Mercury concentrations in bivalves decreased during 1980 – 1992; trend of increase since 1993 has reversed in the past three years.
	Cadmium enrichment in gastropods from southern Haifa Bay relative to other areas.	Cadmium concentrations in Qishon estuary decreased.

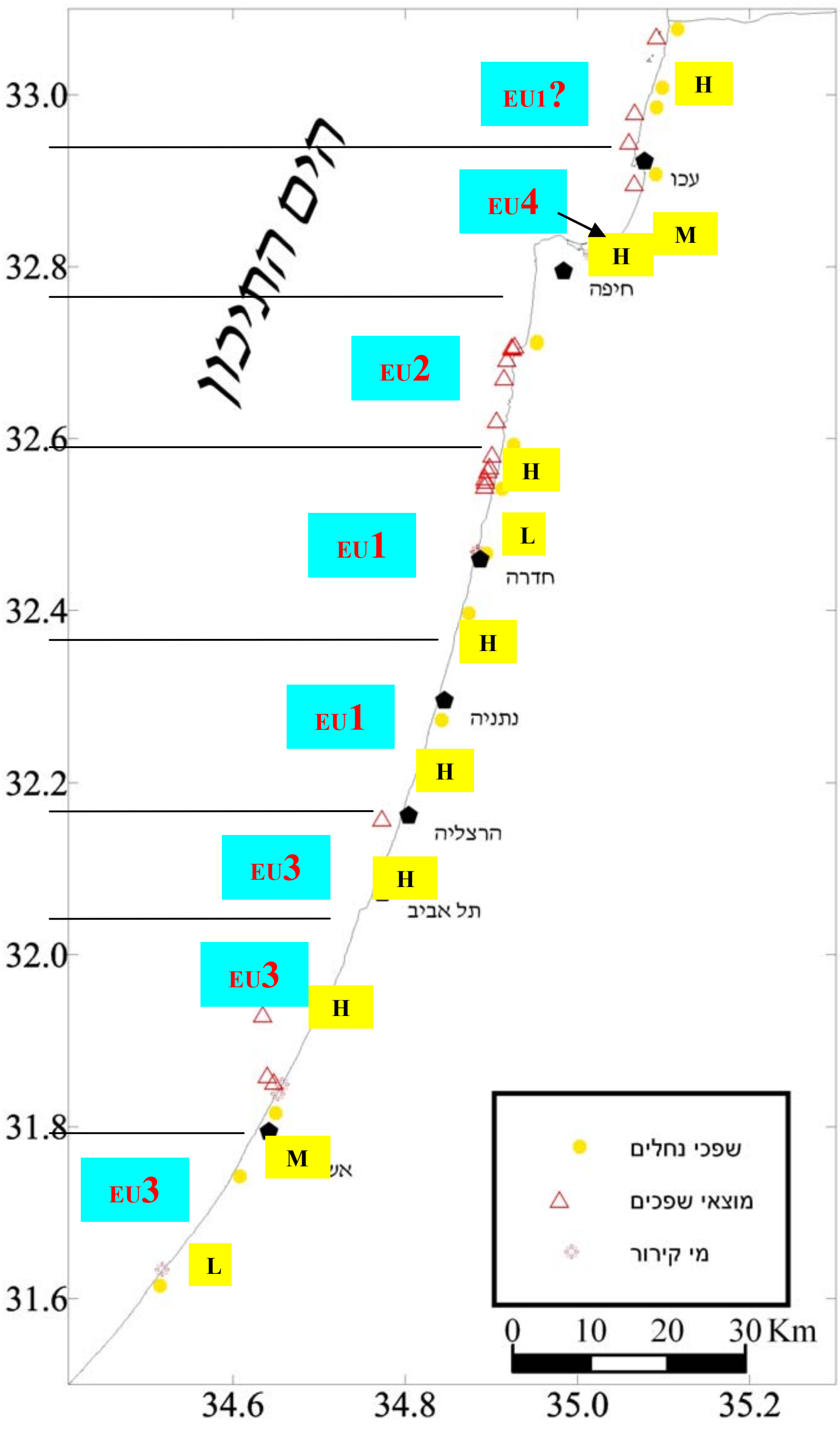
Environmental Indicator	Status in 2004	Trends in Last Decade
	Along the coast (selected sites): Cadmium enrichment in gastropods at Atlit	No change
Heavy metals in dust	Concentrations similar to Europe and higher than in open sea areas.	Lead concentrations decreased. No clear trend of change in cadmium, copper and zinc concentrations.
Organic pollutants in sediments	**Ports and marinas:** Pollution by pesticide residues (DDT) in the ports of Haifa, Qishon and Ashdod, Tel-Aviv marina and the cooling basin of Ashdod power plant. Medium level of pollution in the Qishon Port, Akko marina and the cooling basin of Hadera power plant. High level of PCB's pollution in Haifa and Ashdod ports and Akko marina; medium level of pollution in Qishon Port and Tel-Aviv marina. Medium level of pollution by a few PAH's in Haifa and Ashdod ports. Significant TBT pollution in Haifa, Qishon and Ashdod ports, in Akko, Michmoret, Tel-Aviv and Ashquelon marinas and in the cooling basin of Ashdod power plant. The findings indicate continued TBT input.	Similar levels of pesticide residues, PCB's and TBT found in the years 2000 – 2003. Imposex (indicator of TBT pollution) found in snails from Haifa Bay.
Organic pollutants in water	**Ports and marinas:** At all sites the concentrations of volatile and semi-volatile pollutants were below detection limit or much lower than level harmful to	No significant change during 2000 – 2003.

Environmental Indicator	Status in 2004	Trends in Last Decade
	marine organisms. High levels of TBT pollution found in Haifa and Ashdod ports and in Akko, Michmoret, Hertzelia and Tel-Aviv marinas. At all ports and marinas, TBT concentrations were higher than the Israeli water quality standard.	 No significant change during 2000 – 2003.
Nutrients in rain water	Nitrogen and phosphorus fluxes into the coastal waters smaller than in Europe but higher than in open sea areas.	Nitrogen and phosphorus fluxes depend on annual precipitation. No significant change in nitrogen flux in the last 7 years.
Nutrients in coastal rivers (outlet areas)	Medium to high levels of pollution in most rivers.	Some decrease in nutrient concentrations (especially in Soreq and Qishon rivers).
Nutrient load from point sources	Coastal rivers (including Qishon) > TAS outfall > others	Reported decrease in quantities of nutrients discharged into the rivers.
Nutrients in coastal waters	**Haifa Bay:** Nitrogen and phosphorus enrichment decreasing with distance from the shore. **Along the coast:** Phosphorus enrichment near the outlet of Yarkon river and TAS outfall; nitrate enrichment near the outlets of Yarkon and Taninim rivers. High nutrient concentrations near the effluent outfall of the Hertzelia sewage treatment plant.	Probably decreasing trend since 2002; possibly a change (increase) in N/P ratio of the Qishon River discharge.
Microalgae in coastal waters	**Haifa Bay:** High concentrations relative to other areas.	 Monitoring started in 2000; possibly beginning

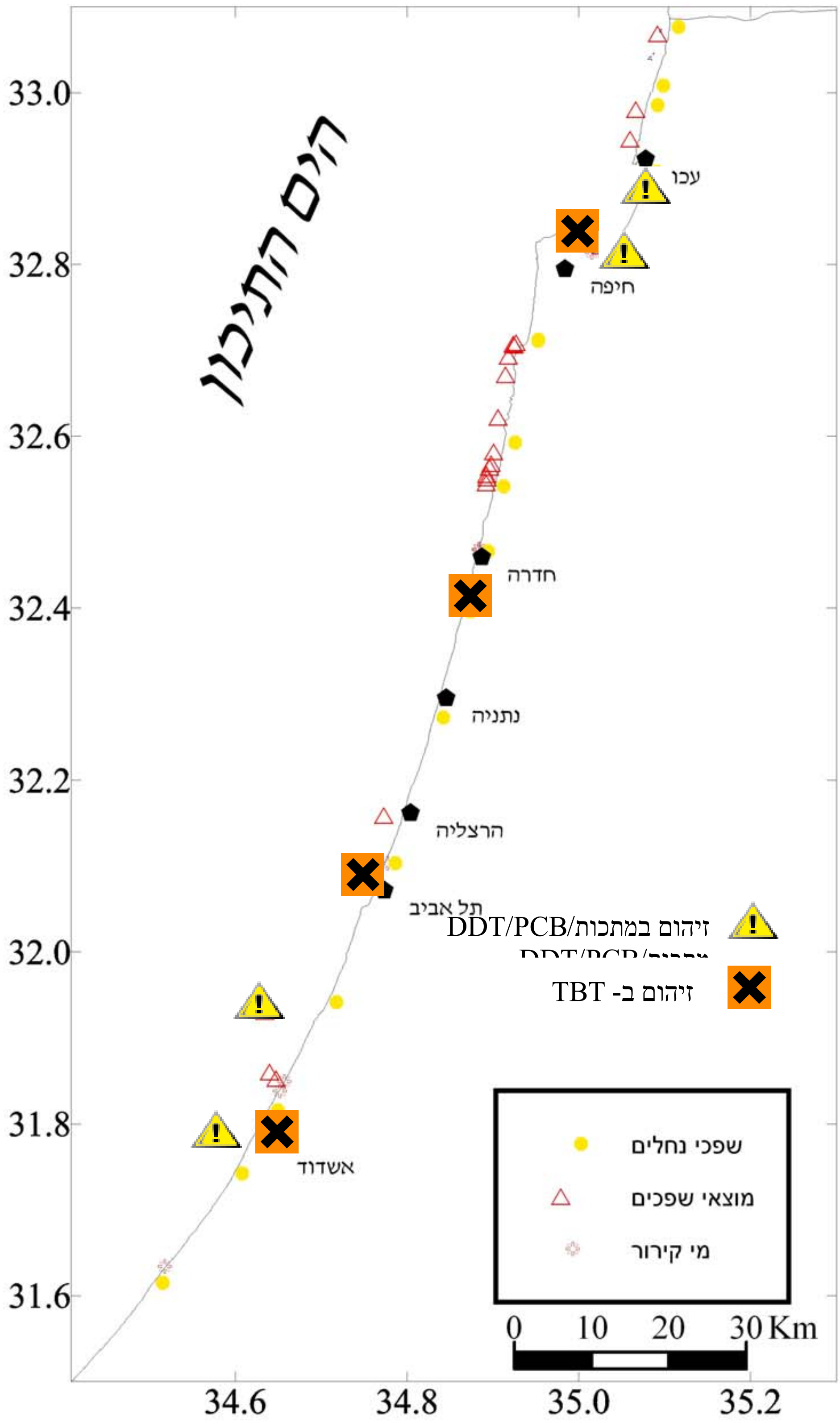
Environmental Indicator	Status in 2004	Trends in Last Decade
		of a decreasing trend.
	Especially high concentrations in the Qishon River estuary.	
	Potentially toxic species found.	Potentially toxic species found previously in Haifa Bay.
	Along the coast: High concentrations near Yarkon River.	
	Relatively high concentration in shallow waters (< 10 m) compared to deeper water (30 m).	
	Genera that might include toxic species found along entire coastline.	Potentially toxic species found in previous years.

Environmental status along the coastline

a. Status of the shallow water area based on the values the Diversity Index of the microalgae populations and of the lower reaches/outlet areas of the coastal rivers based on chlorophyll concentrations.



b. Status of the coastal sediments based on the concentrations of heavy metals, pesticide residues (DDT), PCB's and TBT.



Recommendations

Based on the findings of this report, it is recommended that the relevant government agencies take the following actions in order to reduce pollution of the coastal waters and to prevent potential public health risks and ecological damages:

1. Enhancement of the efforts to reduce wastewater discharges into the coastal rivers.

2. Develpoment of a data management system for wastewater discharges into the coastal rivers (to improve the ability to estimate the overall pollution load from the rivers).

3. Identification of the sources of heavy metals (especially mercury) input to the *Tel-Aviv Region Sewage Treatment Plant* and treatment of the effluents at their sources in order to minimize metal discharges into the sea.

4. Adoption of sediment quality guidelines which would serve as targets for decisions on restriction of wastewater discharge into the coastal waters and as an interpretive tool for monitoring programs.

5. Updating of the national safety limit for mercury levels in edible fish which has been set many years ago. In addition, safety limits for other metals and for organic contaminants should be considered.

6. Porhibition of all fishing activities in polluted areas as well as in areas where there is a risk of accumulation of harmful substances based on information on wastewater discharge into the sea.

7. Strict enfircement of the porhibition to use TBT antifouling paints within Israel and on Israeli vessels.

8. Routine monitoring of bathing water quality in all beaches which are adjacent to the coastal rivers, are not "*Declared Bathing Beaches*" (where routine monitoring is carried out) and yet are open to the public.

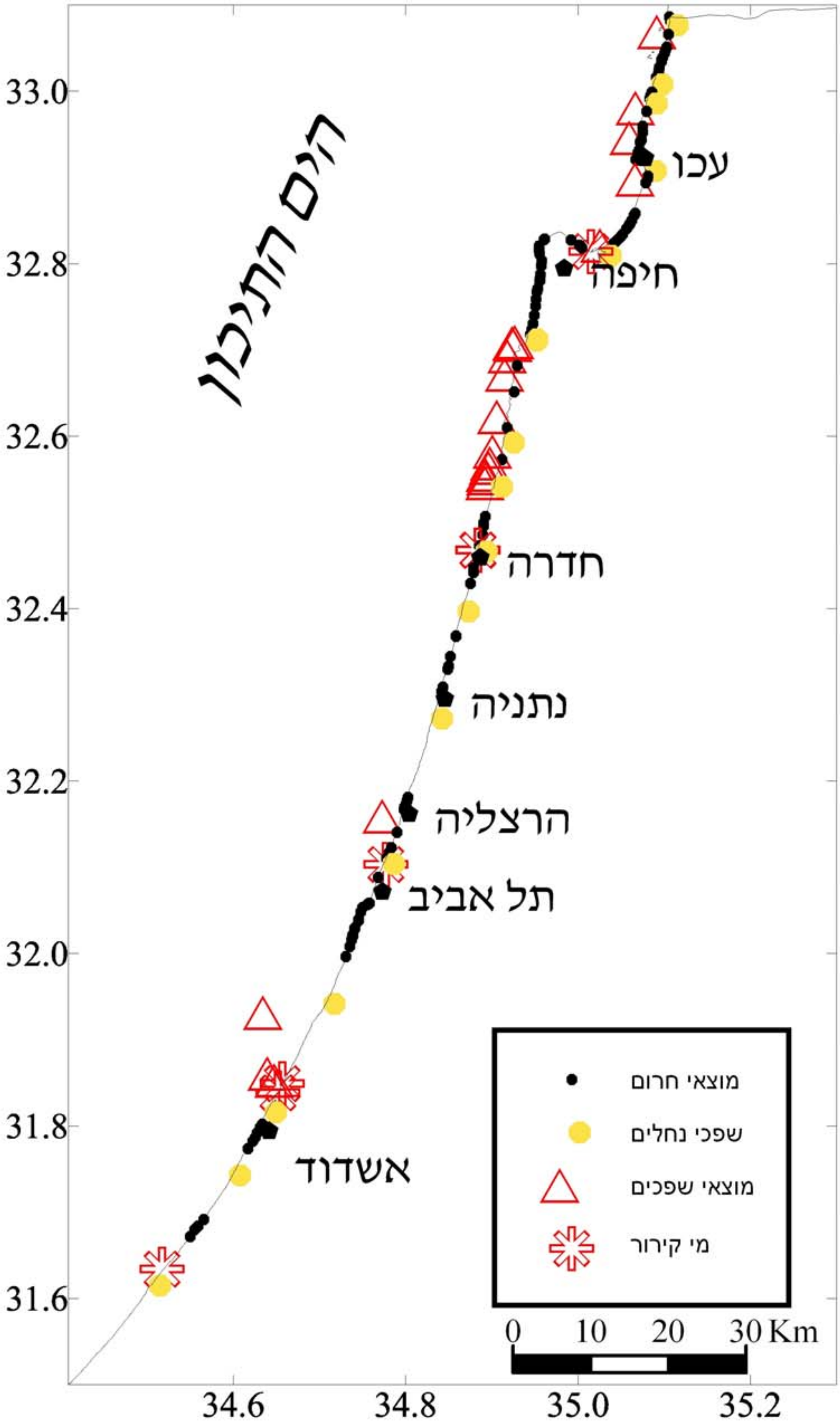


Fig. 1: Location of land-base sources (triangles=marine outfalls, yellow points=coastal river outlets, black points=emergency/drainage outlets, red stars=power plants cooling water).

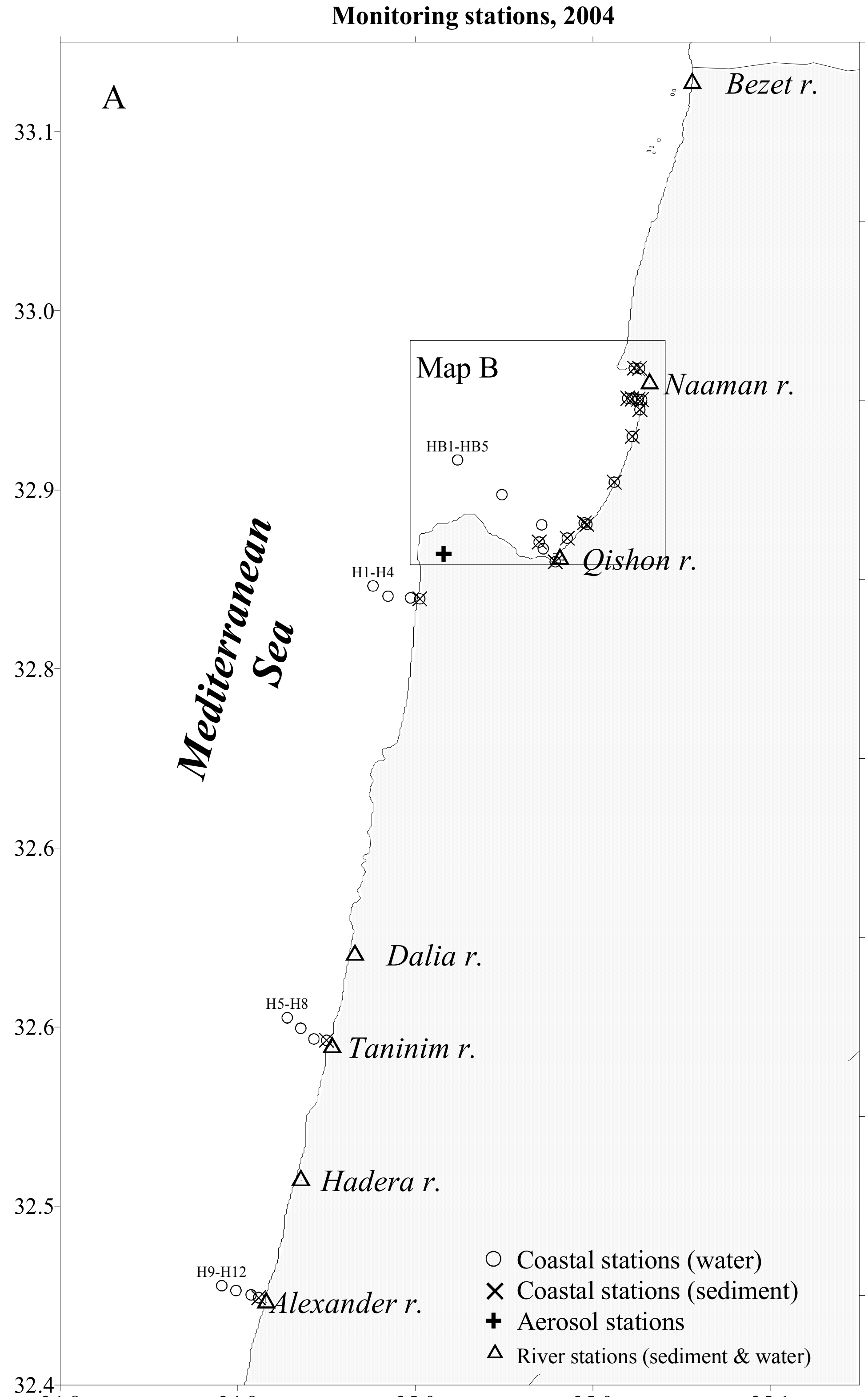


Fig. 2: Location of monitoring stations along the Mediterranean coast of Israel and at the lower reaches of the coastal rivers (A – northern area of the coast, B – Haifa Bay, C – southern area of the coast, D – Locations of benthic fauna sampling). The square south of Tel-Aviv (map C) represents the monitoring area of sewage sludge disposal at sea.

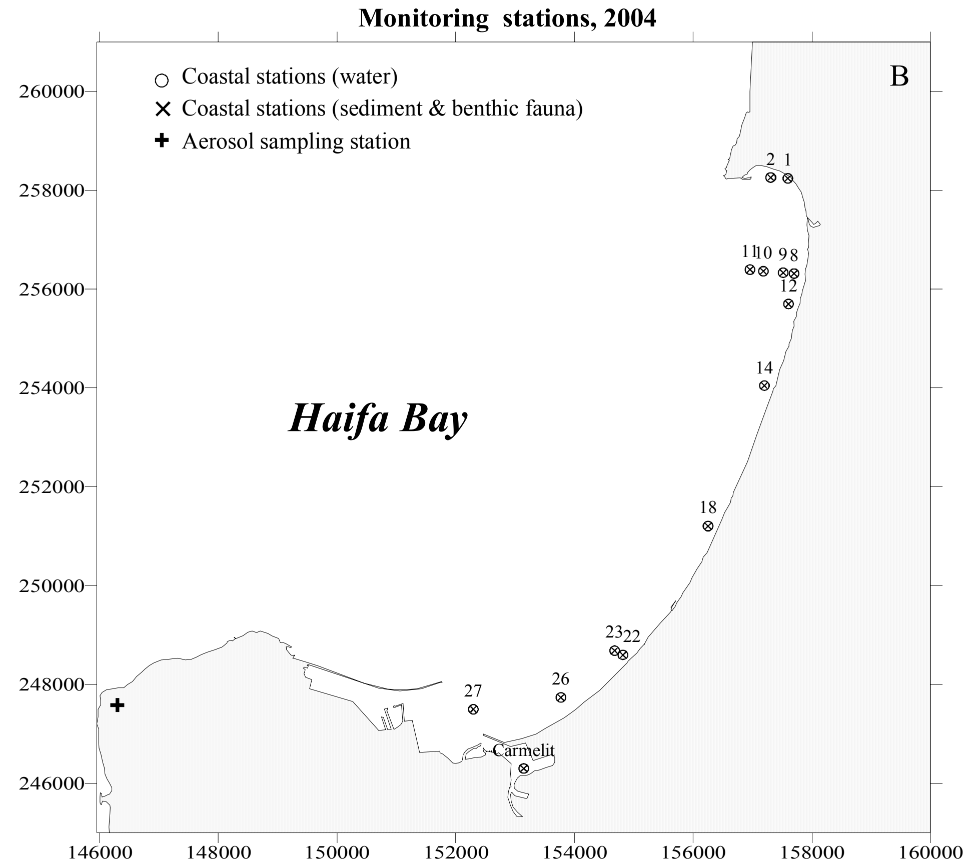
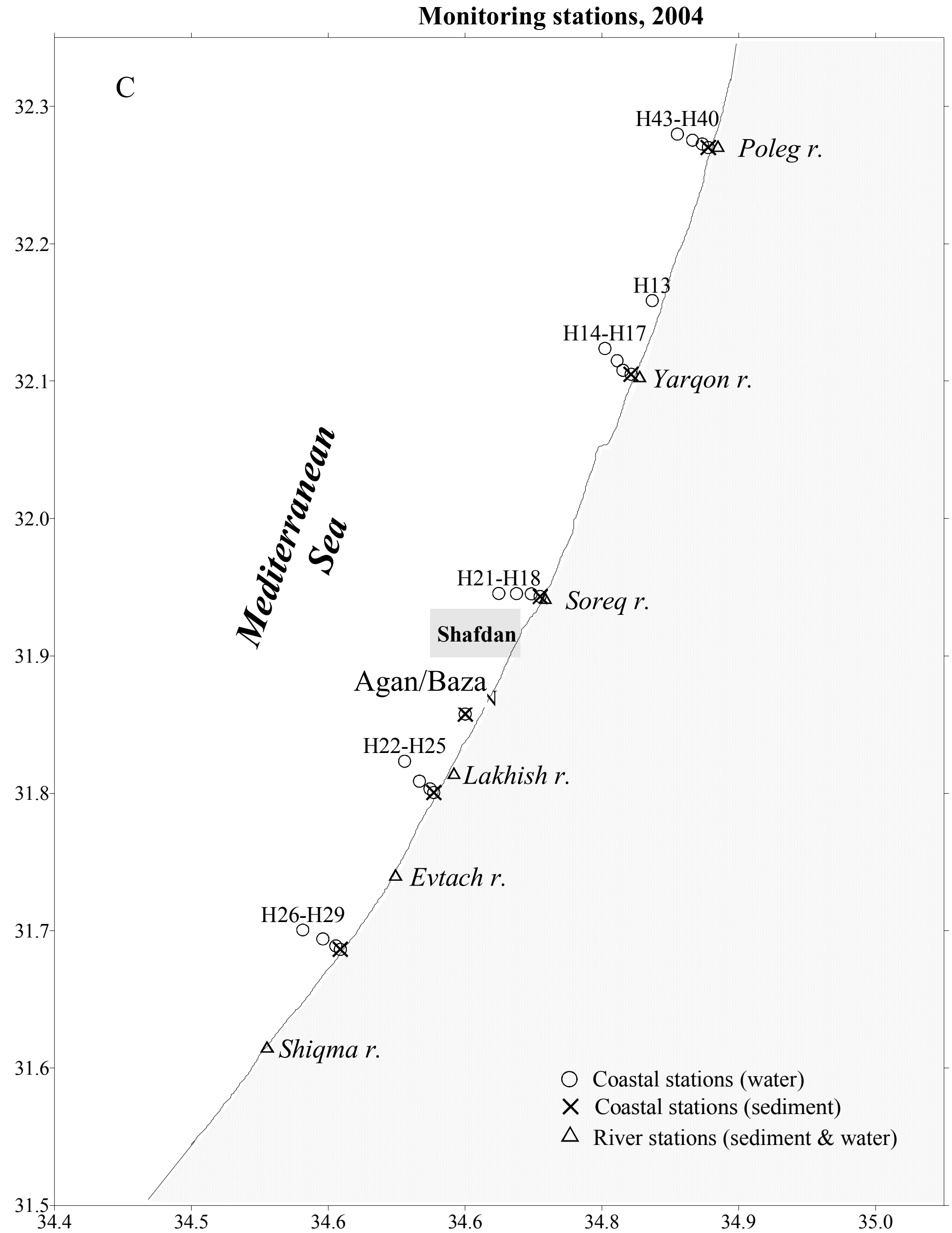

Monitoring stations, 2004
Coastal stations (water)
Coastal stations (sediment & benthic fauna)
Aerosol sampling station
B
Haifa Bay
2
1
11
10
9
8
12
14
18
23
22
26
27
Carmelit
260000
258000
256000
254000
252000
250000
248000
246000
146000
148000
150000
152000
154000
156000
158000
160000

Fig. 2: Cont.



