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The coastal scale observing system component of ADRICOSM: Gulf of Trieste network

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In the framework of the ADRICOSM project, from October 2002 to September 2003, a coastal observing system network was set up in the Gulf of Trieste. During this period, 36 CTD cruises were performed over a grid of 19 stations. An accurate data acquisition and quality check protocol was implemented for data decimation and smoothing. However, data analysis showed that conductivity/salinity spikes were recorded at the depth of the very sharp thermocline observed in summer 2003. The exceptionally high salinity waters and the marked thermocline observed in the Gulf of Trieste in spring and summer 2003 directed us to compare the distributions of the temperature and salinity fields observed during ADRICOSM cruises with the available climatological values of the Gulf of Trieste, in order to assess whether the data collected during this research deviated significantly from the climatology.

Key words: Gulf of Trieste, hydrological features, Isonzo River, climatology, objective analysis, CTD probe

INTRODUCTION

The Gulf of Trieste is a semi-enclosed basin situated in the northern part of the Adriatic Sea (Fig. 1). Though limited in size (about 20 km x 20 km; average depth 17 m; maximum depth 26 m), it plays an important role in the hydrographic properties of the Adriatic Sea (CARDIN & CELIO, 1997). The complex dynamics that characterise this area is due to the freshwater inputs from the rivers of the Friuli plain and karsic terrain, the influence of the water mass flowing northward along the eastern Adriatic coast, the tidal dynamics and the action of wind (CELIO *et al*., 2002). In particular, during bora wind gales, wind speed can reach more than 30 ms^{-1}, producing a water outflow from the Gulf at the surface, an inflow at depth and strong vertical mixing (MOSETTI & MOSETTI, 1990). Moreover, in winter, cold northern winds can enhance the cooling processes of the basin that lead to the formation of dense water (up to 1030 kgm^{-3}) (BUSSANI *et al.*, 2003). However the contribution of the Gulf dense water to the formation of the Northern Adriatic Dense Water (NadDW) is not yet clearly understood, nor is it clear how the advection of NAdDW into the Gulf occurs during the summer period (MALAČIČ & PETELIN, 2001).

Fresh water inputs can severely affect the structure of the water column in the basin; exceptionally high Isonzo River flow rates (>1500 m^{3}s^{-1}) can cause a marked drop in the surface salinity values (< 20) along the northern coastline (NAUDIN *et al.*, 1996) especially in spring and fall.

While tidal currents displace the same water mass with a run of about 1 km (MALAČIČ, 1991), the general circulation of the Gulf is usually described as a three layer structure: the surface layer, about 3-5 m deep, is commonly characterised by a clockwise flow and a speed depending upon sea and land breeze, though generally flowing at about 5-6 cms^{-1}; when eastern winds blow, the surface circulation can be reversed. The bottom layer starts below depths of about 12-15 m, and rotates counterclockwise with a speed of 2-3 cms^{-1}. The speed and direction of the intermediate layer depends on the wind, although on average the flow is counterclockwise and has a speed of about 1-5 cms^{-1} (STRAVISI *et al.*, 1981; MALAČIČ & PETELIN, 2001).

During the ADRICOSM project, biweekly (Oct-02 to Mar-03) and weekly (Apr-03 to Sep-03) CTD cruises were performed over a sampling grid extending from the Italian side of the Gulf to the Slovenian coast, providing an adequate spatial and temporal coverage of the area. Temperature, salinity and dissolved oxygen profiles were collected during one-day cruises and sent to the data collection centre in near real time (i.e. within 24 hours). Moreover, the analysis of temperature and salinity climatological data, collected from 1991 through 2001, was performed in order to gain a better understanding of the thermohaline