Monitoring stations, 2004
C
H43-H40
Poleg r.
H13
H14-H17
Yarqon r.
Mediterranean Sea
H21-H18
Soreq r.
Shafdan
Agan/Baza
H22-H25
Lakhish r.
Evtach r.
H26-H29
Shiqma r.
Coastal stations (water)
Coastal stations (sediment)
River stations (sediment & water)
32.3
32.2
32.1
32.0
31.9
31.8
31.7
31.6
31.5
34.4
34.5
34.6
34.6
34.8
34.9
35.0

Fig. 2: Cont.

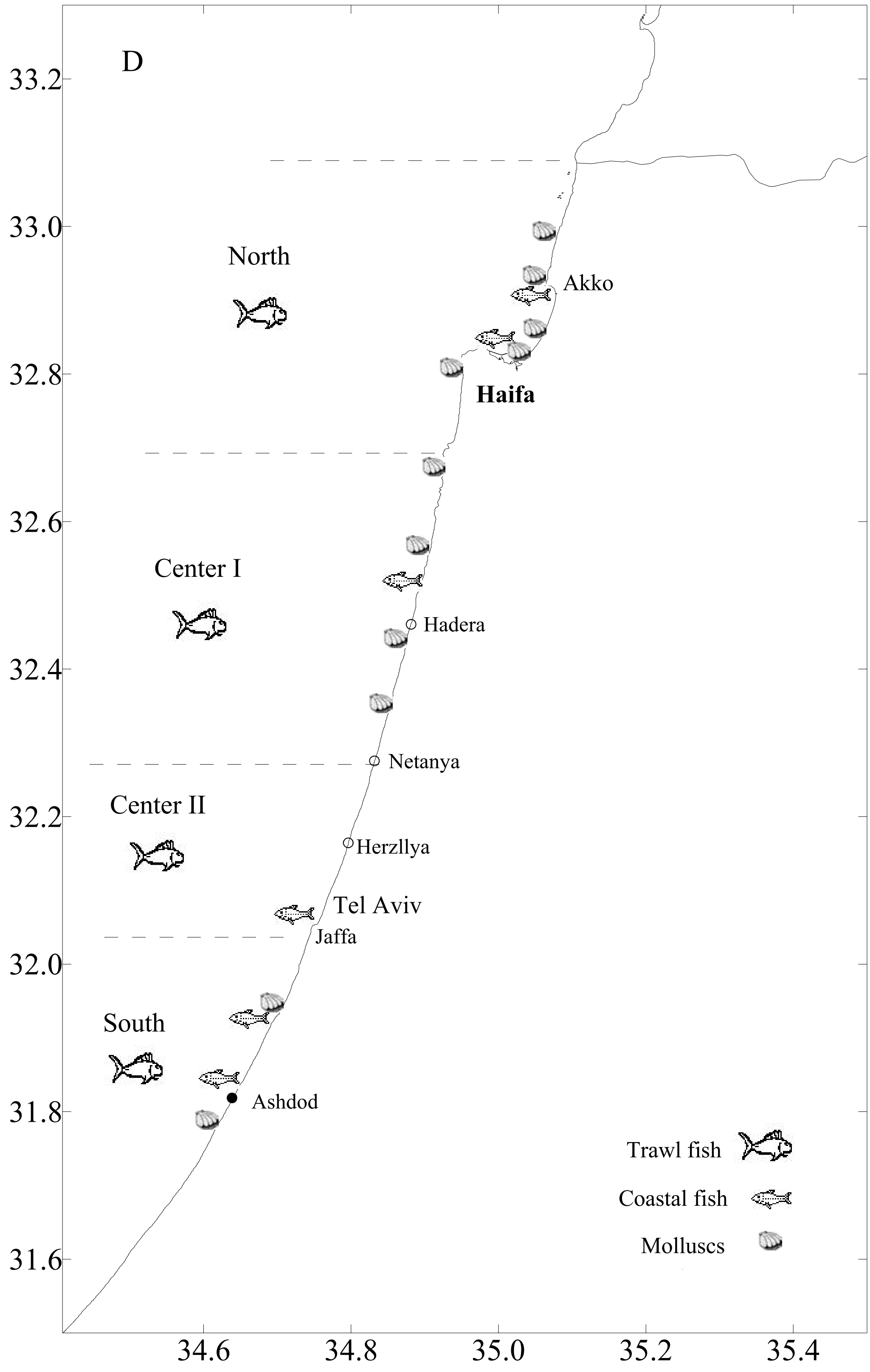

D
33.2
33.0
32.8
32.6
32.4
32.2
32.0
31.8
31.6
34.6
34.8
35.0
35.2
35.4
North
Akko
Haifa
Center I
Hadera
Netanya
Center II
Herzllya
Tel Aviv
Jaffa
South
Ashdod
Trawl fish
Coastal fish
Molluscs

Fig. 2: Cont.

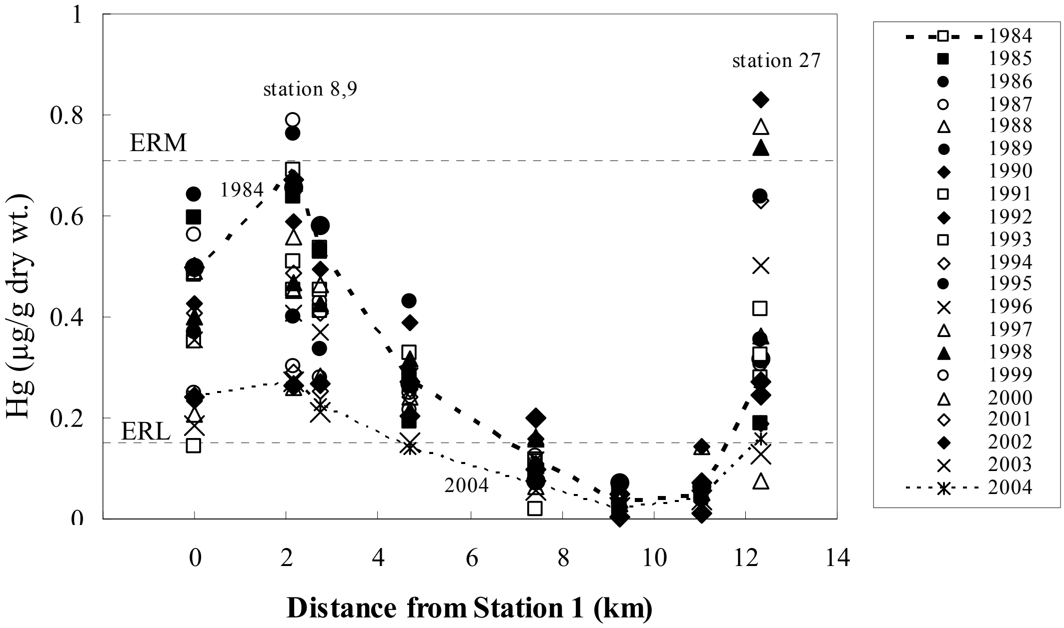


Fig. 3. Mercury concentrations (μg g^{-1} dry wt.) in surficial sediments from the shallow area of Haifa Bay during 1984-2004. ERL is Effects Range Low; ERM is Effects Range Median.

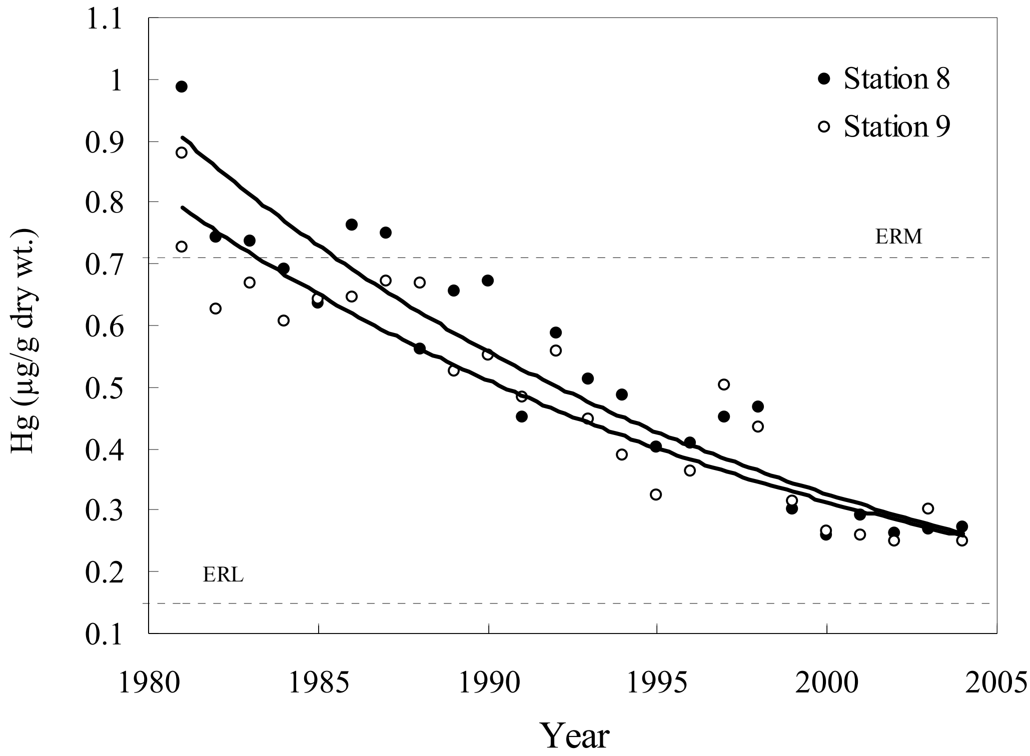


Fig. 4: Mercury concentrations (μg g^{-1} dry wt.) in surficial sediments from stations 8 and 9 in northern Haifa Bay, at water depths of 3 and 6m respectively, during 1981-2004. ERL is Effects Range Low; ERM is Effects Range Median.

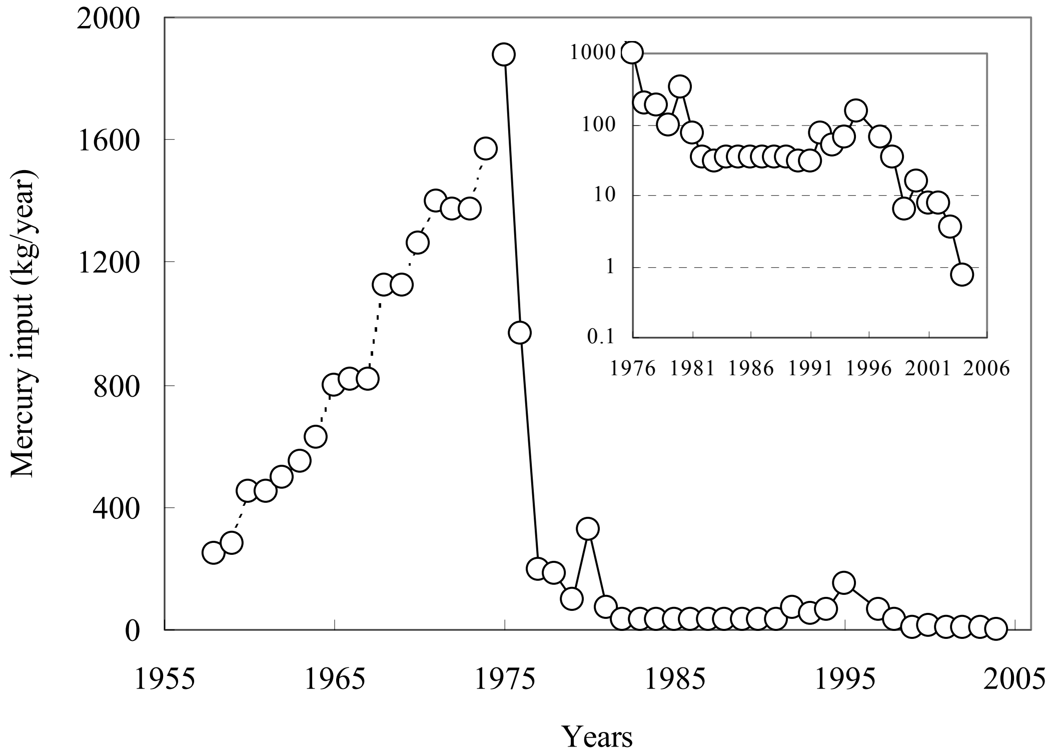


Fig. 5: Annual amounts of mercury introduced into Haifa Bay by effluents from the 'Electrochemical Industries'. The factory was closed in 2004.

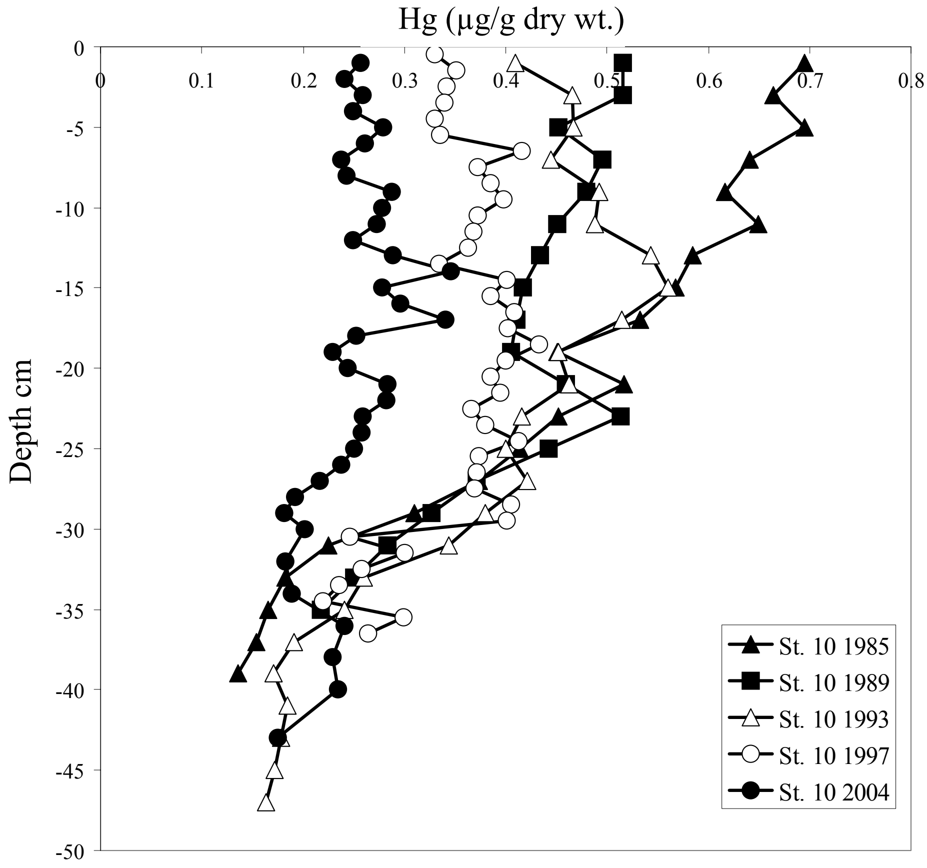


Fig. 6: Profiles of mercury concentrations in sediment cores at station 10 in Haifa Bay during 1985 – 2004 (the integrated area below the profile represents the total amount of mercury in the core per cm^2).

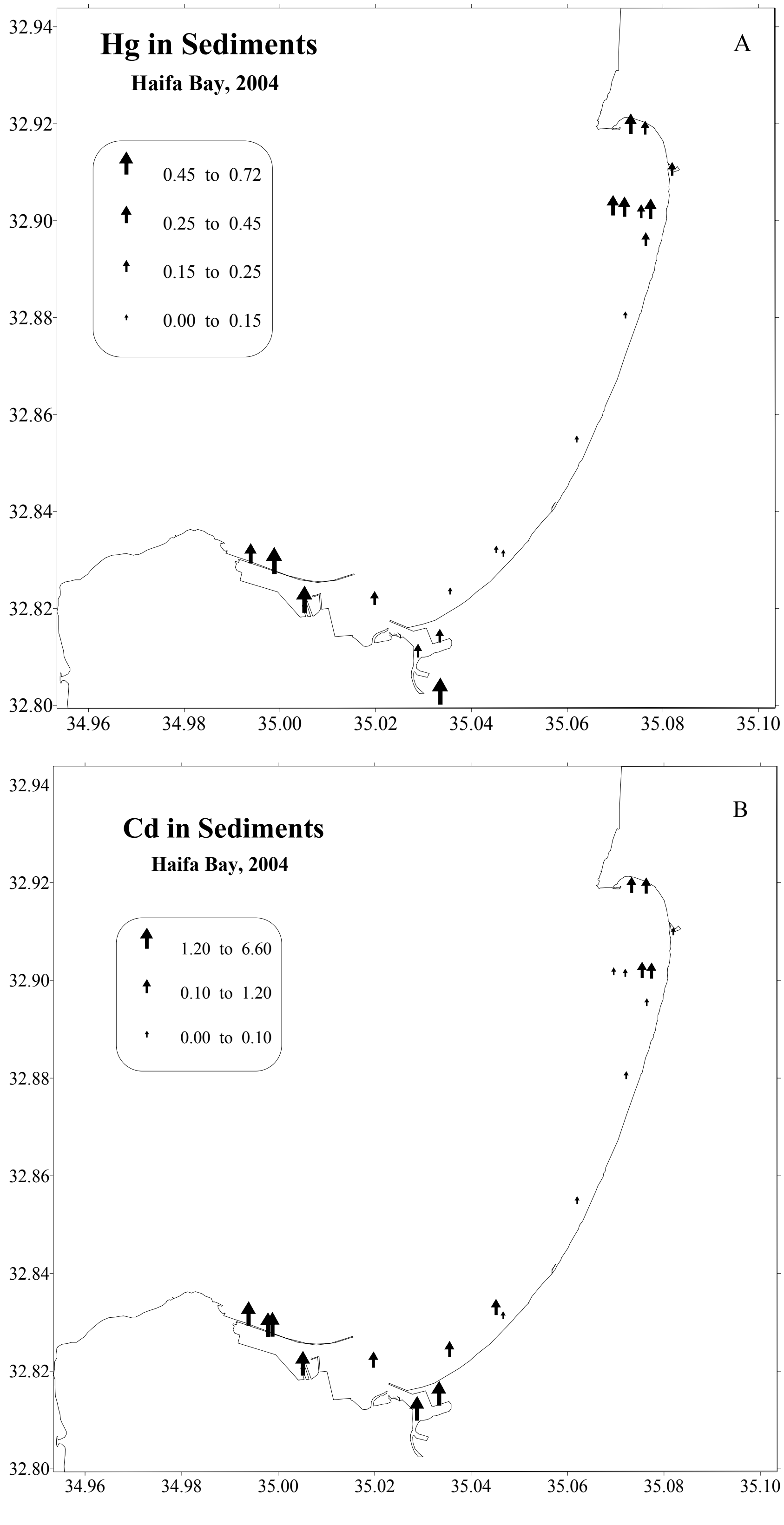


Fig. 7: Mercury (A) and cadmium (B) concentrations ($\mu g\ g^{-1}$ dry wt.) in Haifa Bay sediments, 2004 (size of arrows represents concentration).

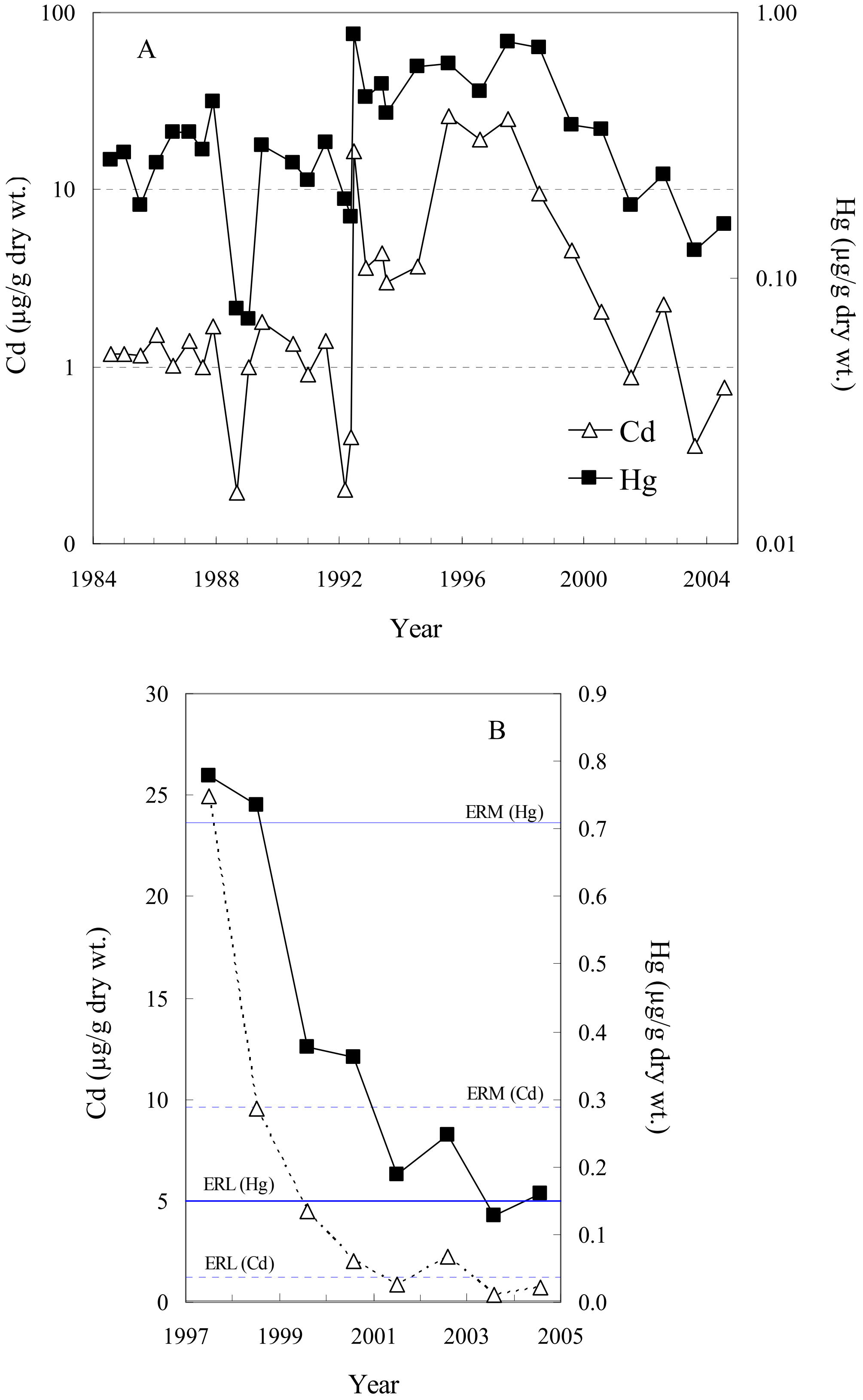


Fig. 8: Cadmium and mercury concentrations (μg g^{-1}dry wt.) in surficial sediments from the Qishon River estuary (station 27) during 1984-2004. (A) logaritmic scale; (B) linear scale for 1997–2004.