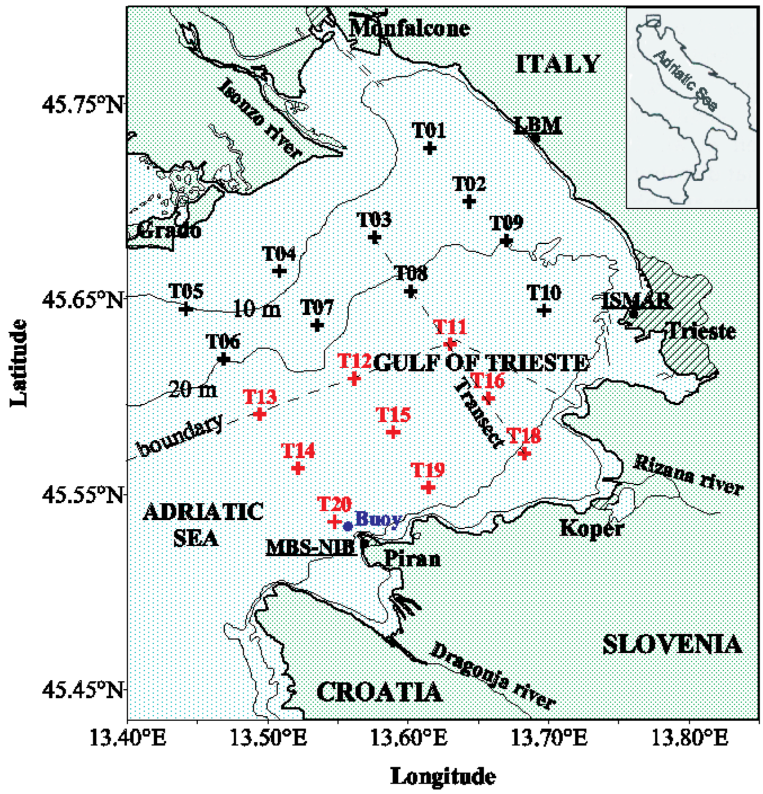

Fig. 1. Gulf of Trieste and ADRICOSM sampling stations

characteristics of the study area and to utilize these results for data validation.

In this paper we give an overview of the main results obtained during ADRICOSM activities with particular regard to the water mass distribution and the water column structure. Moreover, a thorough description of the field work and data quality check protocols is given.

MATERIAL AND METHODS

Vertical profiles of temperature, salinity and dissolved oxygen were collected biweekly (October 2002 – March 2003) and weekly (April 2003 – September 2003) over a sampling grid of 19 stations (Fig 1). A total number of 36 cruises were performed alternatively by the Marine Biology Laboratory of Trieste (LBM) and the Marine Biology Station (MBS) of the National Institute of Biology (NIB); each cruise took approximately 10 hours. LBM used a CTD probe Idronaut 316 while MBS-NIB used a fine-scale probe of the University of Western Australia (FPS2) with Seabird sensors (Table 1). Both probes were calibrated at NATO SACLANT Undersea Research Center in May 2002.

Moreover, all ADRICOSM partners involved in CTD data collection took part in an intercalibration exercise cruise. On 15 May 2003, LBM and MBS-NIB organized a joint CTD validation experiment, during which seven partners deployed their CTD's from three vessels that were positioned in the Bay of Piran ($45^0$30.55' N; $13^0$32.57' E) where the depth is 17 m. Two CTD probes were of the Idronaut type, four were Seabird probes, and one (FPS2 of MBS-NIB) had Seabird sensors but different electronics. CTD probes were lowered at speeds of 0.2-0.3 ms^{-1}, 0.4-0.5 ms^{-1}, and around 1 ms^{-1}, three times each. OGS also analysed the seawater samples for salinity that were collected by LBM using Niskin bottles. The main problem that arose during the validation experiment was evidence (in all collected CTD vertical profiles) of conductivity/salinity spikes in correspondence with a sharp thermocline, due to the different time constant of the temperature/conductivity sensors (Fig. 2). Most of the methods to avoid these spikes are confined to filtering/smoothing of the temperature, conductivity and pressure data; however, shifting the temperature data in time against the conductivity data before the salinity is calculated was demonstrated to be a useful method for reducing salinity spikes. This procedure is usually performed for Seabird probes.