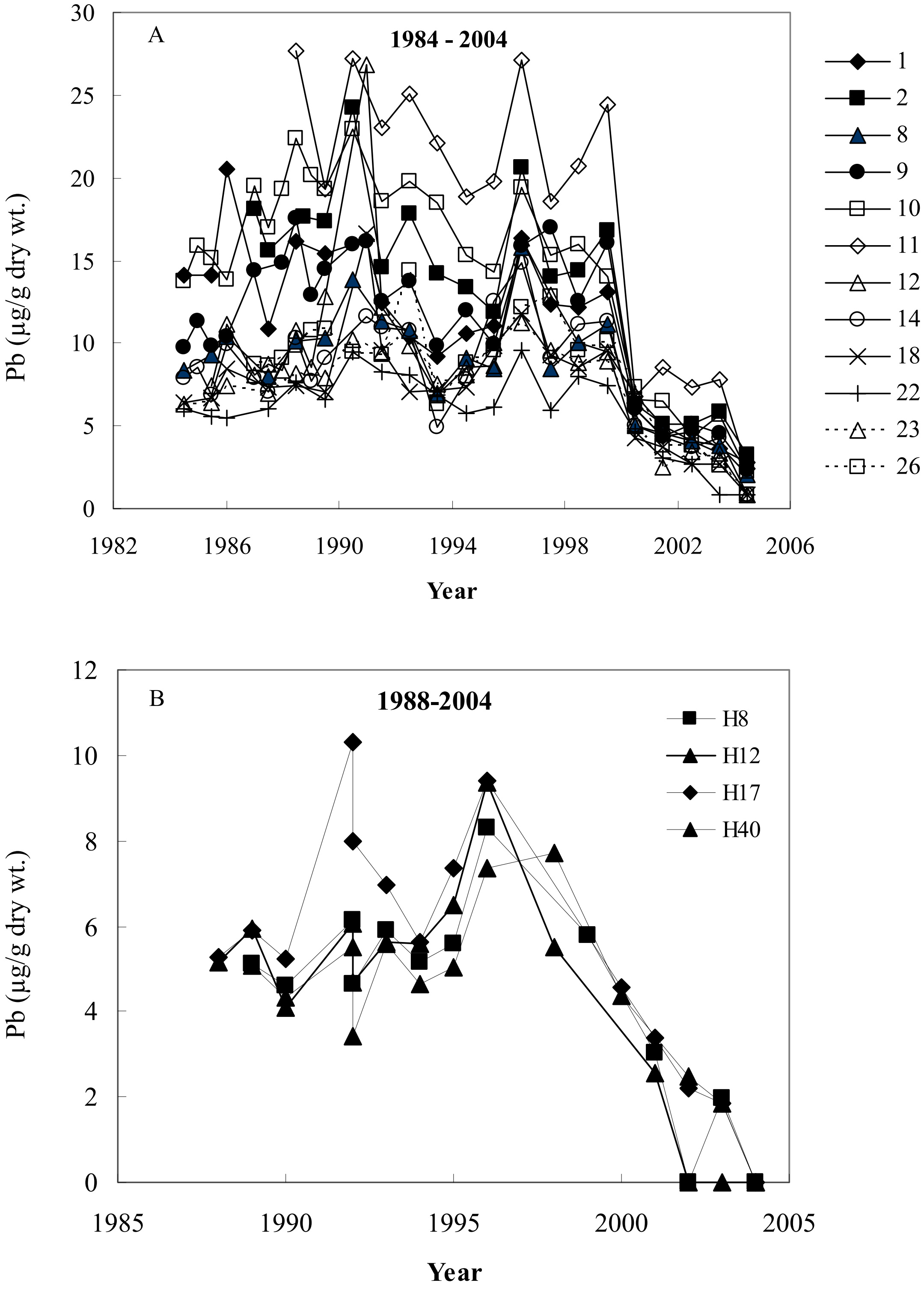


Fig. 9: long-term trends of lead concentrations in surface sediments in Haifa Bay (A) and along the coast (B) during 1984-2004.

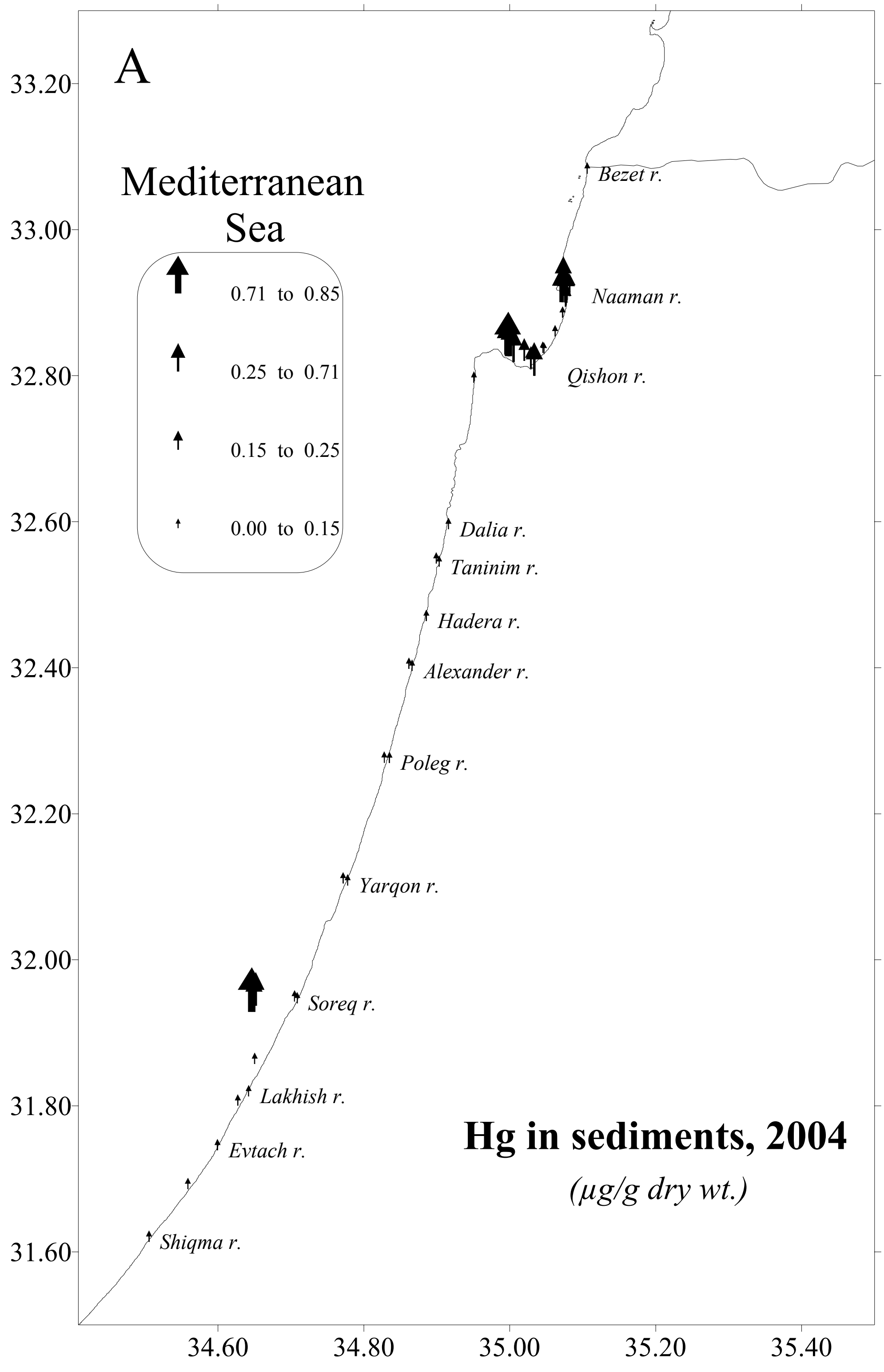


Fig. 10: Mercury (A) and cadmium (B) concentrations in sediments along the Mediterranean coast of Israel in 2004 (size of arrows represents concentration).

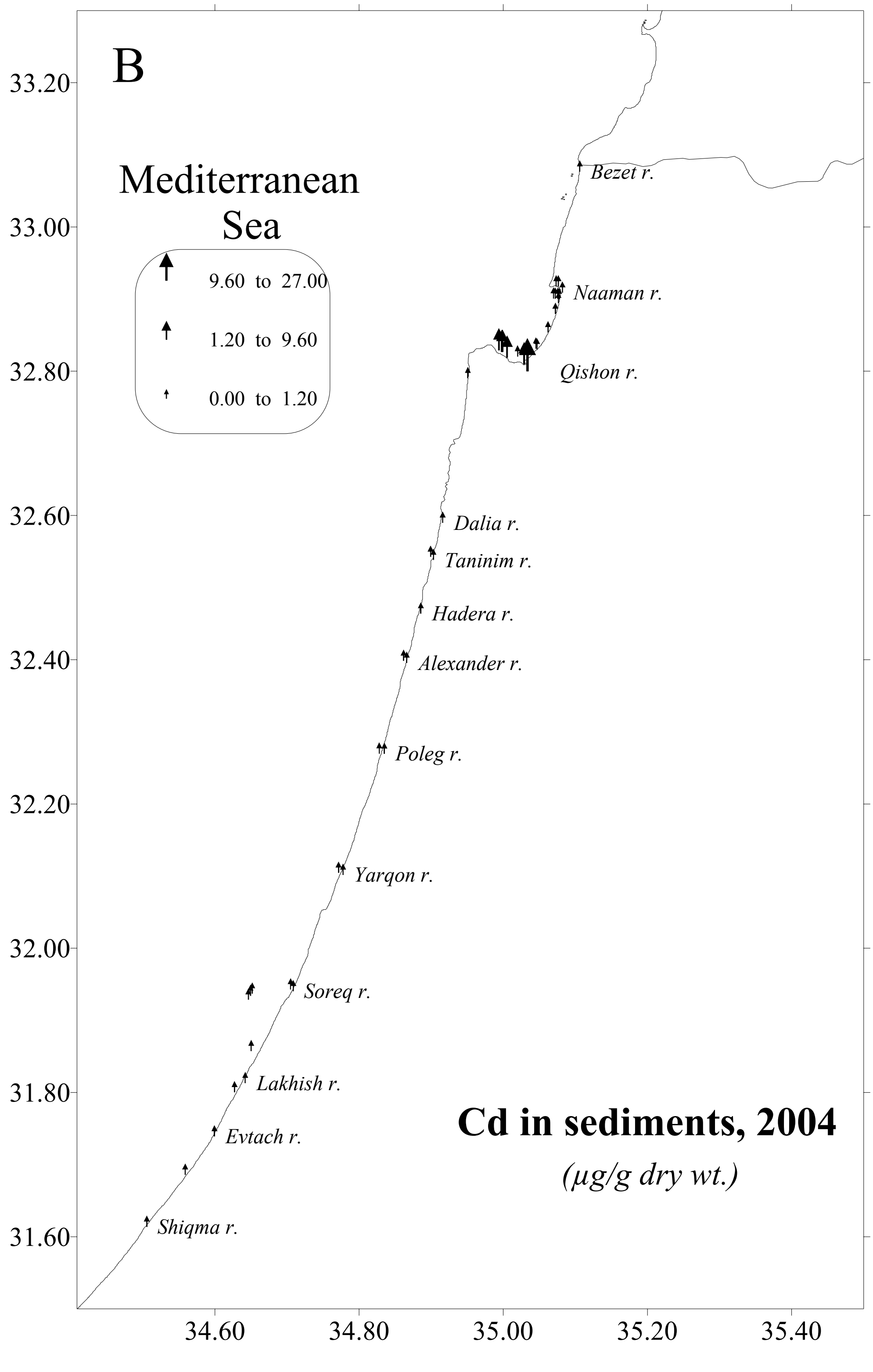

B
Mediterranean Sea
9.60 to 27.00
1.20 to 9.60
0.00 to 1.20
Bezet r.
Naaman r.
Qishon r.
Dalia r.
Taninim r.
Hadera r.
Alexander r.
Poleg r.
Yarqon r.
Soreq r.
Lakhish r.
Evtach r.
Shiqma r.
Cd in sediments, 2004
(µg/g dry wt.)
33.20
33.00
32.80
32.60
32.40
32.20
32.00
31.80
31.60
34.60
34.80
35.00
35.20
35.40

Fig. 10: Cont.

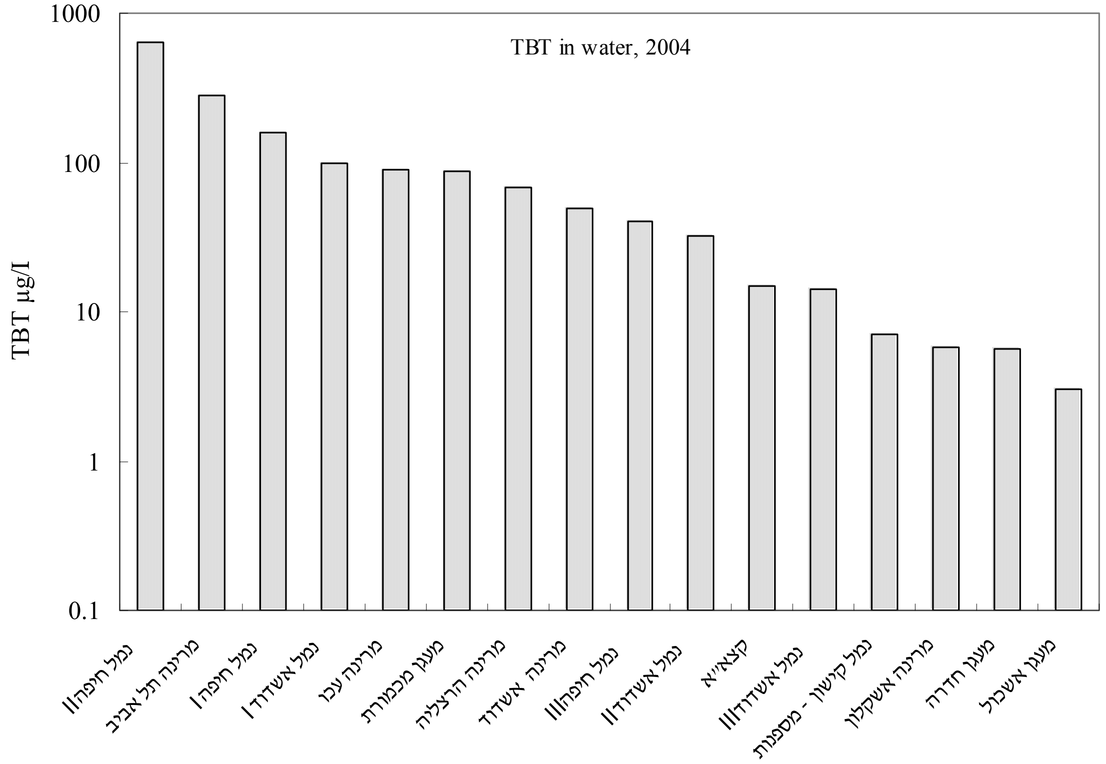


Fig. 11: TBT concentrations (µg/L, logarithmic scale) in seawater at ports and marinas along the Mediterranean coast of Israel (August 2004).

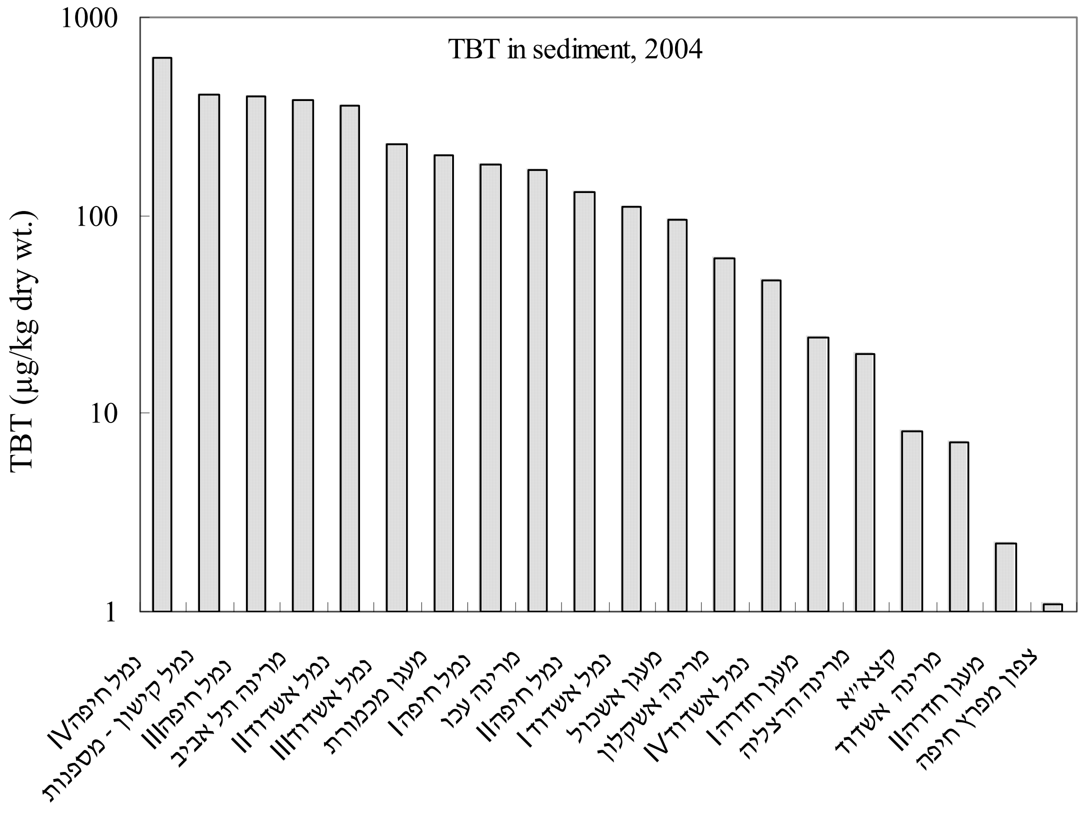


Fig. 12: TBT concentrations (µg/kg, logarithmic scale) in sediments at ports and marinas along the Mediterranean coast of Israel during 2004.

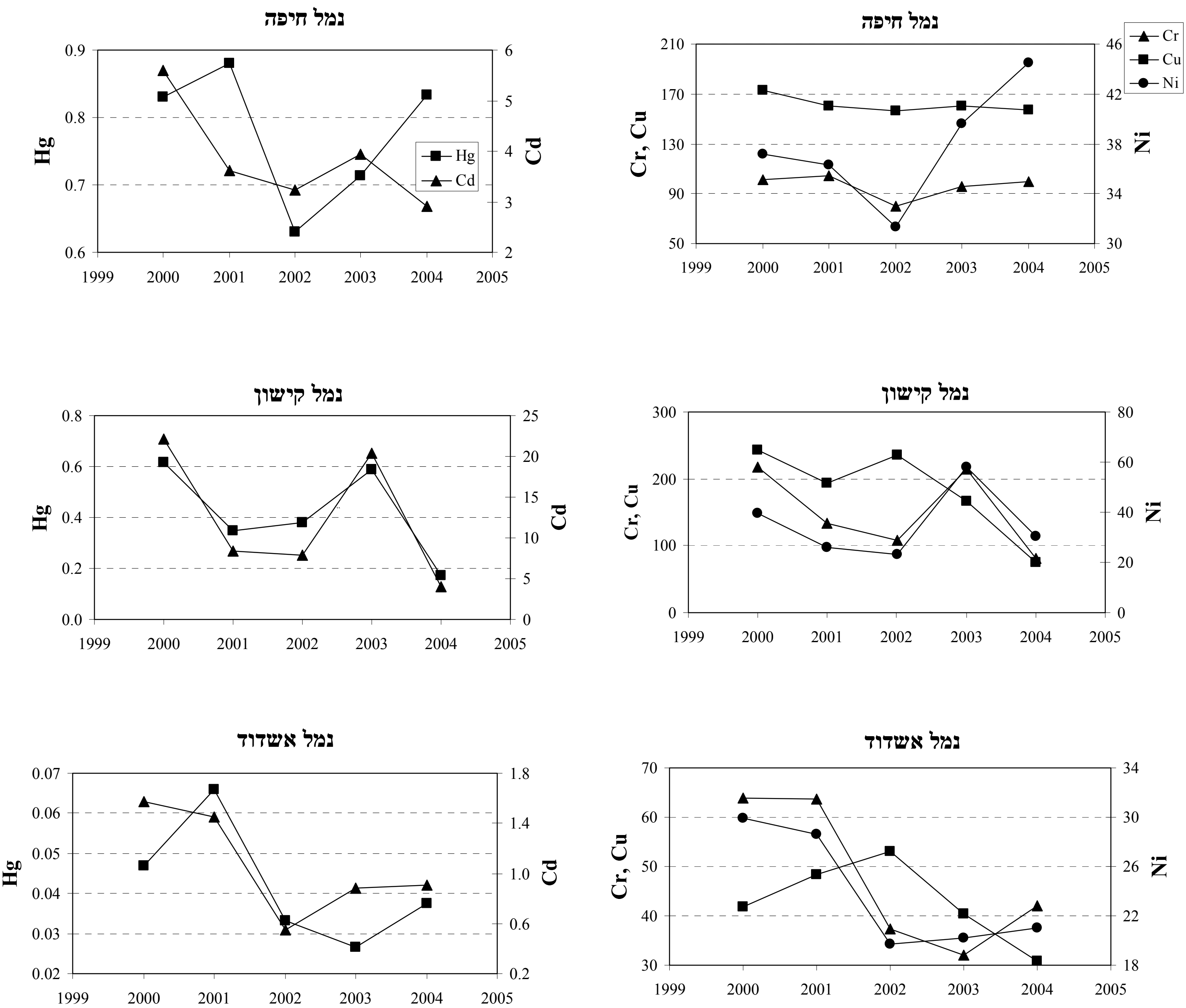


Fig. 13: Trends of heavy metal (μg/g dry wt.), PCB's ((μg/g dry wt.) and TBT (ng/g dry wt.) concentrations in surface sediments in ports and marinas during 2000-2004.

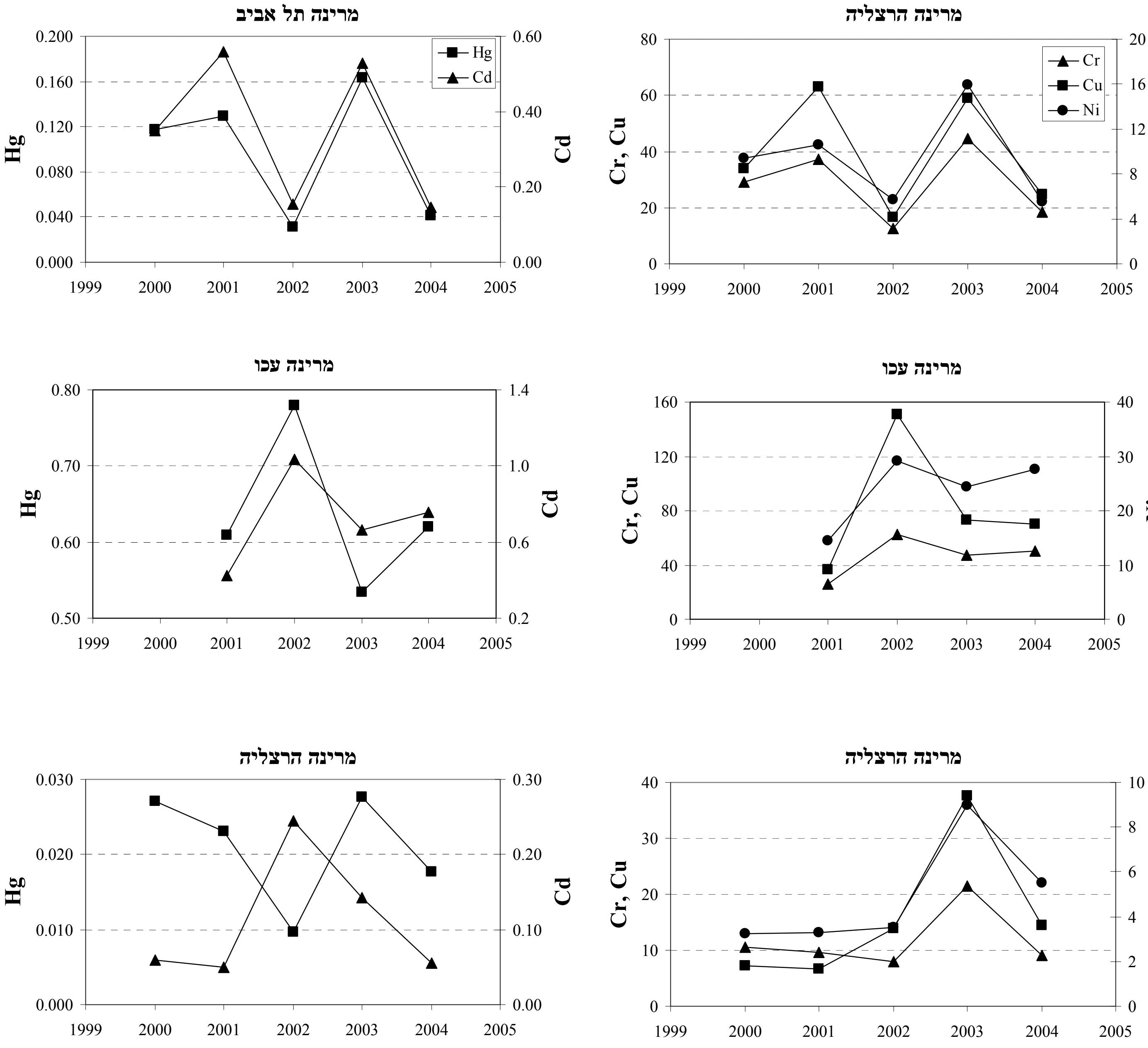


Fig 13: cont. (heavy metals).