Table 1. Specifications of LBM and MBS-NIB CTD profilers

IDRONAUT 316 (LBM): SENSOR SPECIFICATIONS				
	Range	**Accuracy**	**Resolution**	**Time Constant**
Pressure	0..100 dbar	0.1% full scale	0.03%	50 ms
Temperature	-3..+50 °C	0.003 °C	0.0005 °C	50 ms
Conductivity	0..6.4 Sm^{-1}	0.0003 S^{-1}	0.0001 S^{-1}	50 ms
Dissolved oxygen	0..50 ppm	0.1 ppm	0.1 ppm	3 s (in air)
Dissolved oxygen	0..500 % sat.	1 % sat.	0.1 % sat.	3 s
FPS2 (MBS-NIB): SENSOR SPECIFICATIONS				
	Range	**Accuracy**	**Resolution**	**Time Constant**
Pressure	0..60 dbar	0.01%	0.001m	
Temperature	-5..+35 °C	0.001 °C	0.0003 °C	65 ± 10 ms
Conductivity	0..7 S^{-1}	0.0003 S^{-1}	0.00004 S^{-1}	60 ms
Dissolved oxygen	0..15 mll^{-1}	0.1 mll^{-1}	0.01 mll^{-1}	2 -5 s

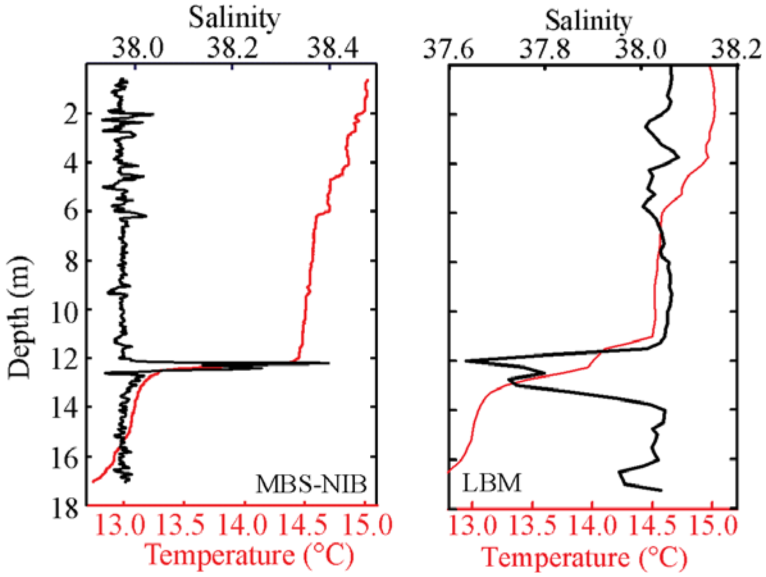

Fig. 2. T-S vertical profiles of the validation experiment. The presence of a strong thermocline results in data spikes during acquisition due to the different time constants of the temperature sensor and conductivity cell

Sampling protocol

The sampling protocol during LBM cruises was as follows: the route to the station and the subsequent correct boat positioning were determined by GPS; at the first station the probe rested for at least 5 minutes in the sea at the surface before pressure calibration (in water) and oxygen calibration (in air) were carried out according to the manufacturer protocols; then the probe was again positioned in the sea at the surface and after 2 minutes the data were collected at a lowering speed of about 0.3 ms^{-1} and a sampling frequency of 4 Hz. At the other stations the pressure and oxygen calibrations were repeated only in case of uncertainty about data reliability and more profiles were performed only in cases of bad data acquisition.

The quality check procedure started soon after data acquisition. First ASCII raw data were checked by visual inspection, in order to remove blatant outliers. Then data underwent a semiautomatic procedure performed by means of a computer program that linearly interpolated possible data gaps and then computed mean values at 0.25 dbar intervals; finally data were written in ADRICOSM format file and sent to the data collection centre in delayed mode (within 24 hours).

After a few days the horizontal distributions at five depths and a NW-SE vertical transect of the thermohaline features observed in each cruise were reported on the ADRICOSM section of the LBM web site.