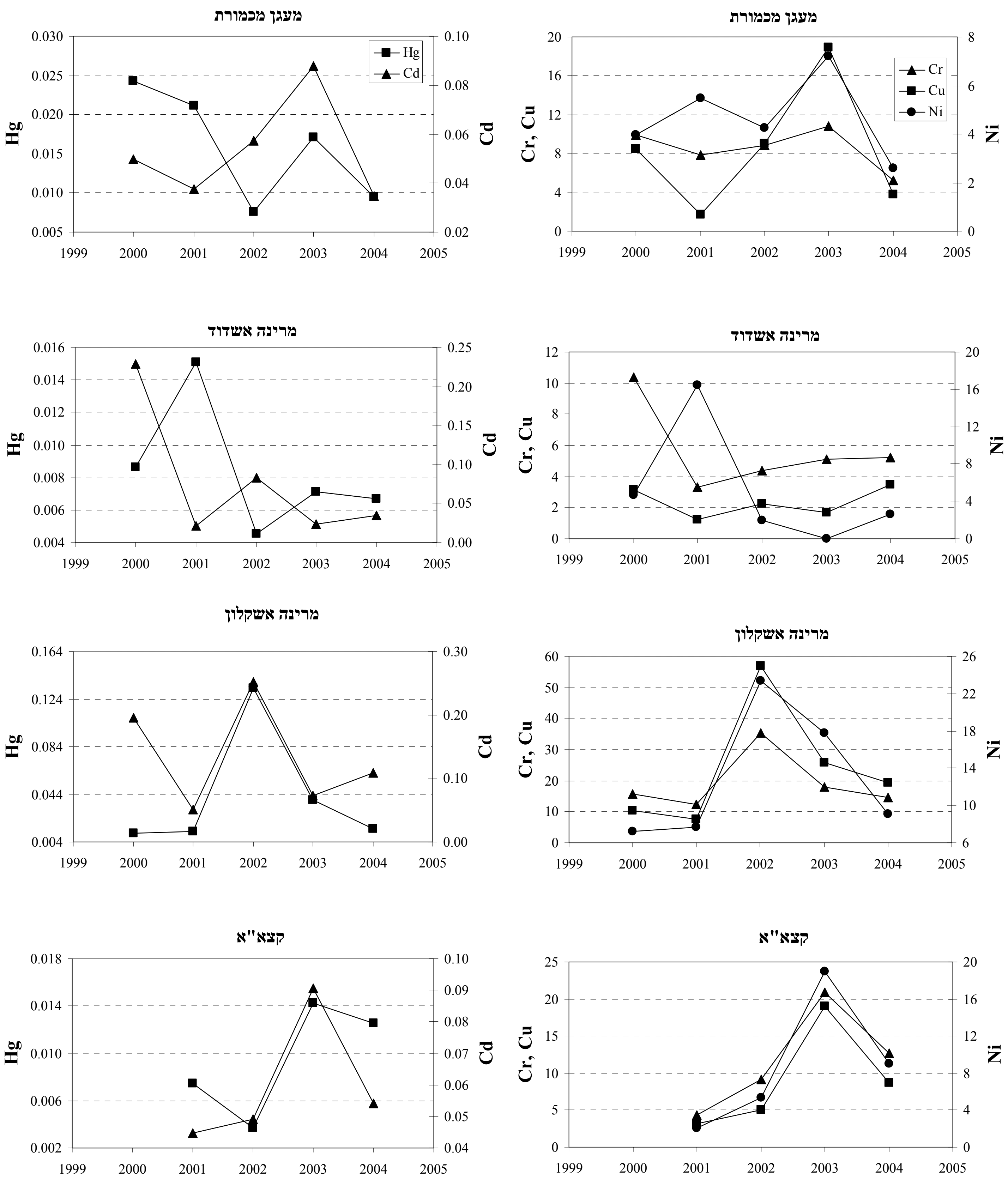


Fig 13: cont. (heavy metals).

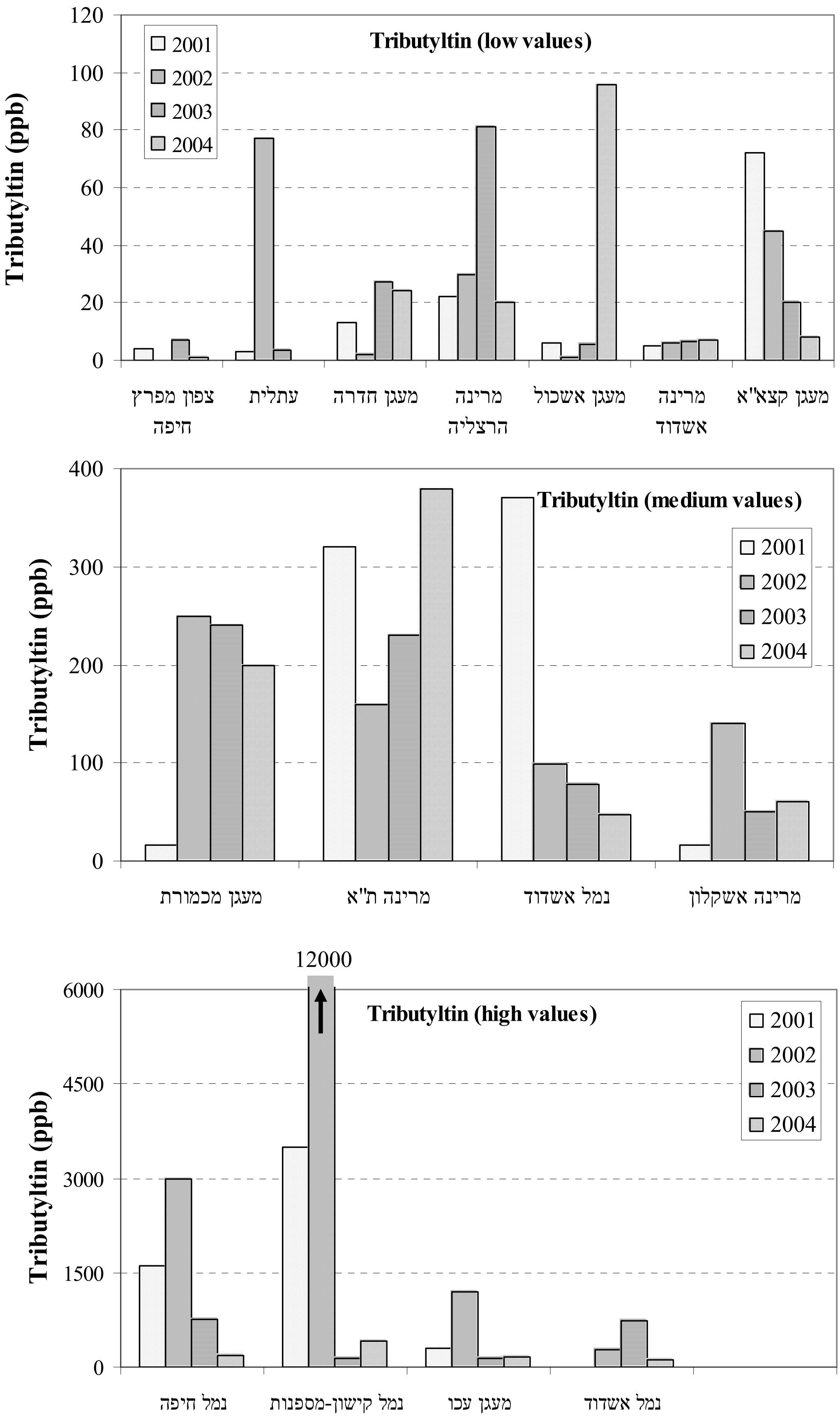


Fig 13: cont. (TBT).

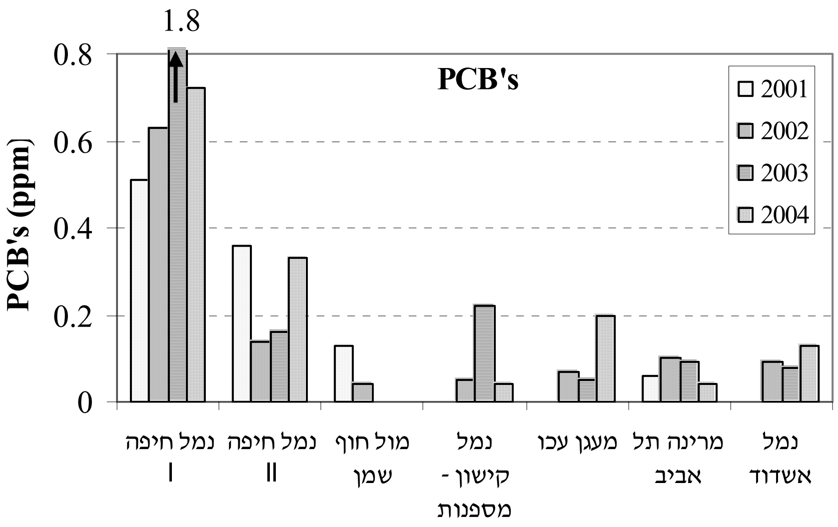
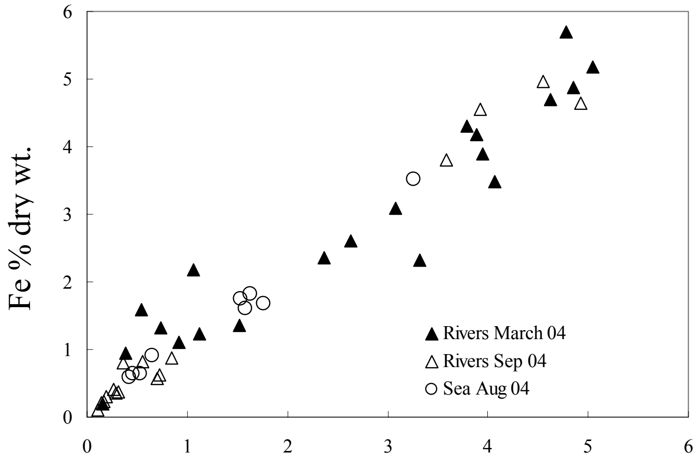


Fig 13: cont. (PCB's).



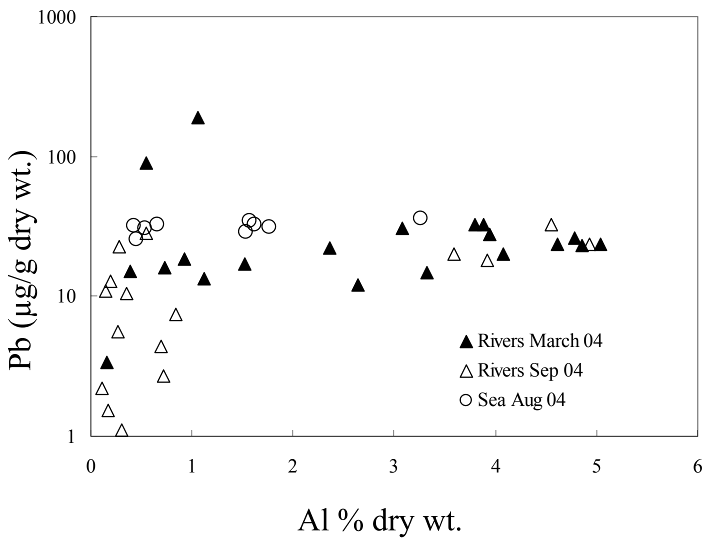
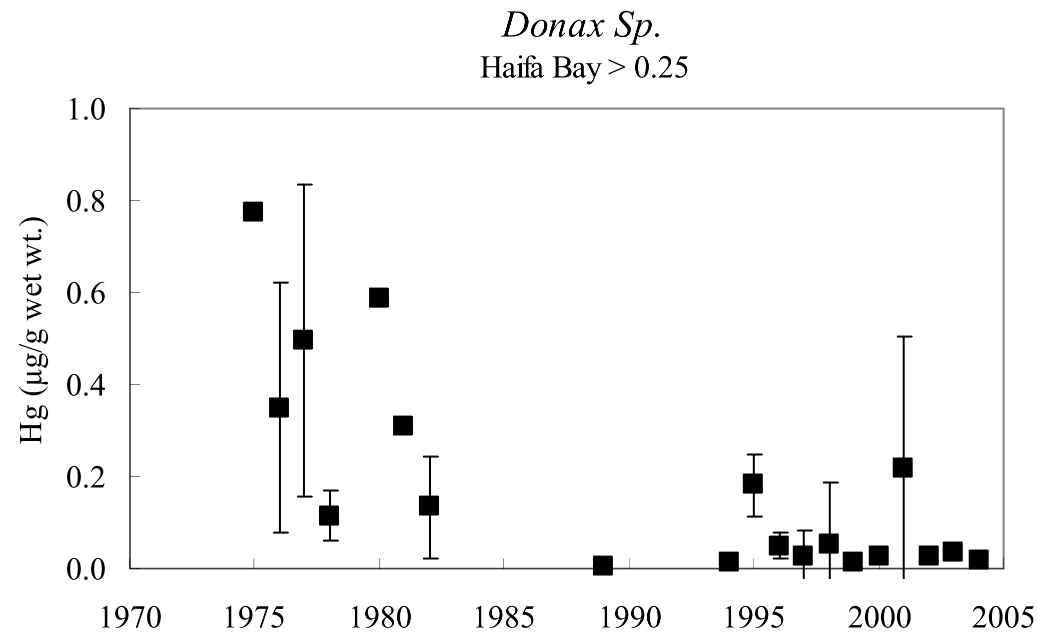


Fig. 14: Relationships between Fe, Pb and Al in suspended particulate matter sampled in shallow surface water along the Mediterranean coast of Israel in 2004.



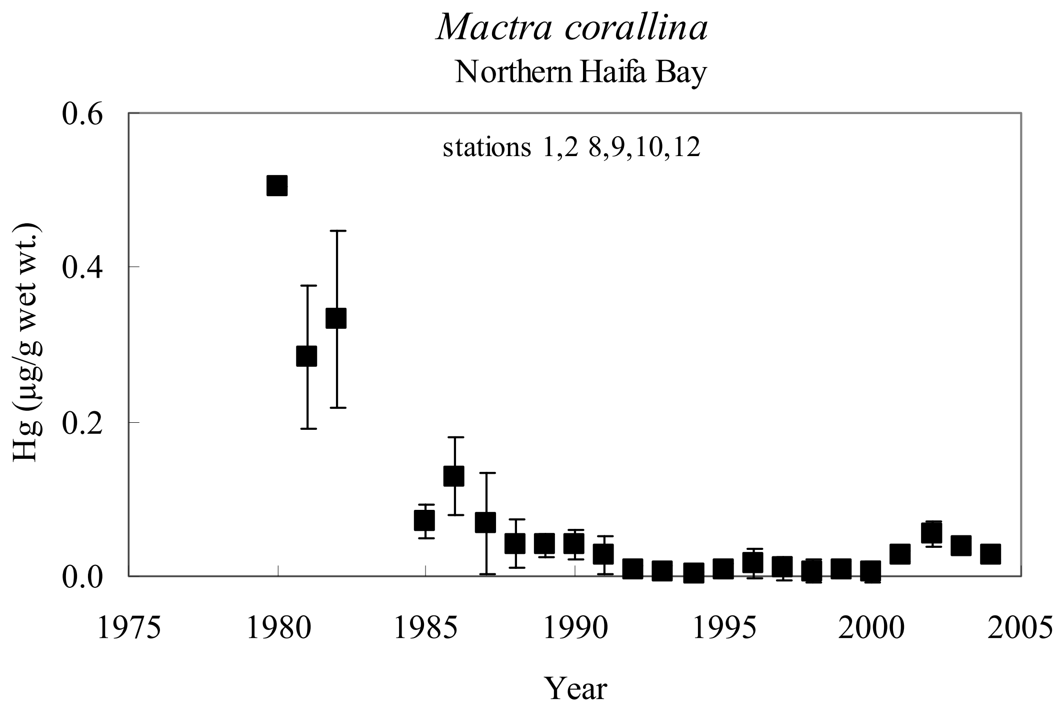


Fig. 15: Decrease of mercury concentrations (µg g^{-1} wet wt.) in bivalves from Haifa Bay: *Mactra corallina* (1980-2004) and *Donax sp*. (1975-2004).

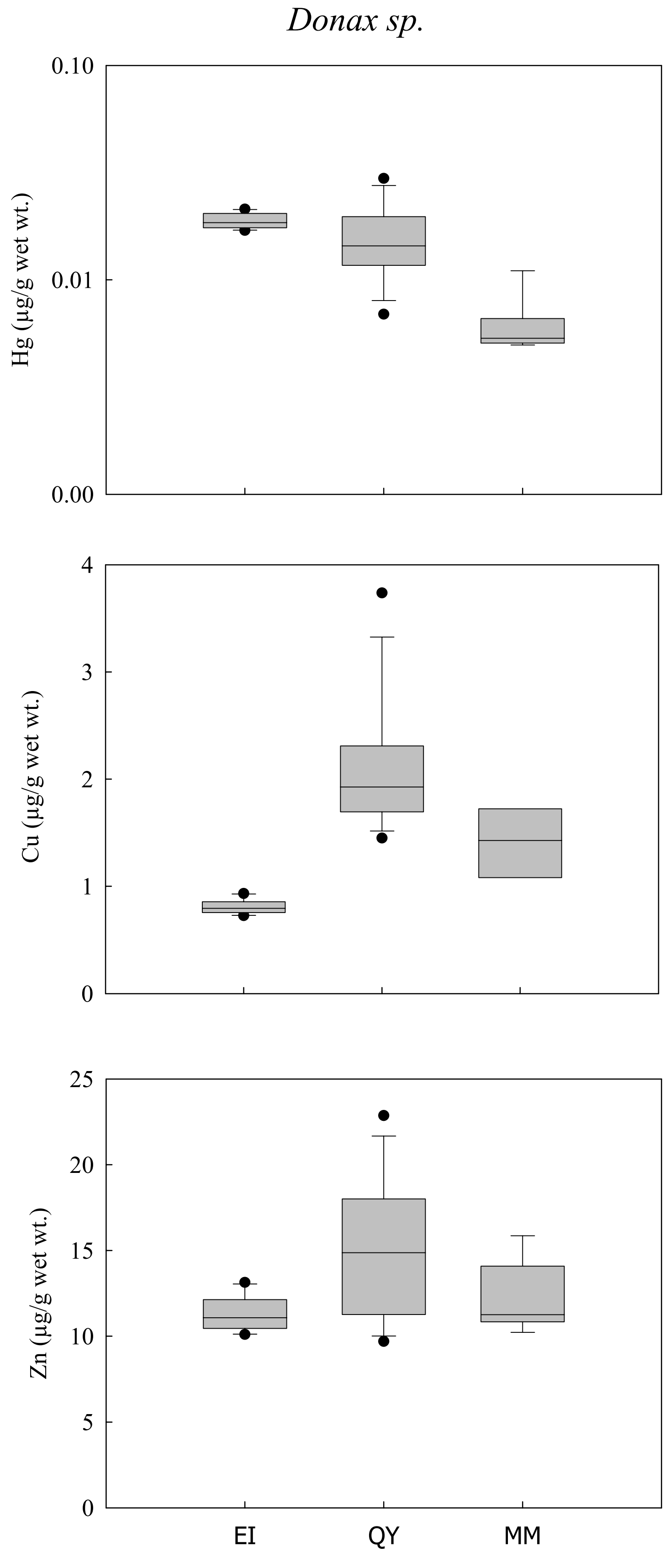
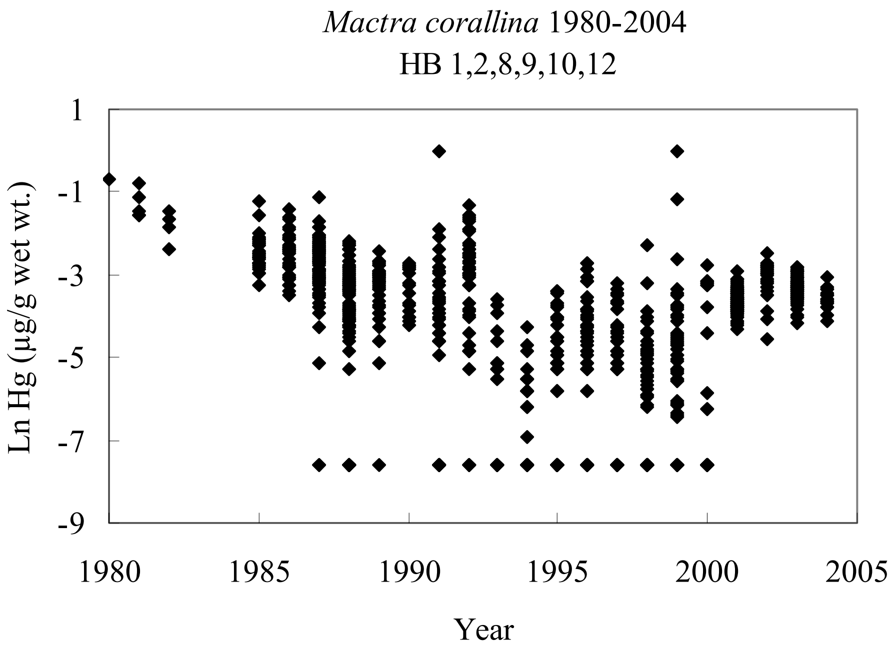


Fig. 16: Box plots of Hg, Cu, and Zn concentrations in the bivalve *Donax sp.* collected at different sites during 2004. The bottom and the top edge of each box are located at the sample 25 and 75 percentiles. The center horizontal line is drawn at the sample median (EI=Electrochemical industries, QY=Qiryat Yam, MM=Maagan Michael).



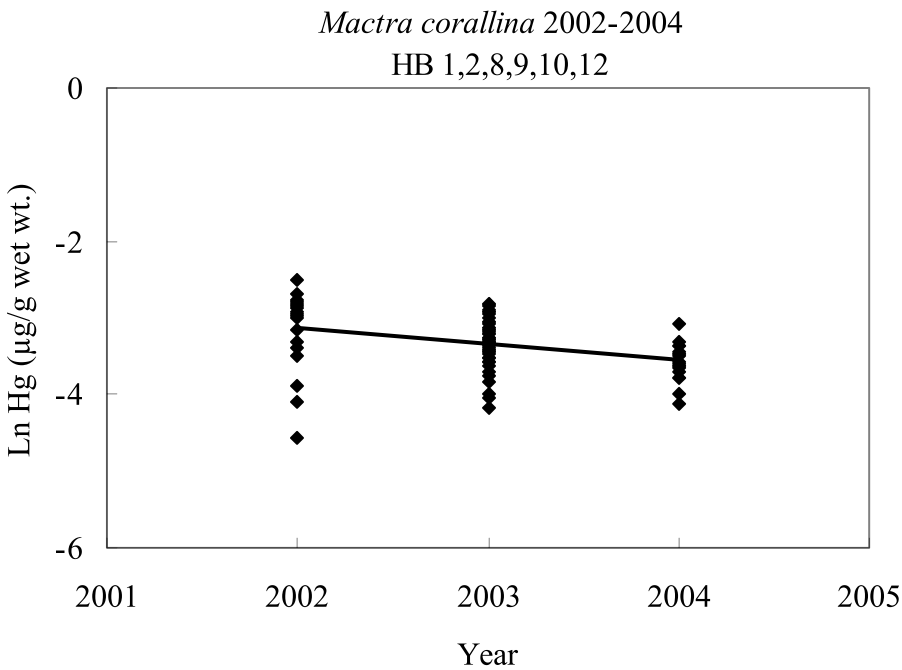


Fig. 17: Variations of Hg concentrations (logarithmic scale of µg g^{-1} wet wt.) in the bivalve *Mactra corallina* from northern Haifa Bay during 1980 – 2004. Analytical detection limit was 0.0005 µg g^{-1} dry wt.