The MBS-NIB sampling protocol consisted of the following steps: the route to the station and the subsequent correct boat positioning were determined by GPS; the probe was always released in a free fall mode (vertical speed of 1.0 ms^{-1} at depth, around 0.3-0.6 ms^{-1} in the surface layer of thickness less than 2 m) down to the muddy sea-floor with a sampling rate of about 50 Hz. The collected data underwent a filtering/despiking/smoothing procedure using software of the Center for Water Research of the University of Western Australia in Perth (VOLLMER, 1991). All CTD casts were visually inspected. Since the FPS2 was always lowered down to the sea-floor (in the Gulf of Trieste), software removed the last data after the maximum depth had been reached. All profiles also passed through the basic quality control of gross-error limit for the removal of potential spikes that might have been missed by visual inspection. It was decided that the raw temperature should be in the range: 6°C <T <29°C, and the salinity in the range: 18 <S< 40. These range limits are the summary of historical data that passed all quality checks. There were few data outside of these range, but were dubious and therefore not taken into account and were deleted from the vertical profiles.

Meteorological data

Air temperature and total precipitation in Trieste city from 1961 to 1990 were made available by the University of Trieste, Department of Oceanography and Meteorology (DST-OM).

Air temperature and total precipitation in Trieste city from July 2002 to December 2003, as well as wind speed from 1998 to 2003, were recorded by the Institute for Marine Science (Istituto di Scienze Marine – ISMAR) of Trieste. Slovenian meteorological data (air temperature and wind speed) from September 2002 through 2003 were provided by the coastal oceanographic station of MBS-NIB (Fig. 1).

Isonzo River flow rates from July 2002 to December 2003 were made available by the Regional Bureau for Environment of Autonomous Region of Friuli Venezia Giulia (Direzione Regionale dell'Ambiente – Friuli Venezia Giulia). Flow rate is measured at Turriaco station, 15 km north of the river mouth.

Objective analysis

To obtain an effective tool for the temperature and salinity data quality check and to determine the presence of trends in such parameters a climatological analysis was performed.

LBM and MBS-NIB set up a common data base covering the 1991 to 2001 period, including 13039 CTD profiles: 3237, 1202 and 8600 from LBM, MBS-NIB and Atosmed6 (ZAVATARELLI & PINARDI, 2003) data sets, respectively. The stations distribution covers that part of the northern Adriatic Sea which is the domain of the circulation model (ACOAST-2) of the Gulf of Trieste. The coastal strip next to the Istrian peninsula is unfortunately not covered with the data (Fig. 3).

For this study an Objective Analysis (OA) interpolation method has been used (BRETHERTON *et al.*, 1976). LBM and MBS-NIB were provided with a Fortran code for the OA by the SINCEM Laboratory (Numerical Simulation of Climate and Marine Ecosystems). A grid of 1.6 km x 2.2 km was utilized due to the distribution of sampling stations. The covariance function used was the following:

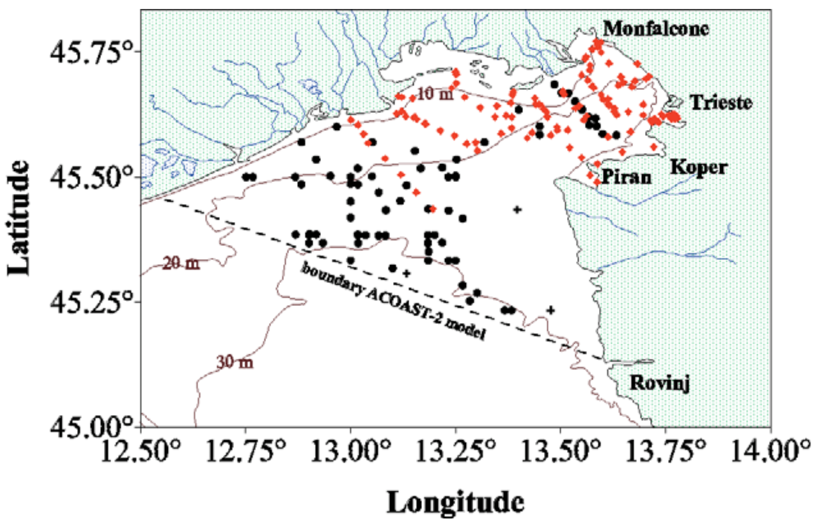

Fig. 3. Northern Adriatic: LBM and MBS-NIB (♦), ATOS (•) and RBI.CMR (+) sampling stations used in the climatological analysis (1991-2001)

$$F(r)=\left(1-\frac{r^2}{a^2}\right)e^{-\frac{r^2}{2b^2}}$$

where:
a is the zero crossing correlation scale (km);
b is the decay length scale (km).