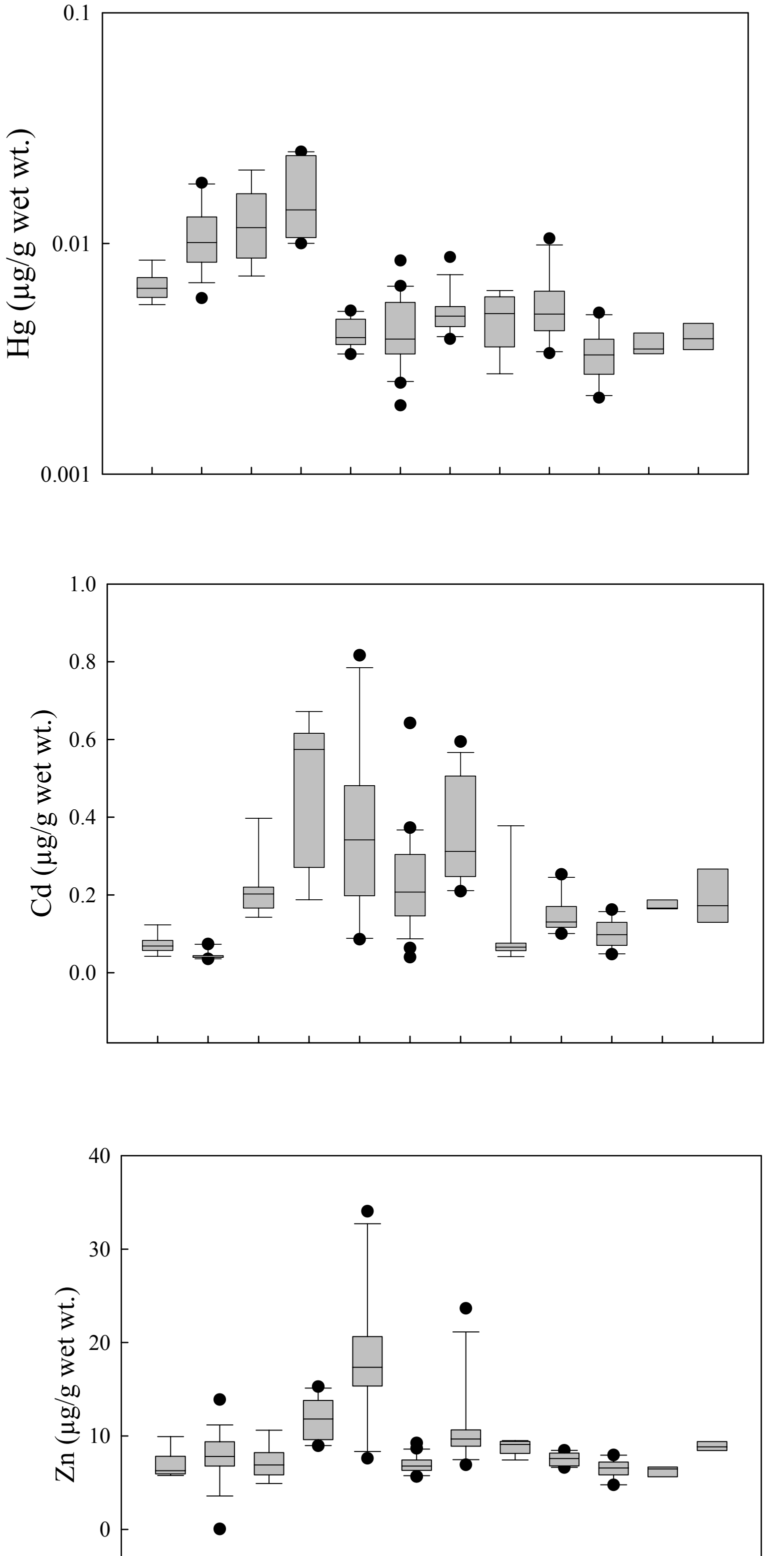


Fig. 18: Box plots of Hg Cd and Zn concentrations in the gastropods *Patella sp.* collected at different sites during 2004. The bottom and the top edge of each box are located at the sample 25 and 75 percentiles. The center horizontal line is drawn at the sample median (ACH=Achziv, AK-B=Akko sewage, AK-P=Akko port, QY=Qiryat Yam, HS=Hof Shemen, TS=Tel Shiqmona, AT=Atlit, MM=Maagan Michael, HAD=hadera, MIC=Michmoret, PAL=Palmachim, ASH=Ashdod marina).

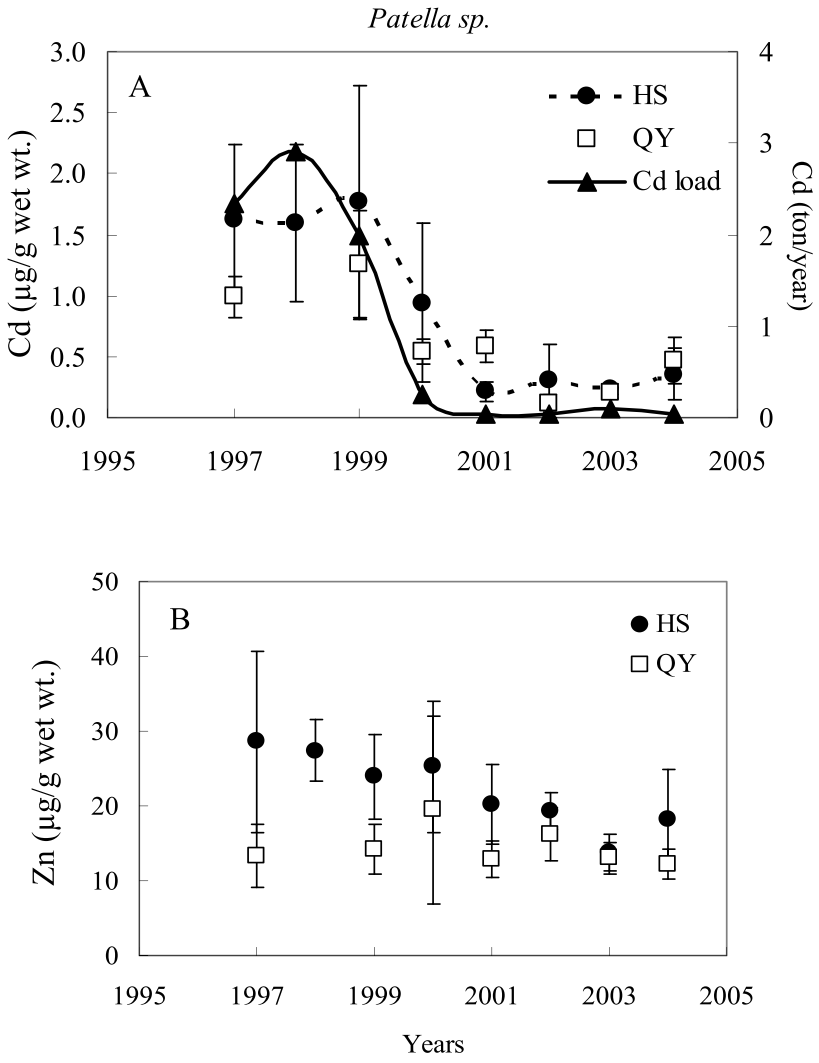


Fig. 19: Cadmium (A)and zinc (B) concentrations (µg g^{-1} wet wt.) in the gastropods *Patella* sp. at the Qishon River estuary (HS) and Qiryat Yam (QY), during 1997–2004. Bold line (in graph A) represents the anthropgenic Cd load introduced into the Qishon River

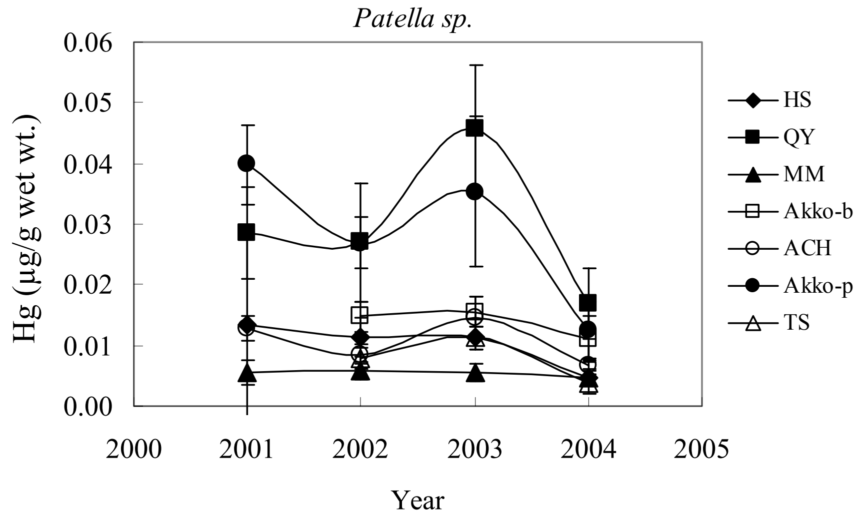
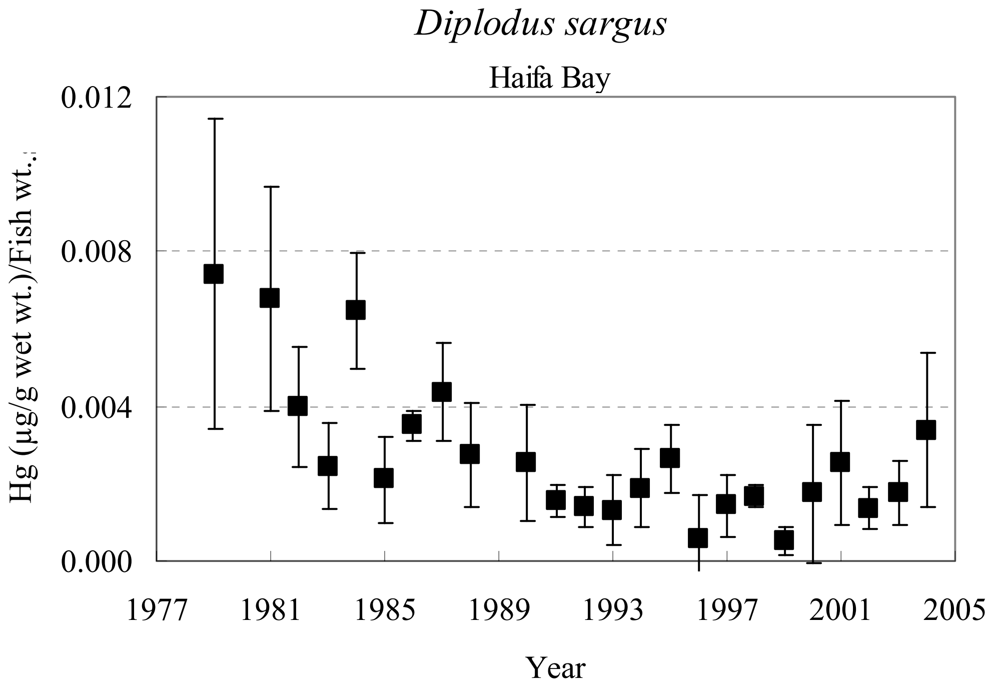


Fig. 20: Mercury concentrations (µg g^{-1} wet wt.) in the gastropods *Patella* sp. at different sites in Haifa Bay during 2001 – 2004.



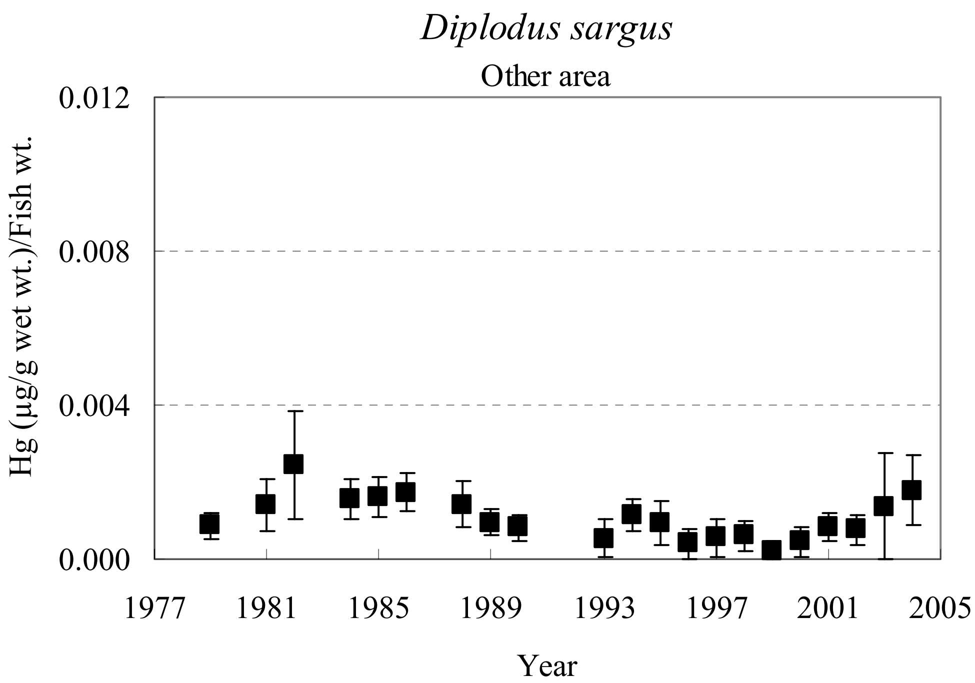
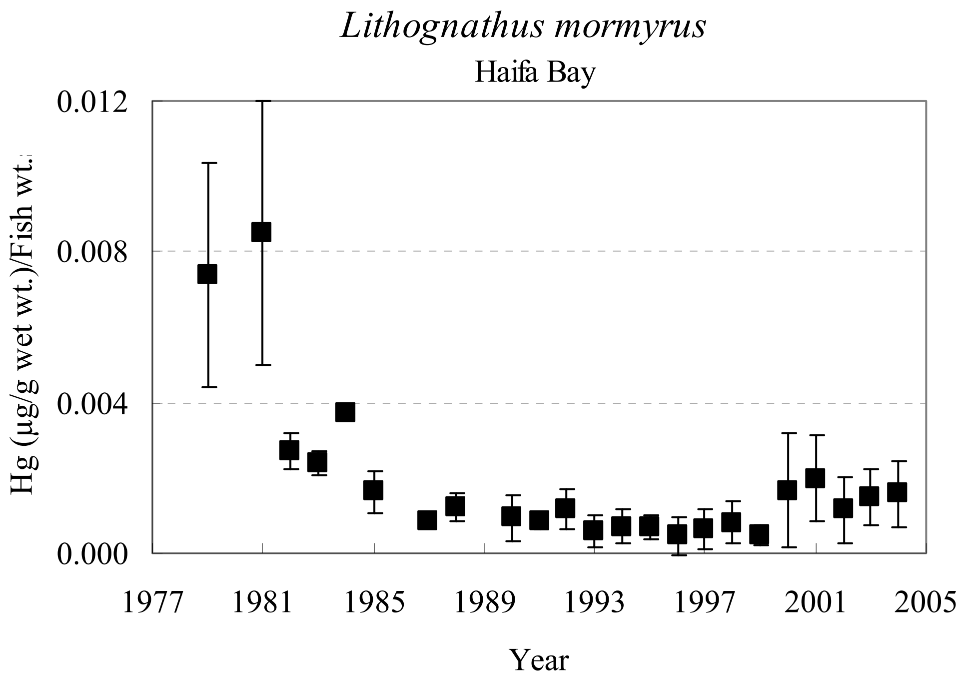


Fig. 21: Mercury/body weight ratios in the muscle tissues of specimens of *Diplodus sargus* (annual average±standard deviation) from Haifa Bay and from other areas along the Israeli coastline, during 1979-2004.



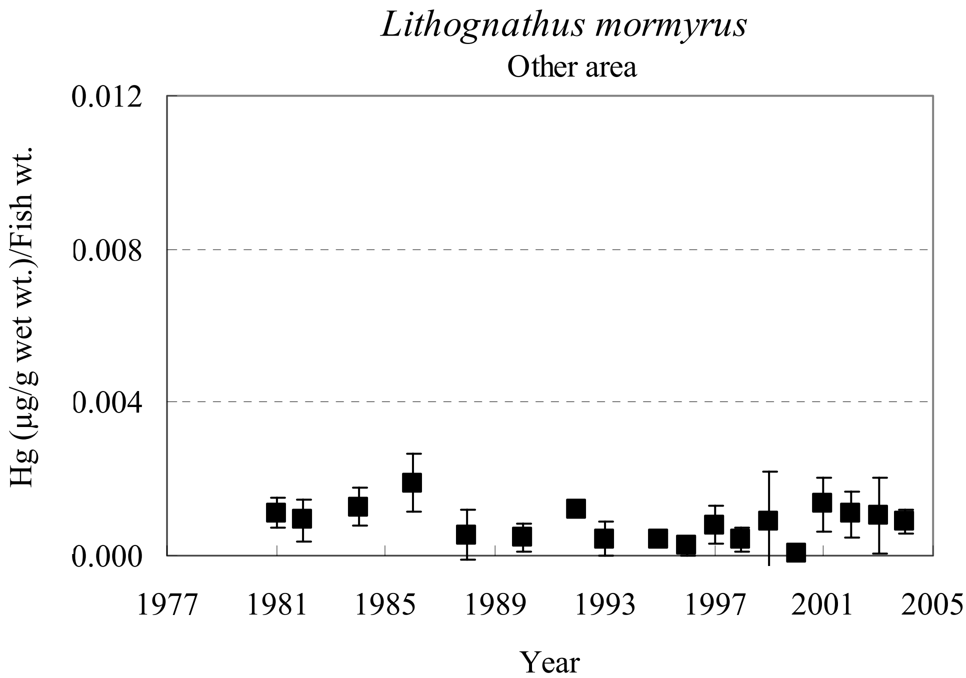


Fig. 22: Mercury/body weight ratios in the muscle tissues of specimens of *Lithognathus mormyrus* (annual average ±standard deviation) from Haifa Bay and from other areas along the Israeli coastline, during 1979-2004.

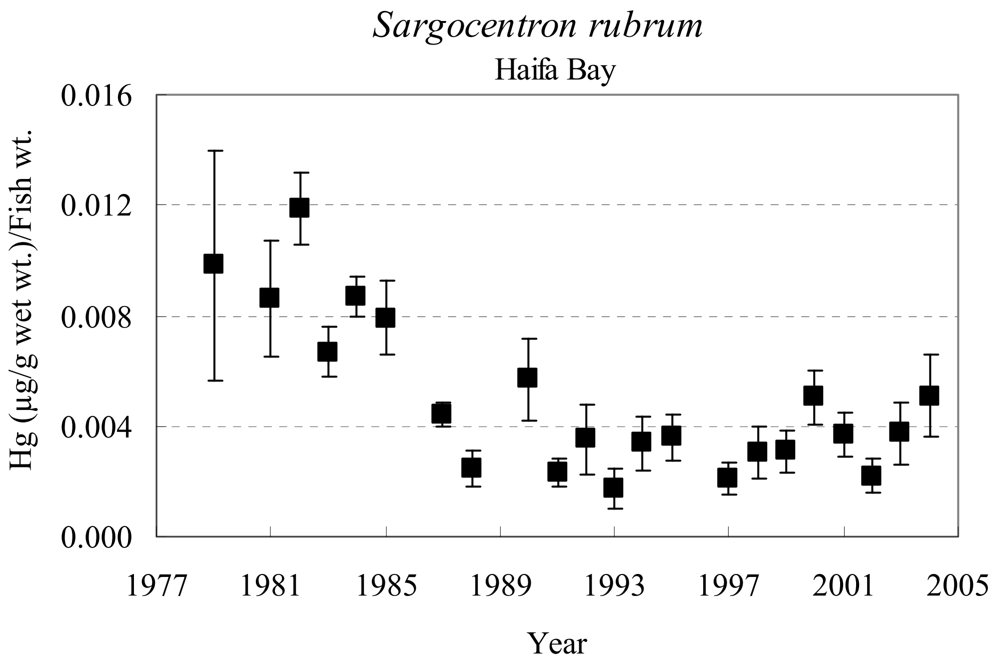


Fig. 23: Mercury/body weight ratios in the muscle tissues of specimens of *Sargocentron rubrum* (annual average ±standard deviation) from Haifa Bay and from other areas along the Israeli coastline, during 1979-2004.

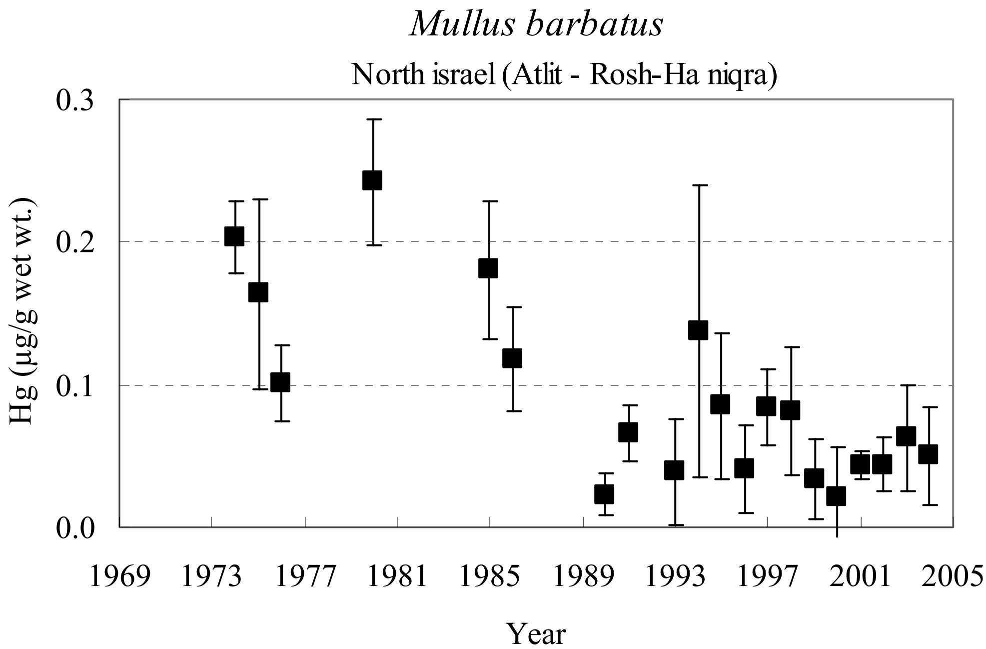


Fig. 24: Changes in mercury concentrations (µg/g wet wt.) in specimens of *Mullus barbatus* (annual average±standard deviation) caught along the northern part of the Israeli coastline during 1974-2004.

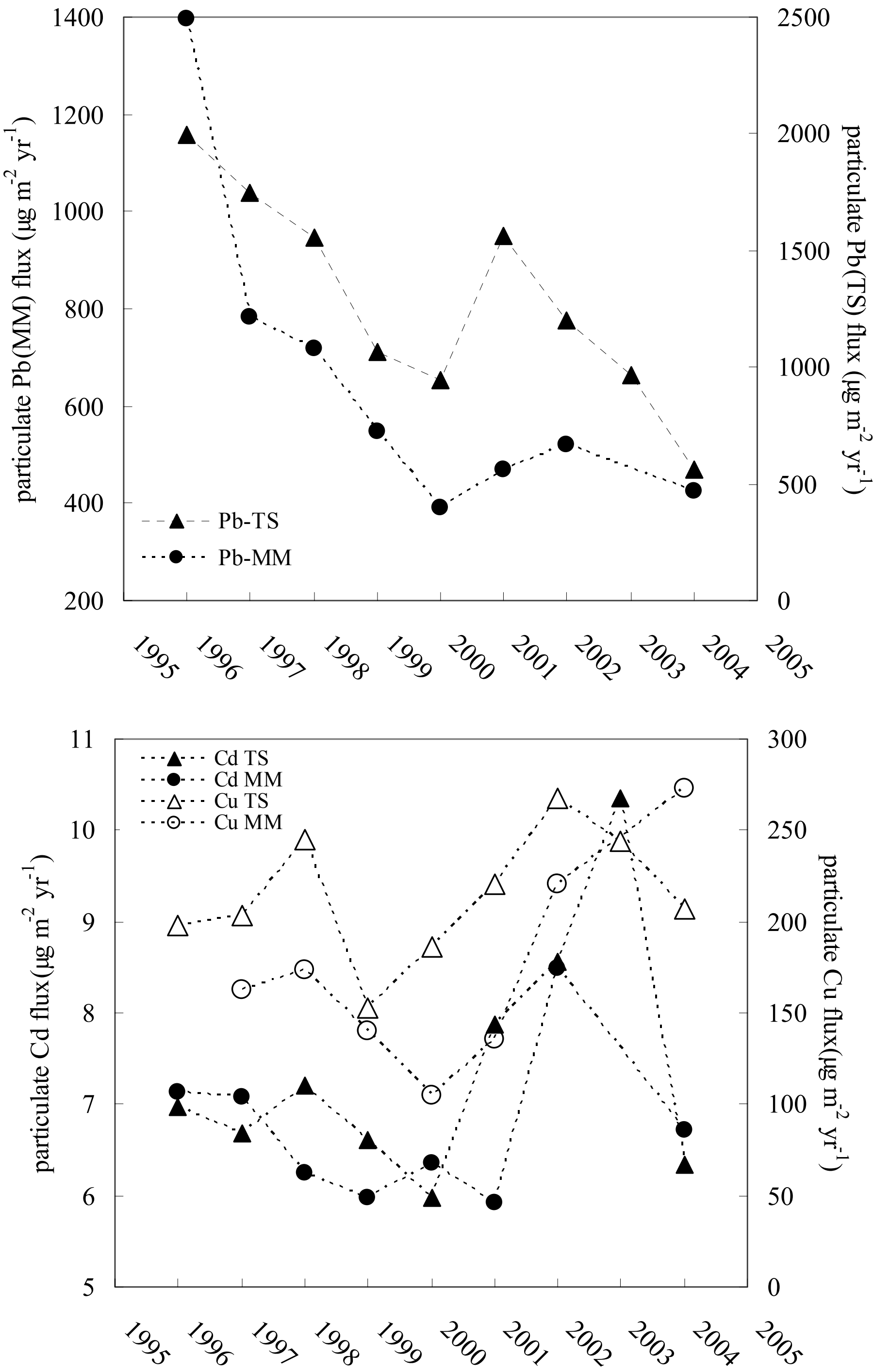
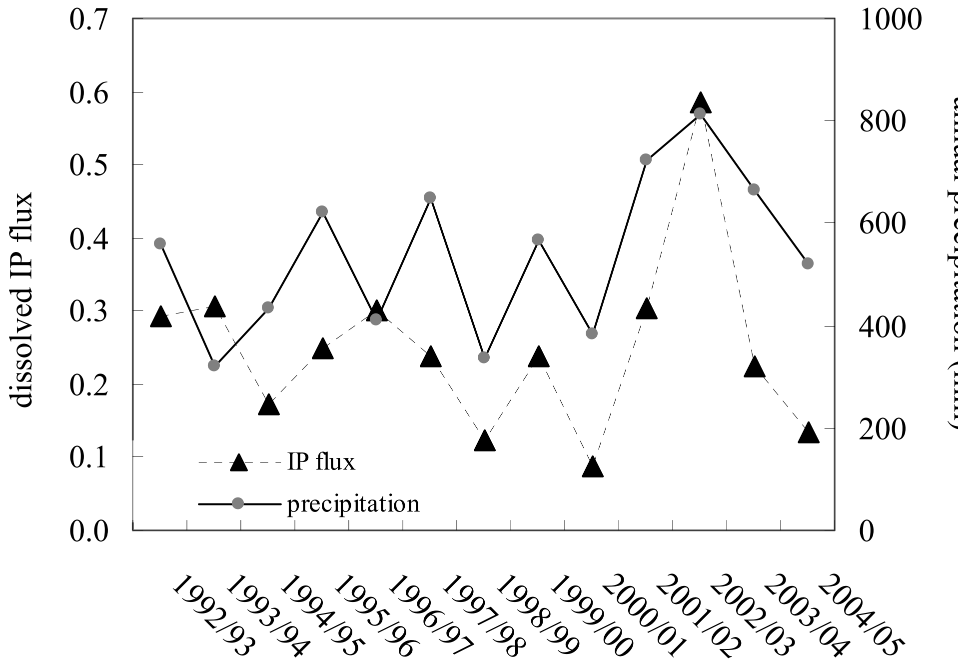


Fig. 25: Atmospheric fluxes of particulate Pb Cd and Cu at Tel-Shikmona (TS) and Maagan Michael (MM) during 1996 – 2004. Annual fluxes were calculated on the basis of sampling during 25% of the total annual days.



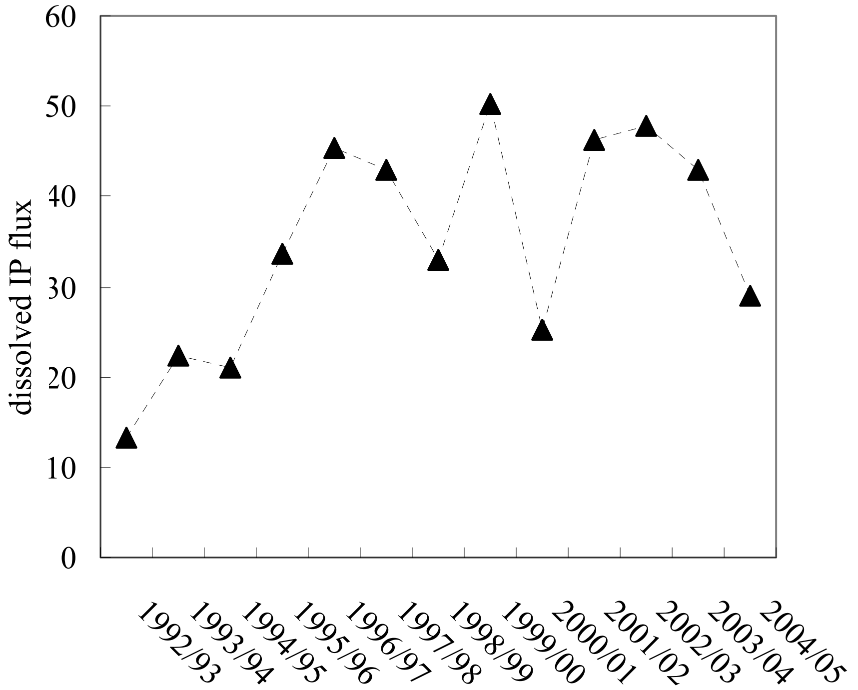
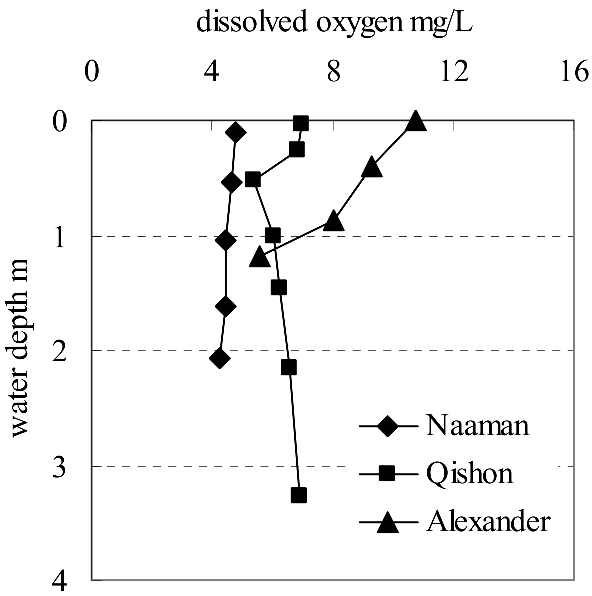
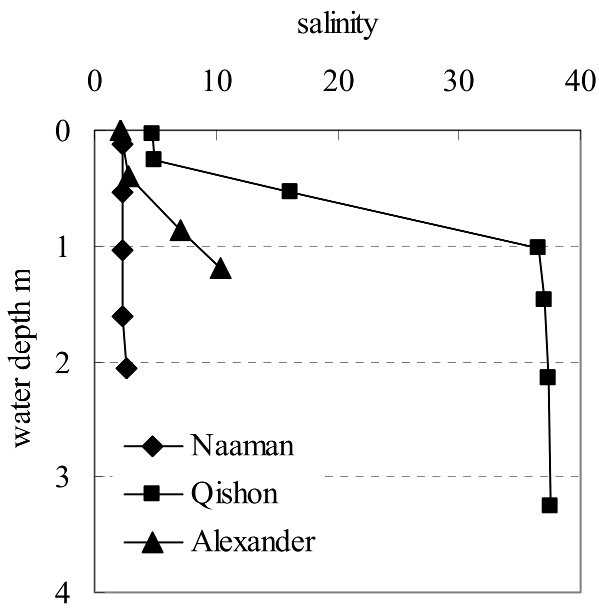


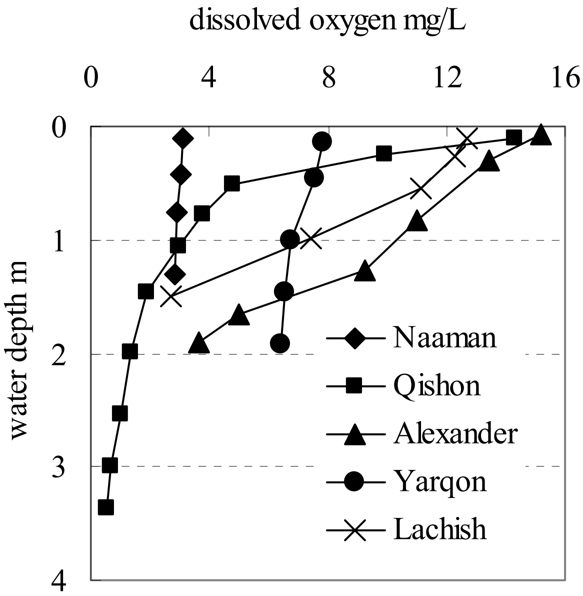
Fig. 26: Atmospheric wet fluxes of inorganic phosphorus (IP) and inorganic nitrogen (IN) (mmol m^{-2} yr^{-1}) at Tel-Shikmona during 1992 – 2004. The annual amount of precipitation at Haifa port is included.

March 2004





September 2004



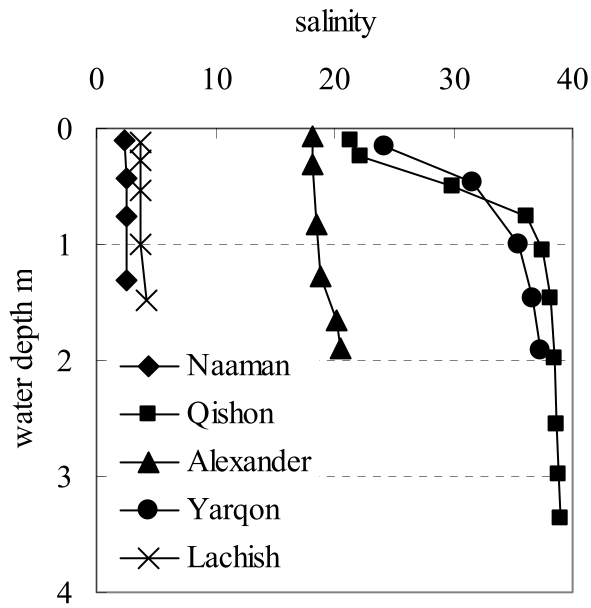
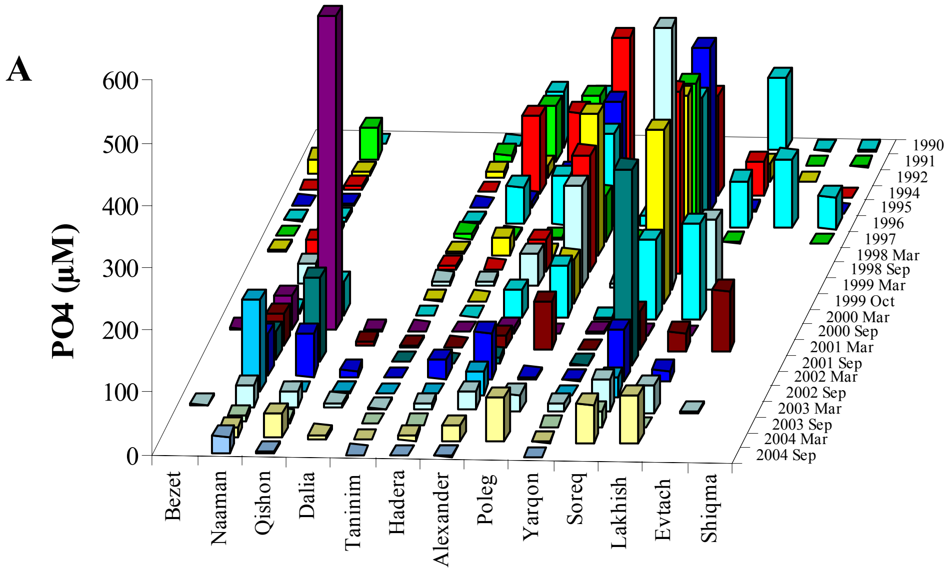


Fig. 27: Depth-profiles of salinity and dissolved oxygen concentrations at the estuaries of Naaman, Qishon and Alexander Rivers during March and September 2004.

Shoreline sampling (A stations)

A



50 m from shoreline (B stations) or more

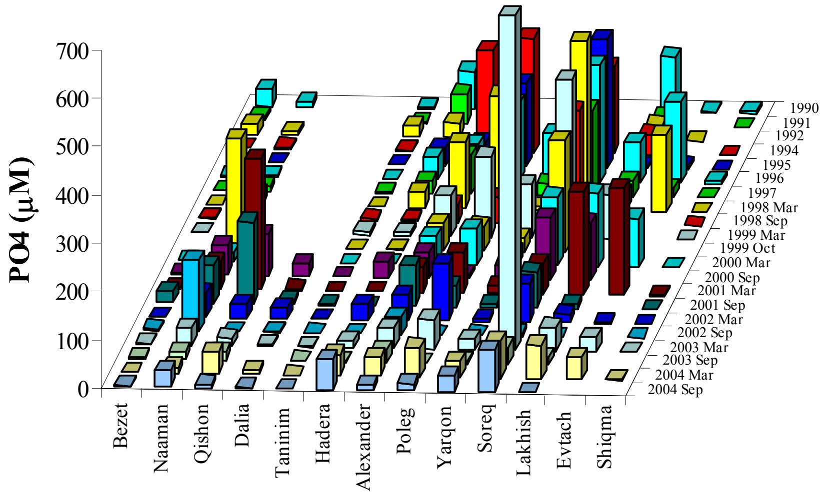
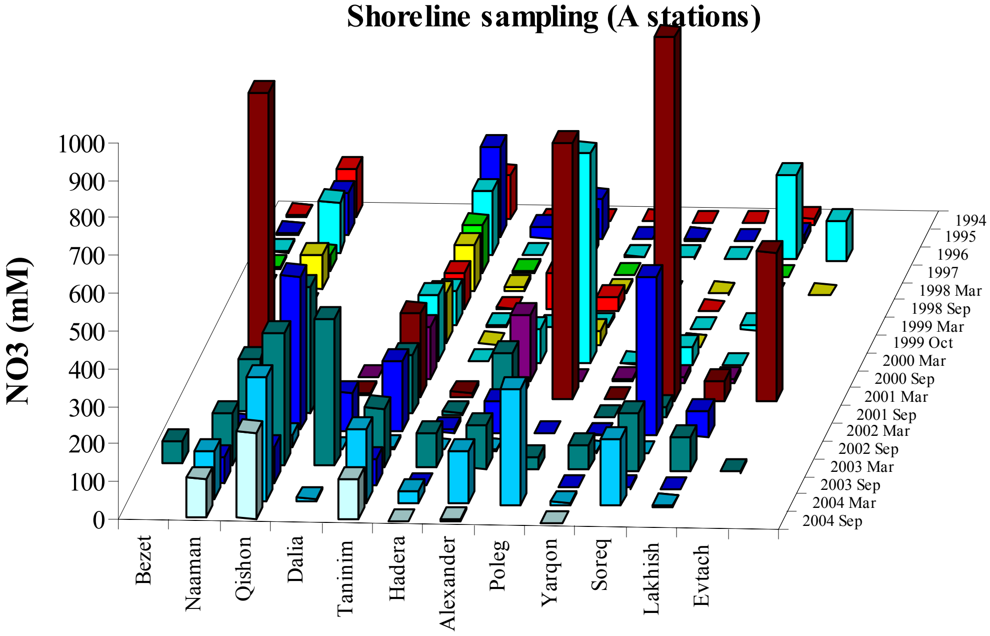


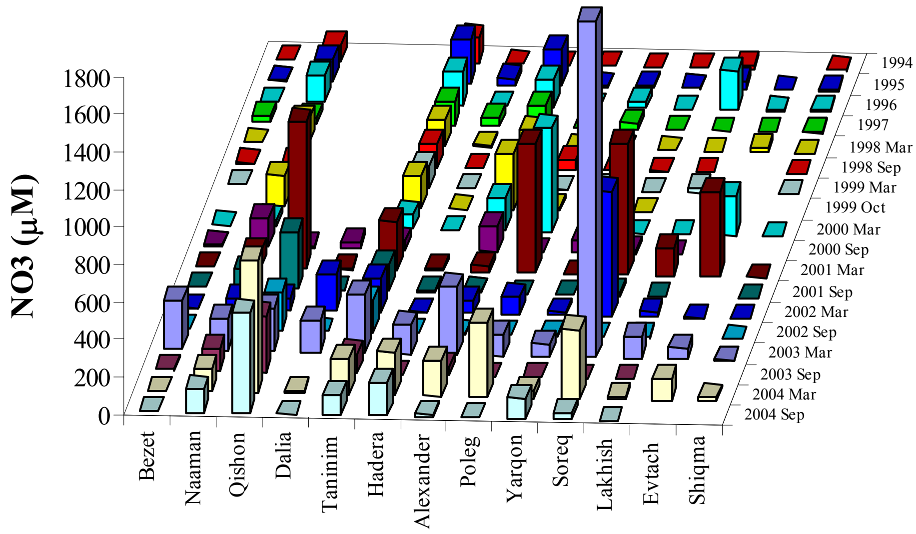
Fig. 28: Phosphate (A), ammonium (B) and nitrate (C) concentrations (µM) in surface water at the coastal river outlets along the Mediterranean coast of Israel, during 1990–2004 (March & September).

B

Shoreline sampling (A stations)

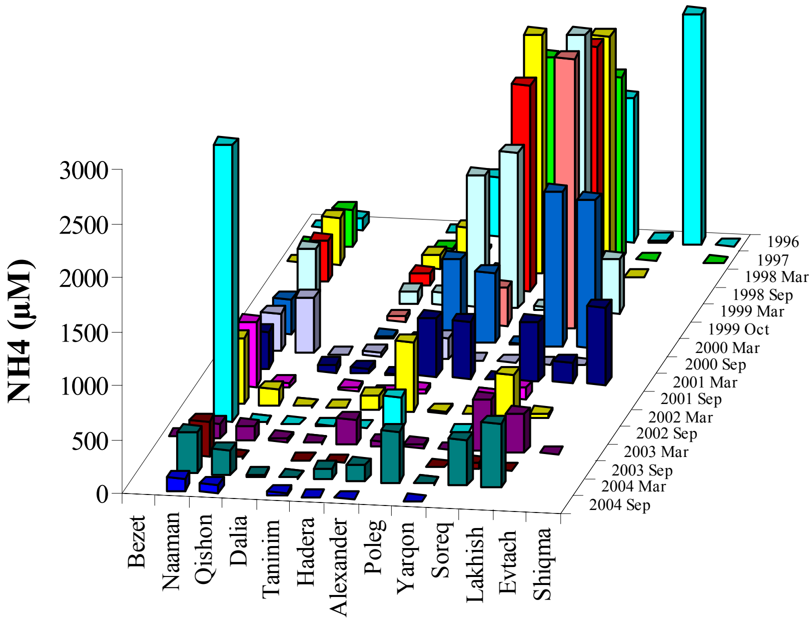


50 m from shoreline (B stations) or more

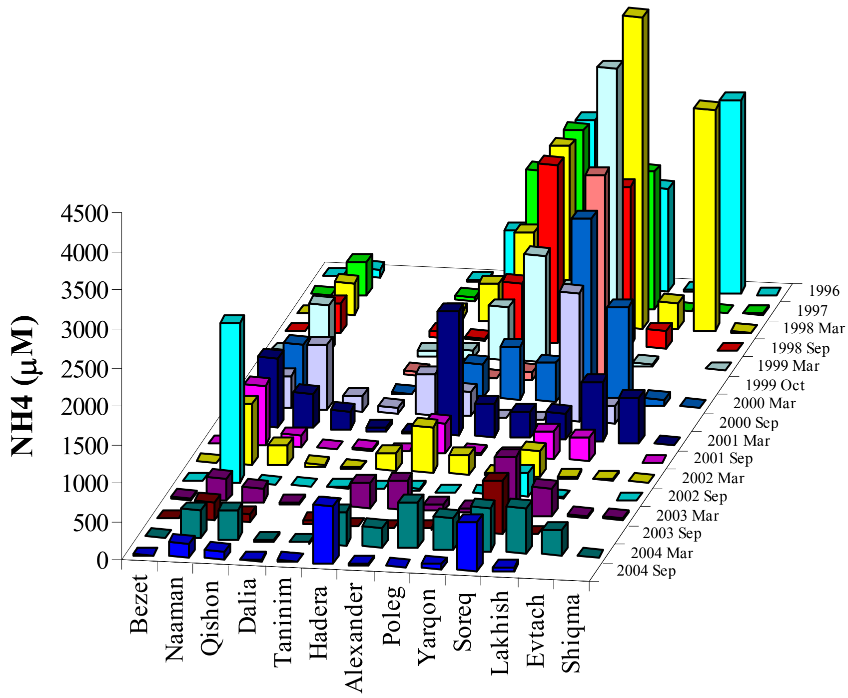


C

Shoreline sampling (A stations)



50 m from shoreline (B stations) or more



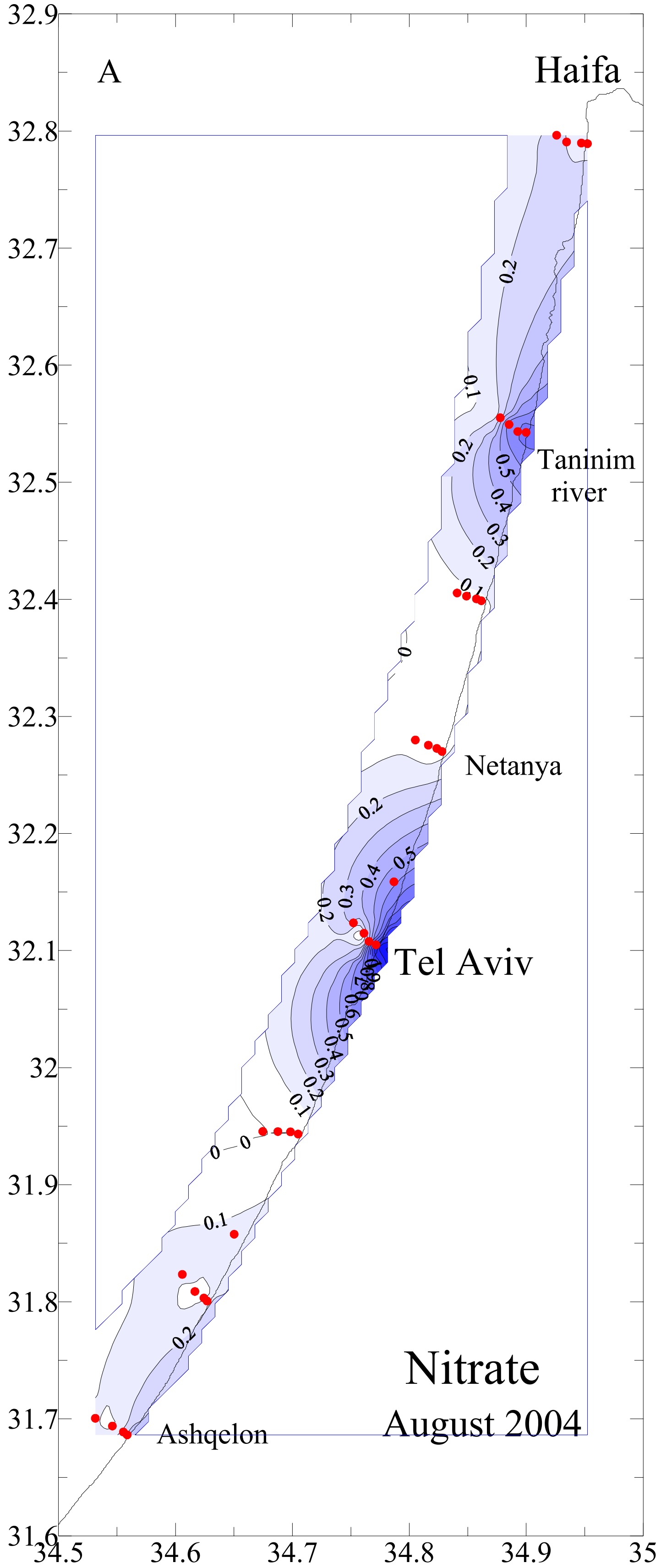
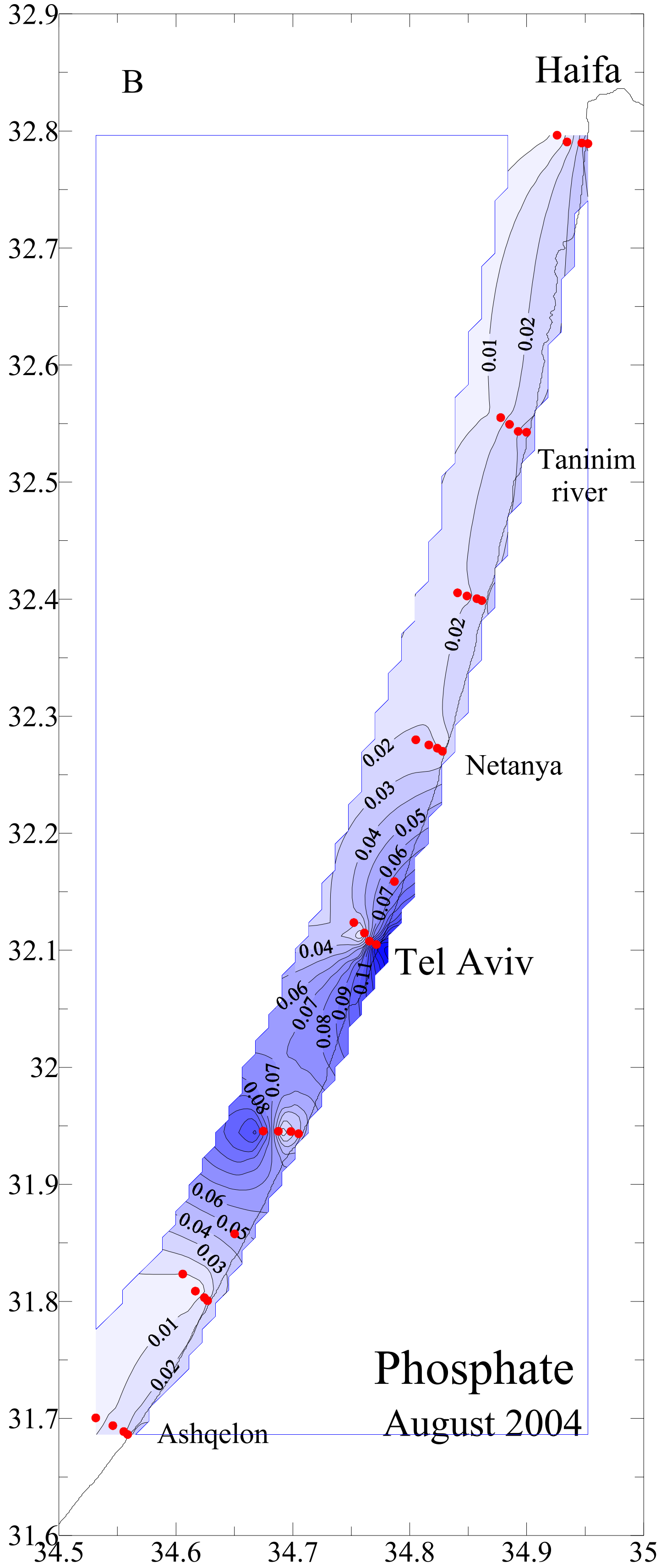
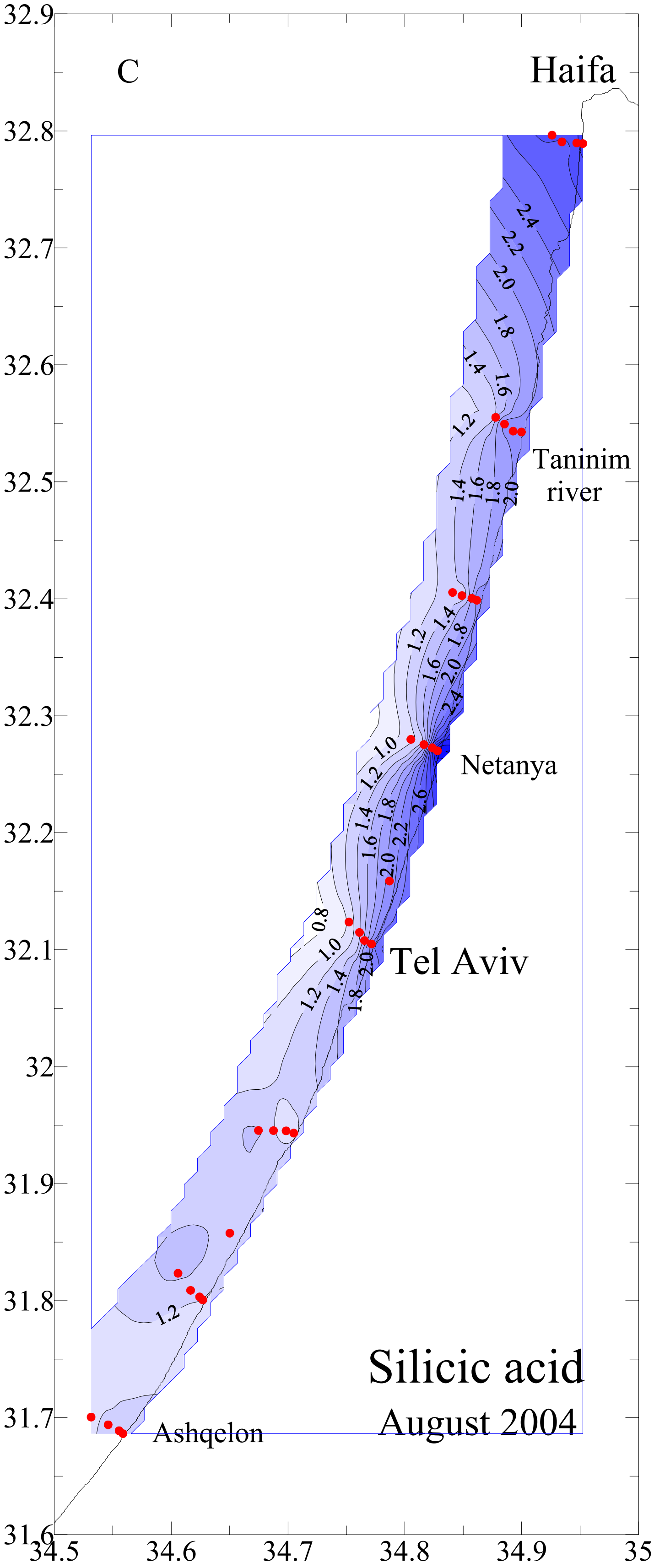
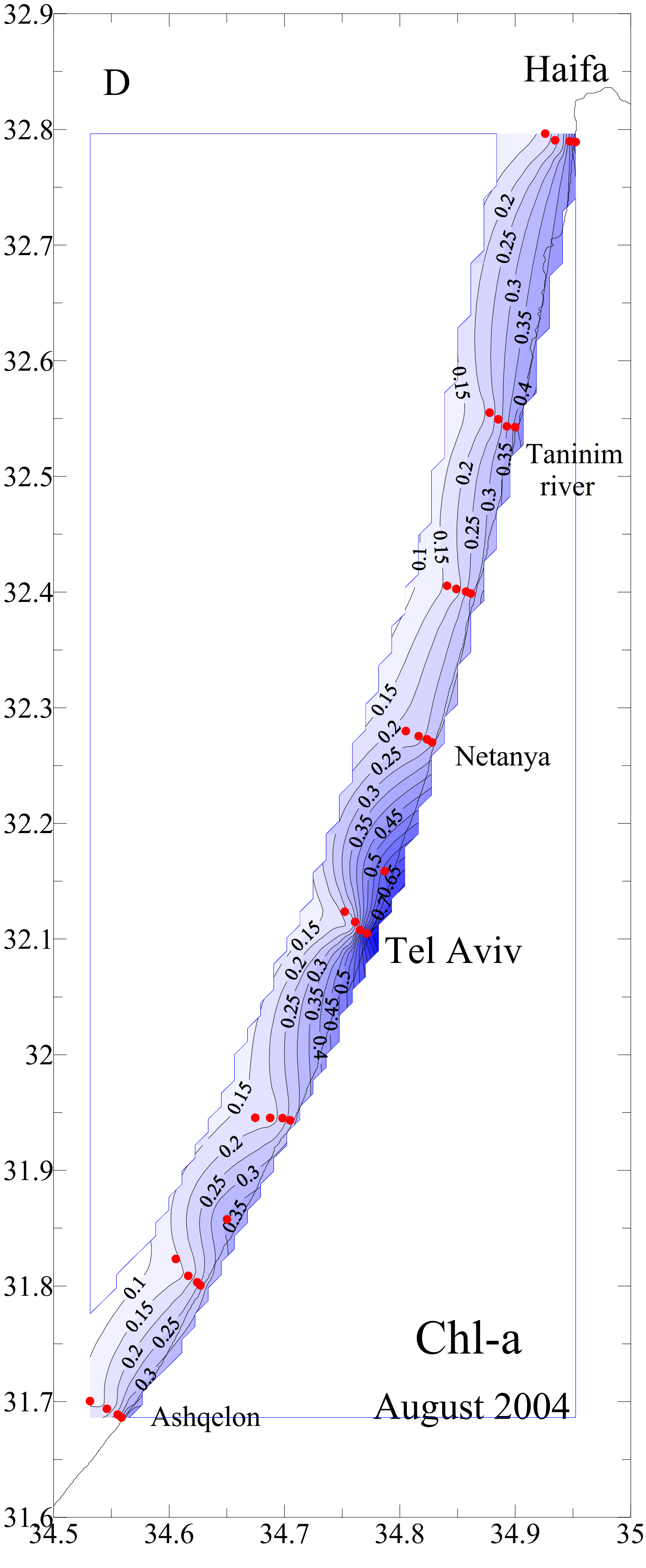


Fig. 29: Nutrient (μM) – nitrate (A), phosphate (B), silicic acid (C), and Chlorophyll a (D) (μg/l) concentrations in surface water along the Mediterranean coast of Israel (depth <30m) during 2004.



B
Haifa
Taninim river
Netanya
Tel Aviv
Ashqelon
Phosphate
August 2004
32.9
32.8
32.7
32.6
32.5
32.4
32.3
32.2
32.1
32
31.9
31.8
31.7
31.6
34.5
34.6
34.7
34.8
34.9
35


C
Haifa
Taninim river
Netanya
Tel Aviv
Ashqelon
Silicic acid
August 2004
32.9
32.8
32.7
32.6
32.5
32.4
32.3
32.2
32.1
32
31.9
31.8
31.7
31.6
34.5
34.6
34.7
34.8
34.9
35


D
Haifa
Taninim river
Netanya
Tel Aviv
Ashqelon
Chl-a
August 2004

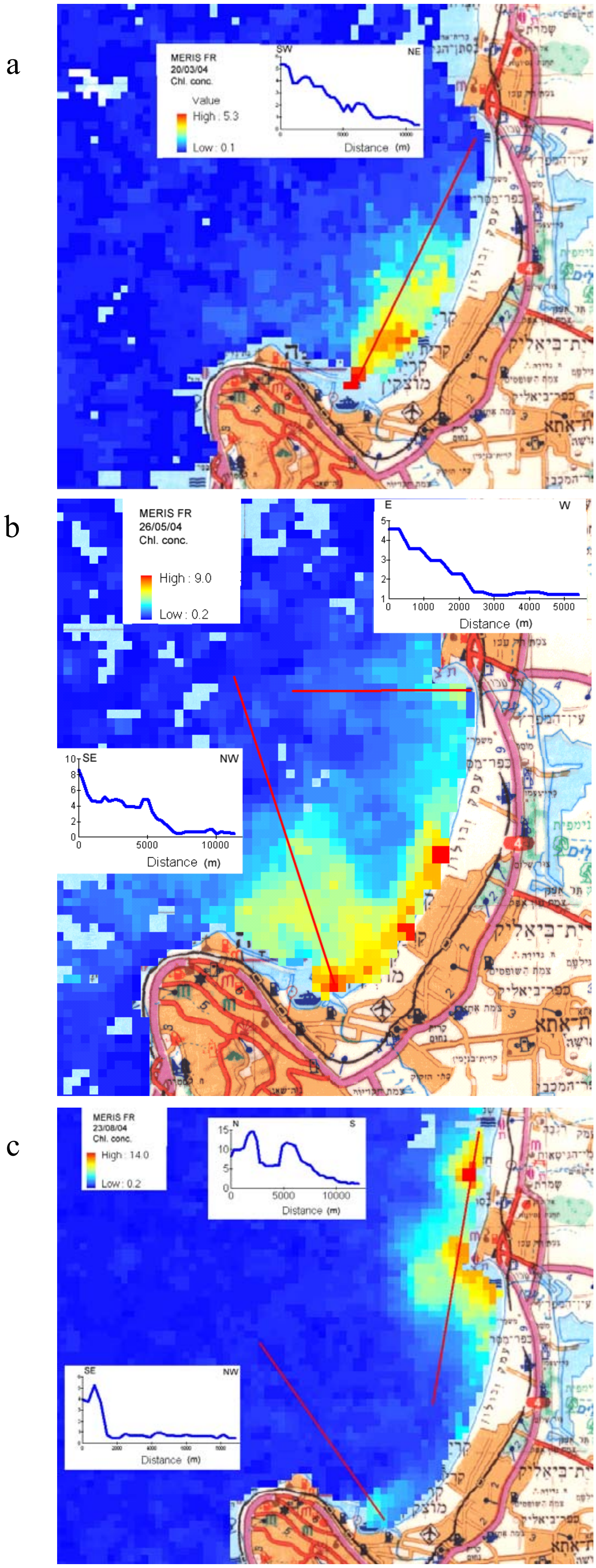


Fig. 30: Relative concentrations of Chl a derived from MERIS satellite images in 20 March 2004 (a), 25 May 2004 (b) and 20 August 2004 (c).

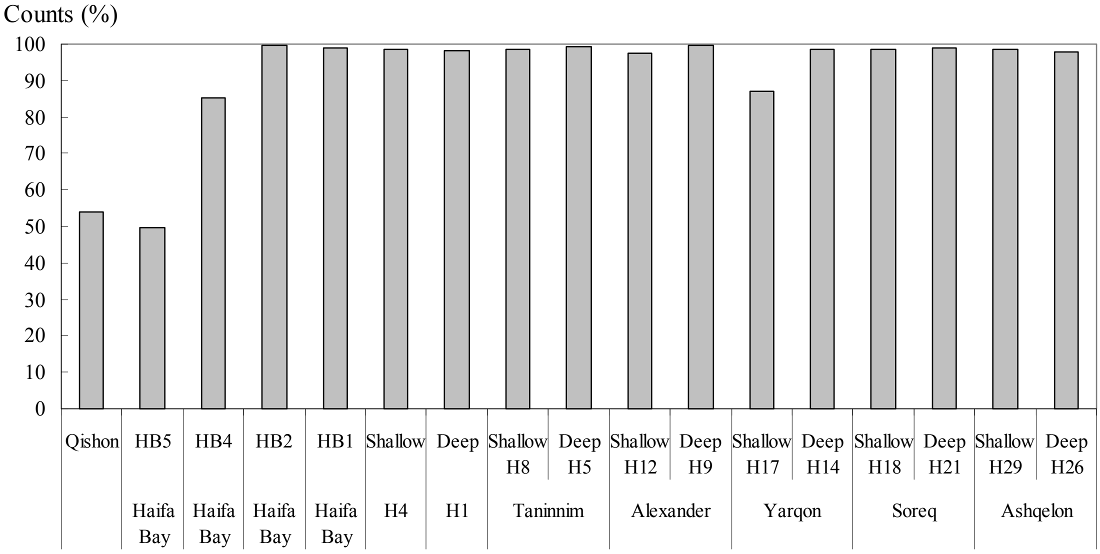


Fig. 31: Distribution of *Synechococcus* counts in surface water at Haifa Bay and along the Mediterranean coast of Israel taken from shallow and deeper (30m) stations during August 2004.

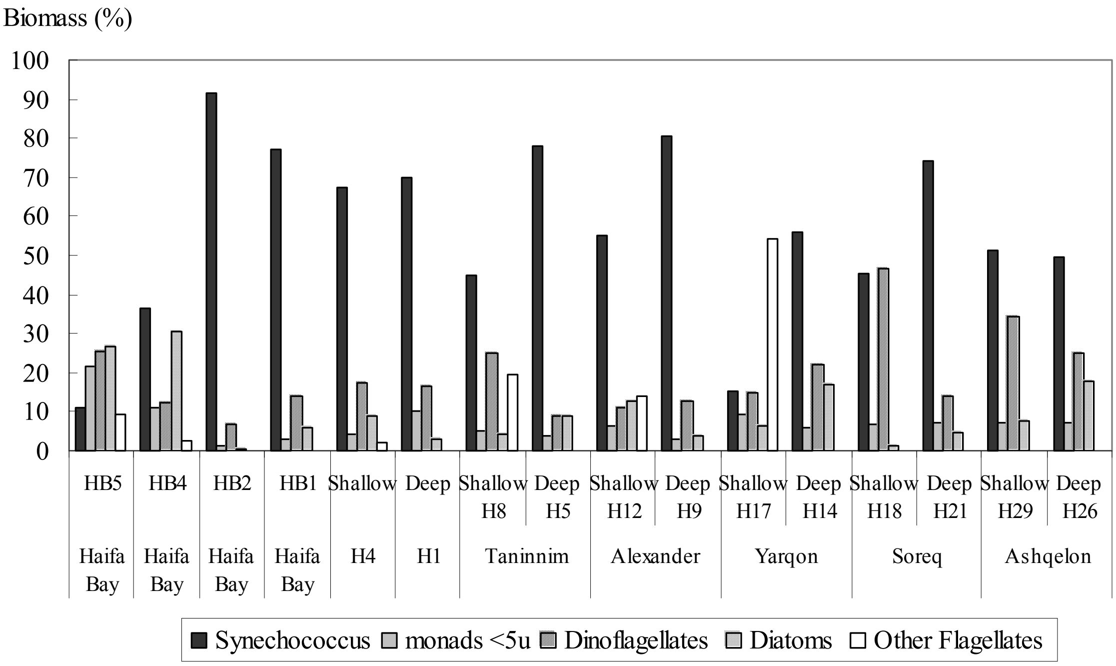


Fig. 32: Relative distribution of phytoplankton group biomass (µgC/L) in surface water at Haifa Bay and along the Mediterranean coast of Israel taken from shallow and deeper (30m) stations during August 2004.

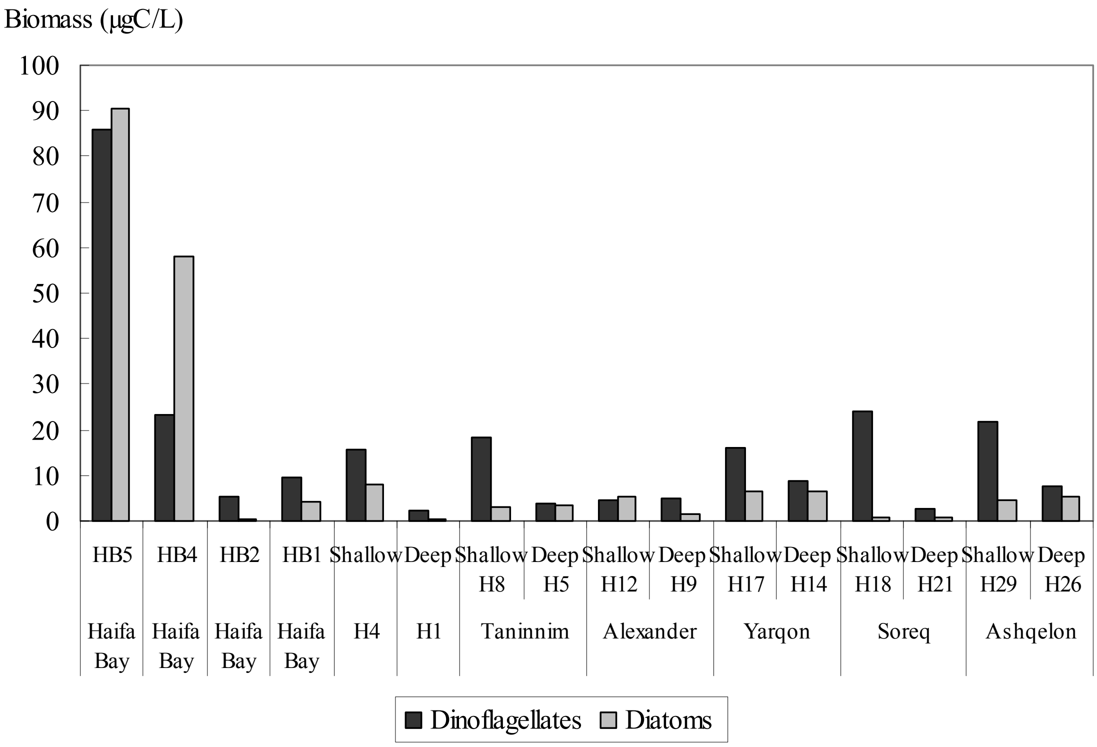


Fig. 33: Distribution of microplankton (>10µm) biomass (µgC/L) of dinoflagellates and diatoms in surface water at Haifa Bay and along the Mediterranean coast of Israel taken from shallow and deeper (30m) stations during August 2004.

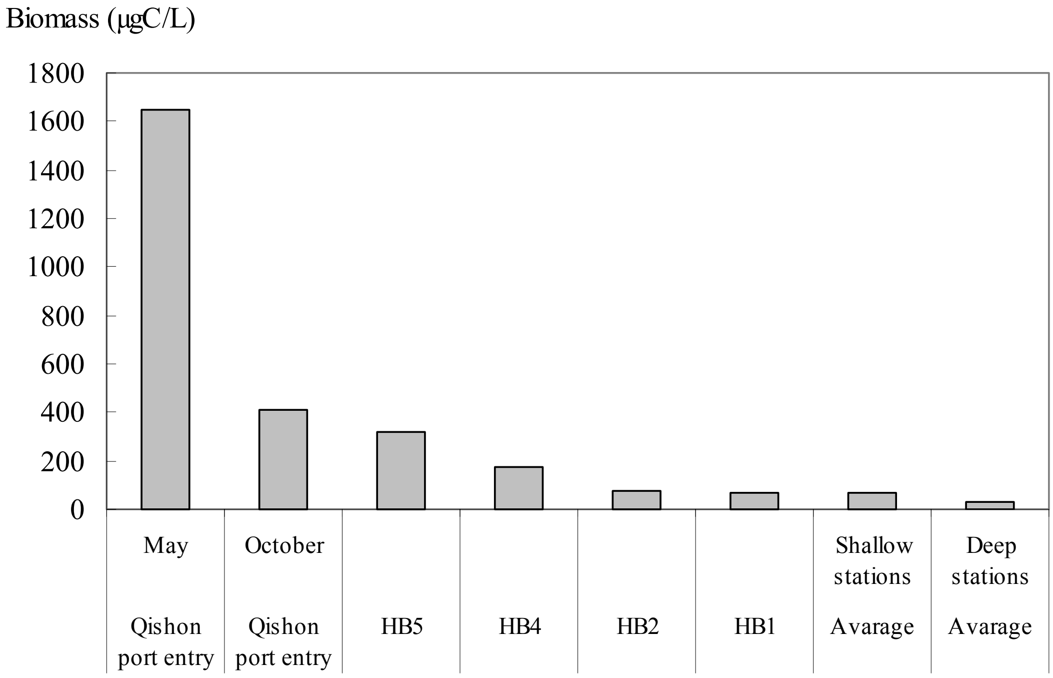


Fig. 34: Distribution of phytoplankton biomass (µgC/L) in surface water at Haifa Bay (August 2004) and at the Qishon River estuary (May and October 2004).

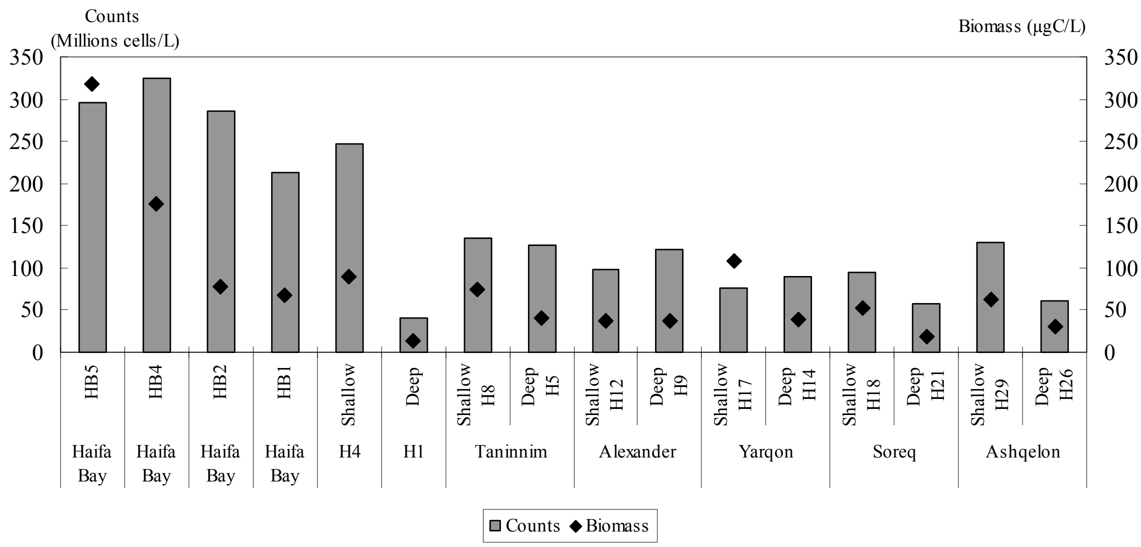


Fig. 35: Distribution of total phytoplankton cells and biomass (µgC/L) in surface water at Haifa Bay and along the Mediterranean coast of Israel taken from shallow and deeper (30m) stations during August 2004.

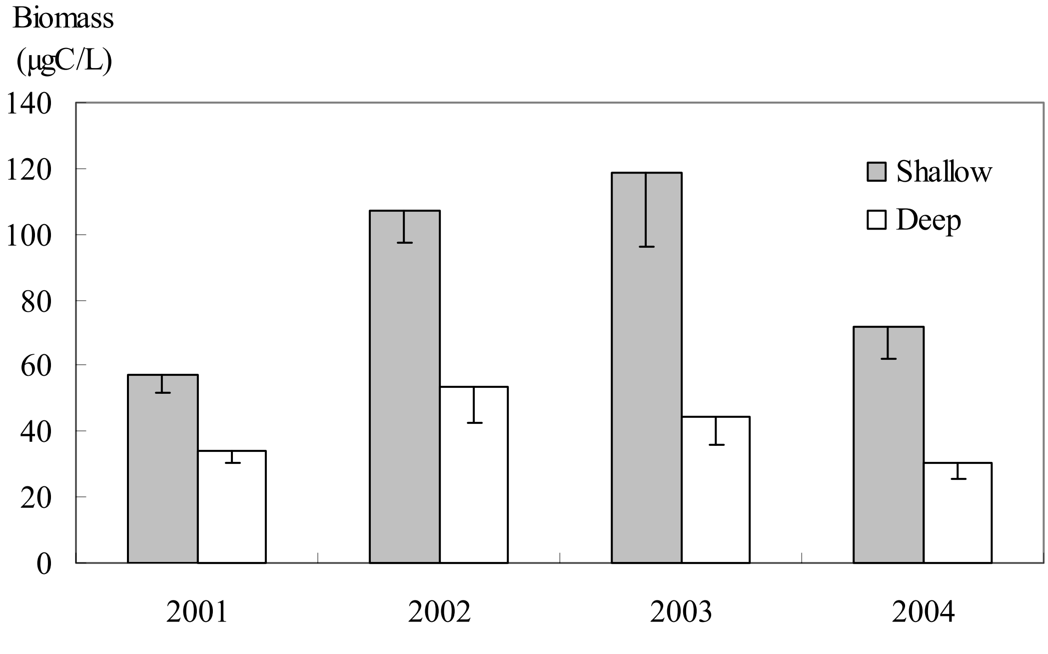


Fig. 36: Average phytoplankton biomass (µgC/L) in surface water at Haifa Bay and along the coast (in shallow and deeper (30m) stations) during 2001 – 2004.

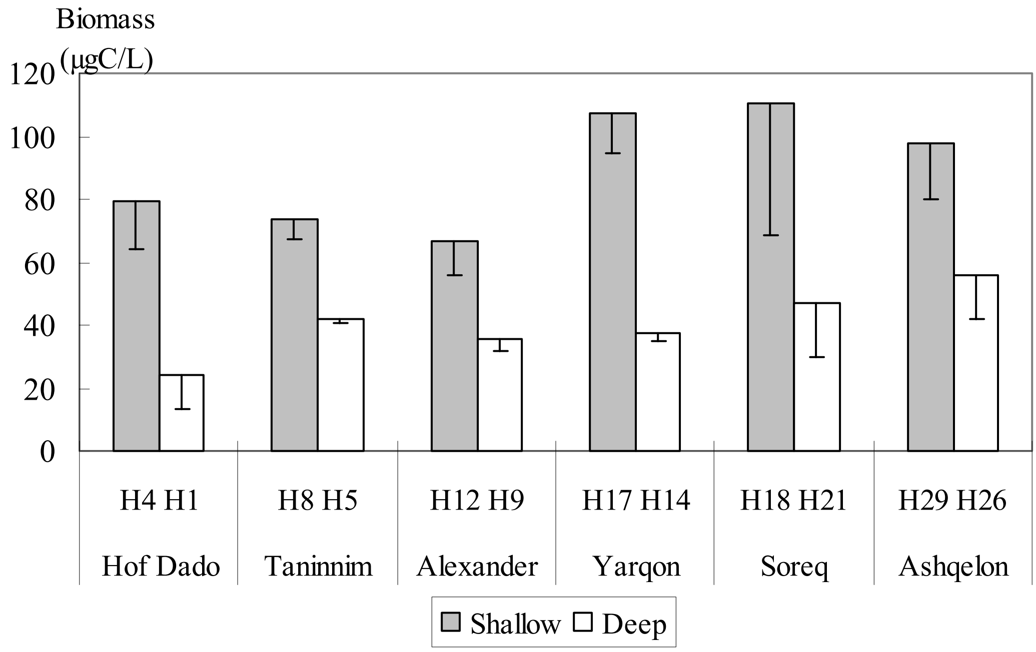


Fig. 37: Average microplankton biomass (µgC/L) in surface water at stations (in shallow and deeper (30m) water) along the coast during 2001 – 2004.

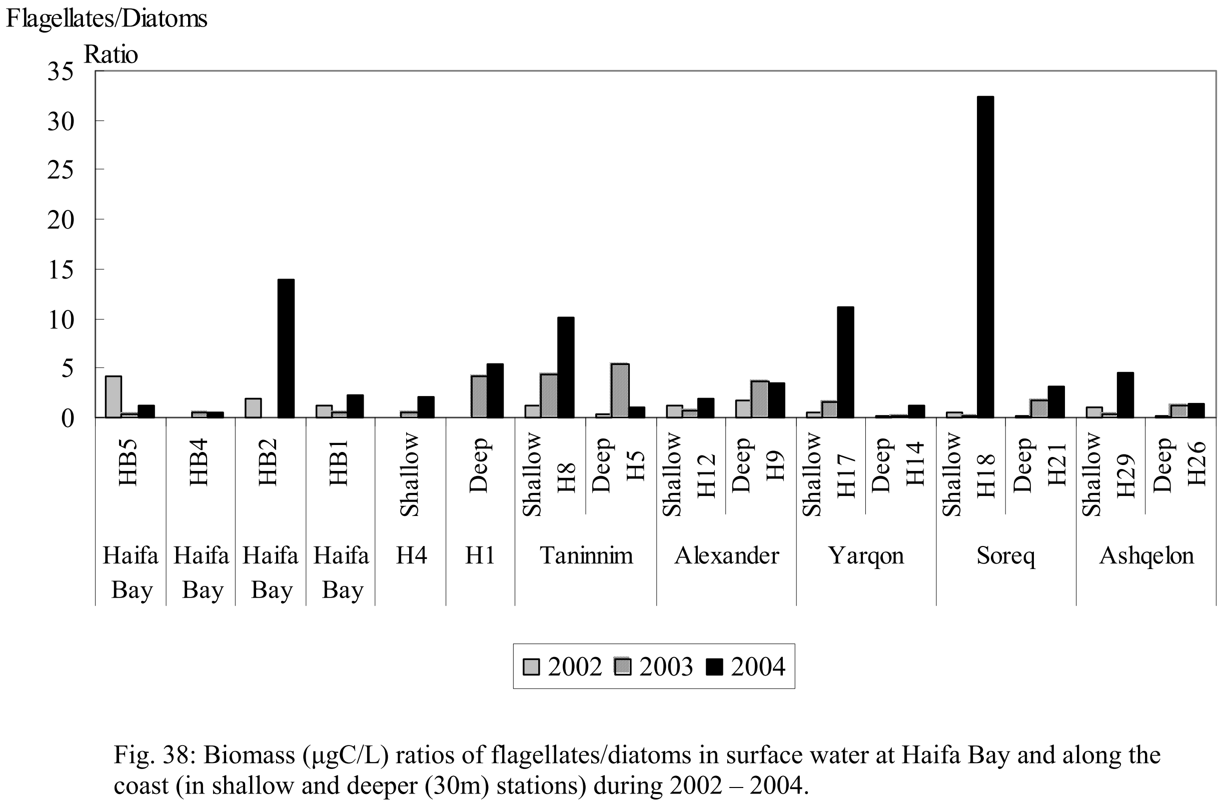


Fig. 38: Biomass (µgC/L) ratios of flagellates/diatoms in surface water at Haifa Bay and along the coast (in shallow and deeper (30m) stations) during 2002 – 2004.

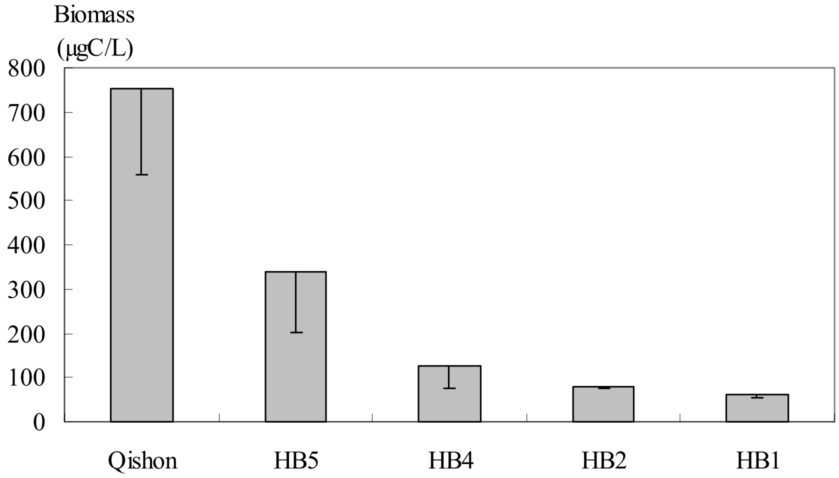


Fig. 39: Average microplankton biomass (µgC/L) in surface water at stations in Haifa Bay and the Qishon River estuary during 2002 – 2004.

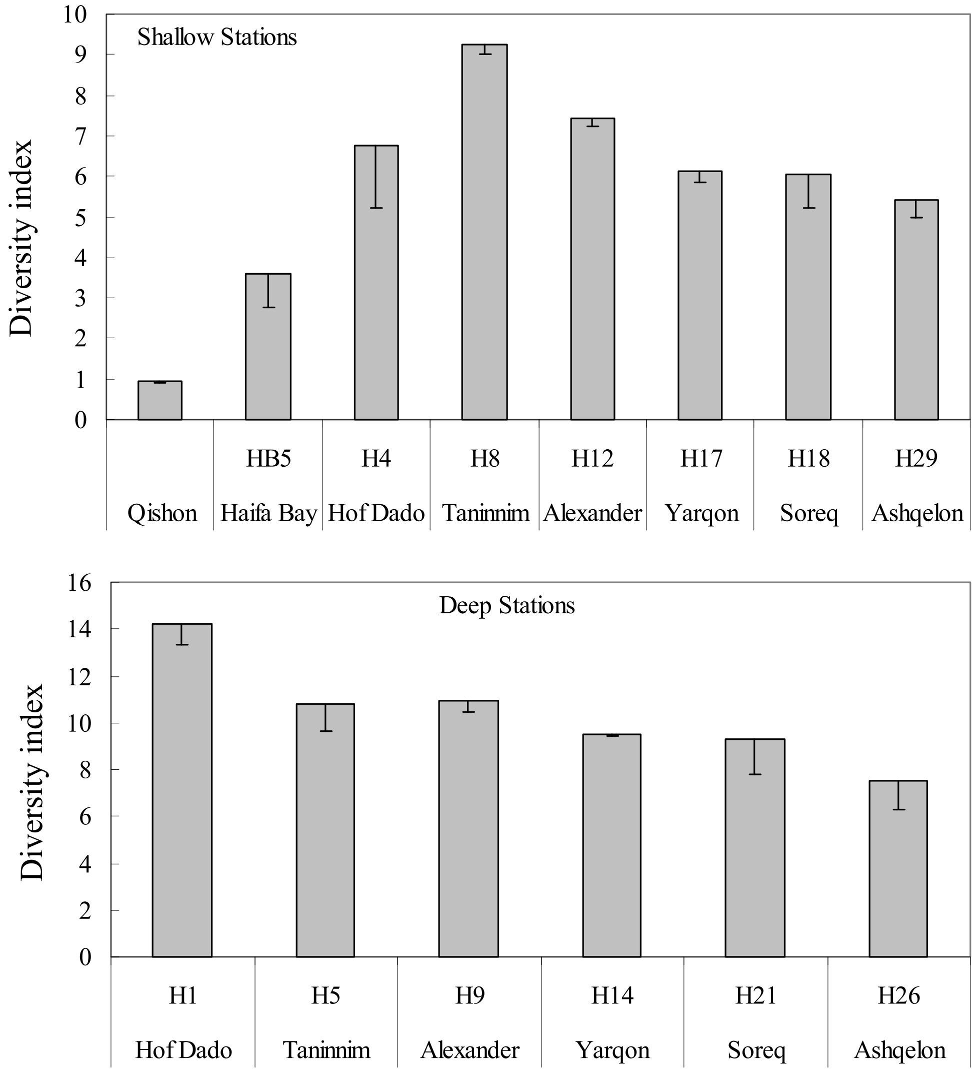


Fig. 40: Diversity Index of the phytoplankton in surface water at Haifa Bay and along the Mediterranean coast of Israel taken from shallow and deeper (30m) stations during 2001 - 2004. The Diversity Index is calculated by dividing the number of species by the root square of total cell density.

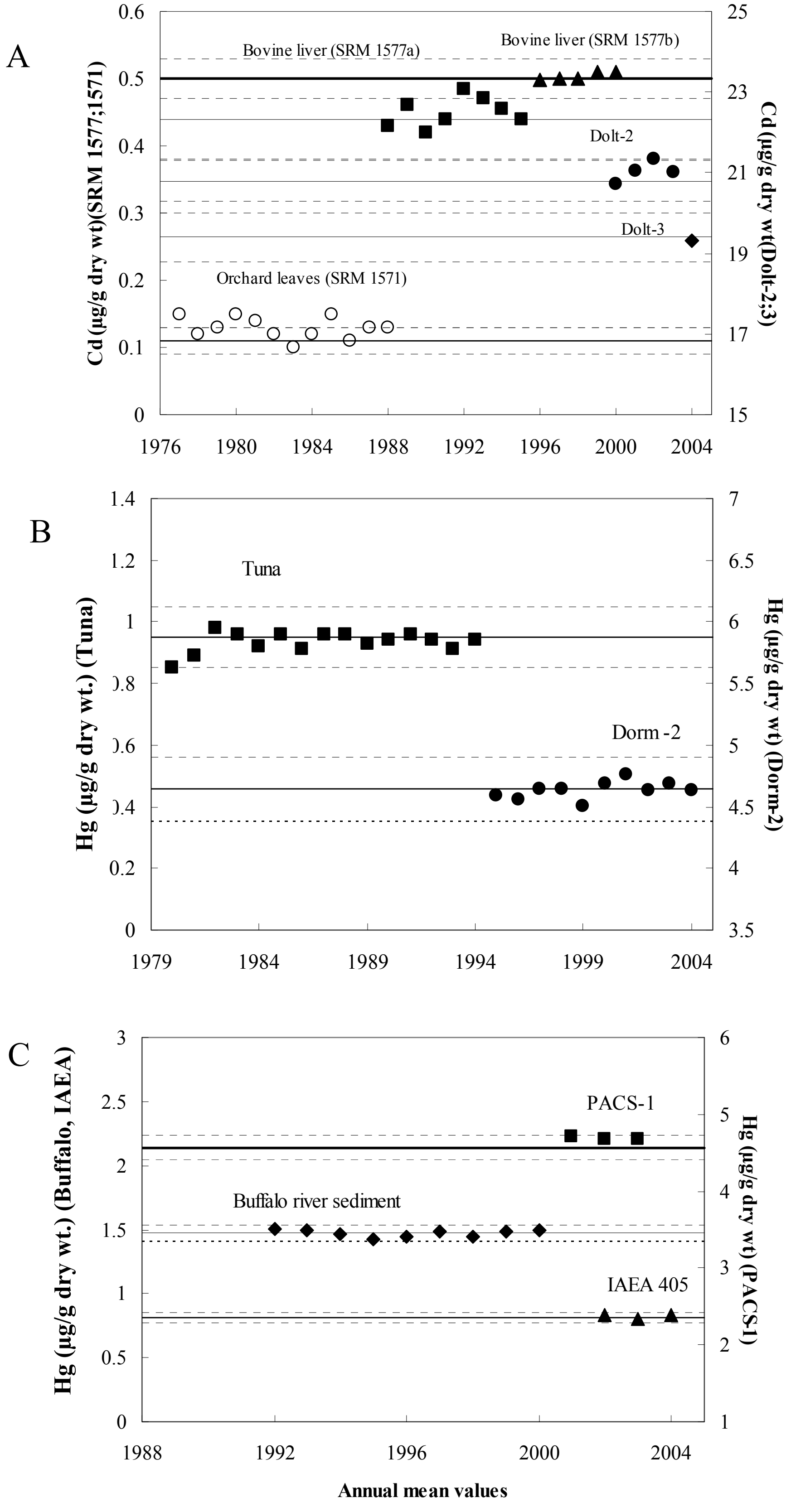


Fig. 41. Quality control charts for determination of cadmium (A) and mercury (B) in fish tissues and mercury in sediments (C). Points represent results (annual averages) of analyses of standard reference materials. Solid and dotted lines represent the certified values and their standard deviations.

Table: Heavy metal concentration range ($\mu g\ g^{-1}$ wet wt.) in muscle tissue of inshore and trawl fish collected along the Mediterranean coast of Israel during 2004.

Species	Location	No. of specimens	Size (cm)	Hg	Cd	Cu	Zn	Fe
דגי מכמורת								
Mullus barbatus	North part of Israel, 32-56 m	50	11.0-20.0	0.014-0.162	bdl	0.275-1.28	3.16-7.07	2.84-13.94
	South part of Israel, 36 m depth	15	14.0-19.0	0.014-0.053	bdl	0.265-0.511	2.95-4.92	3.49-11.28
Upeneus moluccensis	North part of Israel, 32-54 m	7	13.0-18.0	0.049-0.391	bdl	0.387-0.630	4.47-7.70	5.51-8.63
	South part of Israel, 36 m depth	12	13.5-20.5	0.055-0.418	bdl	0.332-1.889	3.78-7.90	2.91-14.40
Pagellus erythrinus	North part of Israel, 32-56 m	33	13.0-23.0	0.038-0.428	bdl	0.194-0.565	3.66-6.19	1.47-8.02
	South part of Israel, 36 m depth	11	16.5-17.5	0.051-0.218	bdl	0.126-0.309	2.95-4.32	1.31-6.04
	Rafael, 15 m depth.	10	12.0-18.0	0.143-0.493	bdl	0.247-0.412	3.33-4.86	1.81-8.39
	Bat galim, 5 m depth	12	14.0-17.5	0.039-0.079	bdl	0.251-0.520	3.57-4.58	1.85-6.85
Epinephelus aeneus	off Yafo, 35 m depth	7	20.0-69.0	0.028-0.211	bdl	0.220-0.275	3.45-4.74	0.27-2.80
Pargus coeruleostictus	off Yafo, 35 m depth	2	34.0	0.265-0.295	bdl	0.182-0.244	2.90-2.92	1.75-2.33

Table: cont.

Species	Location	No. of specimens	Size (cm)	Hg	Cd	Cu	Zn	Fe
דגים חופיים								
Lithognathus mormyrus	Qiryat Yam, 2 m depth	11	16.0-21.0	0.067-0.428	bdl	0.246-0.490	4.61-6.74	2.34-5.02
	Qiryat Haim, 10 m depth	9	14.5-16.0	0.026-0.069	bdl	0.168-0.427	3.95-5.69	3.62-9.72
	Bat galim, 5m depth	18	12.5-17.0	0.025-0.089	bdl	0.218-1.75	4.53-7.36	1.22-9.37
	Jisr-az-zarqa, 3.5m depth	6	14.0-20.5	0.034-0.162	bdl	0.215-0.292	25.29-6.79	1.60-5.32
	Qesarya, 8 m depth	2	16.0-205	0.031-0.062	bdl	0.442-0.486	4.22-5.84	3.67-5.95
Diplodus sargus	Frutarom, 15m depth	4	12.0-16.5	0.064-0.403	bdl	0.217-0.279	3.72-5.09	3.45-4.50
	Bat galim, 5 m depth	10	15.0-25.0	0.036-0.568	bdl	0.246-0.487	1.81-2.50	1.26-3.88
	Qesarya, 8 m depth	10	14.0-22.0	0.050-0.239	bdl	0.217-0.532	3.45-5.79	2.71-6.95
	Herzliyya, 8m depth	6	19.5-22.5	0.102-0.433	bdl	0.252-0.416	3.19-6.38	3.85-9.13
	Yafo, 35 m depth	2	2.75	0.293-0.492	bdl	0.227-0.283	3.04-3.21	2.34-3.77
	Palmahim, 8 m depth.	12	16.0-20.0	0.100-0.405	bdl	0.173-0.428	3.70-5.58	3.56-8.21
Diplodus vulgaris	Frutarom, 15m depth	10	14.0-17.0	0.148-0.482	bdl	0.199-0.814	4.04-5.21	2.30-10.1
Sargocentron rubrum	Nahariyya,	11	14-20.5	0.285-0.740	bdl	0.175-0.794	2.84-4.64	4.0-6.3
	Frutarom, 12m depth	10	14.5-16.5	0.274-0.485	bdl	0.221-0.536	3.07-3.5	3.2-7.3
	Bat galim, 28 m depth	10	15-19	0.221-0.545	bdl	0.221-0.455	3.34-4.92	5.0-7.9
	Palmahim, 8 m depth	5	15.5-18.0	0.159-0.226	bdl	0.309-0.441	3.15-3.87	3.42-8.31
Siganus rivulatus	Bat galim, 5 m depth	1	18	0.012	bdl	0.257	3.53	3.44
	Qesarya, 8 m depth	11	17.5-22.0	0.002-0..012	bdl	0.323-0.784	4.59-6.62	3.70-7.83
	Frutarom, 16 m depth	10	15.0-18.0	0.006-0.026	bdl	0.171-0.449	4.39-6.58	3.69-5.87
	Yafo, 10 m depth	8	14.5-18.0	0.005-0.010	bdl	0.485-1.117	3.81-5.67	3.80-12.08
	Palmahim, 8 m depth.	3	19.0-25.5	0.005-0.008	bdl	0.154-0.283	3.07-4.55	2.31-2.74
Mullu surmuletus	Frutarom, 17 m depth	8	18.0-22.0	0.157-0.384	bdl	0.289-0.649	3.24-4.18	3.77-9.65
Epinephelus marginatus	off Yafo, 35 m depth	2	54.0-58.0	0.208-0.341	bdl	0.220-0.240	3.76-4.23	2.42-3.91
Epinephelus costea	off Yafo, 35 m depth	1	33.5	0.117	bdl	0.275	3.86	2.8

bdl = below detection limit Cd<0.04µg/g wet wt.

Appendix

Total number of heavy metal analyses in fish, mollusks and sediments since the beginning of the monitoring program

Fish (1974-2004)

Diplodus sargus	848
Lithognathus mormyrus	993
Mullus barbatus	759
Sargocentron rubrum	452
Upeneus asymmetricus	287
Upeneus moluccensis	107
Siganus rivulatus	278
Mullus surmuletus	254
Oblada melanura	122
Pagellus erythrinus	353
Saurida undosquamis	148
Other	925
Total	**5526**

Mollusks* (1975-2004)

Mactra corrallina corrallina	1780
Astropecten bispinosus	55
Rudicardium tuberculatum	145
Neverita josephinia	80
Patella sp.	713
Diogenes pugilator	196
Donax trunculus	585
C. gallina	36
Arcularia gibbosula	69
Cellana rota	92
other	528
Total	**4724**

Sediment and suspended particulate matter

Sea Sediments	(1981-2004)	682
River Sediments	(1988-2004)	530
SPM	(1994-2004)	859
	Total	**2080**

* Composite samples (>10,000 specimens)