Two other parameters needed to be fixed before running the OA code:

• *dist* is the influential radius (km) within which measurement points were selected;

• *iflag* enables averaging of temperature and salinity data of different points; if set to 1, all data within a user defined radius are averaged and considered as a single value.

After several tests, the following set of values was used:

a = 20 km;

b = 10 km;

dist = 15 km;

iflag = 0.

RESULTS AND DISCUSSION

Meteorological observations

In the October 2002-September 2003 period, the daily mean of air temperature ranged between 4.10 °C (February 2003) and 27.60 °C (August 2003) (Fig. 4). Total precipitation was very scarce, ranging between 2 mm (March 2003) and 195 mm (November 2002) (Fig. 5). Due to low precipitation the Isonzo's (main river pouring into the basin) flow rate as well as the flow rates of other northern Adriatic rivers were extremely low (Fig. 5) and consequently the salinity of the water column was high. The 2003 mean wind speed did not show significant differences with respect to the 1998-2003 mean values. The mean wind speed recorded at the MBS-NIB station was constantly higher than that observed at the ISMAR-Trieste station due to the strong gusts of the easterly winds that affect the Slovenian coast (Fig. 6).

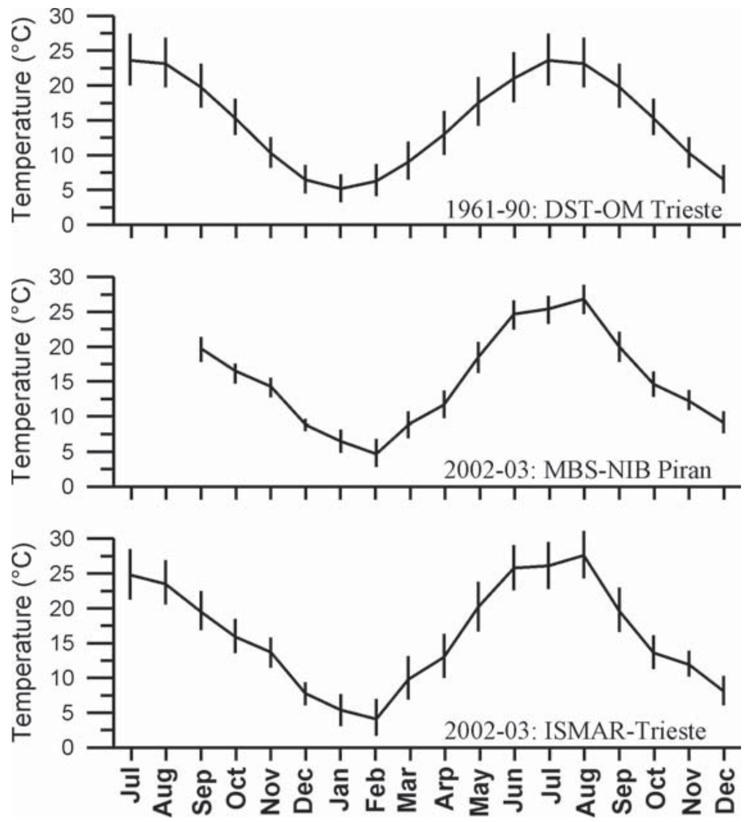

Fig. 4. Air temperature (monthly mean, minimum, maximum) from 1961-1990, DST-OM Trieste. Air temperature (monthly mean, minimum, maximum) from July 2002 to December 2003, and from September 2002 to December 2003, ISMAR-Trieste and MBS-NIB meteorological stations. See Fig. 1 for the locations of those stations

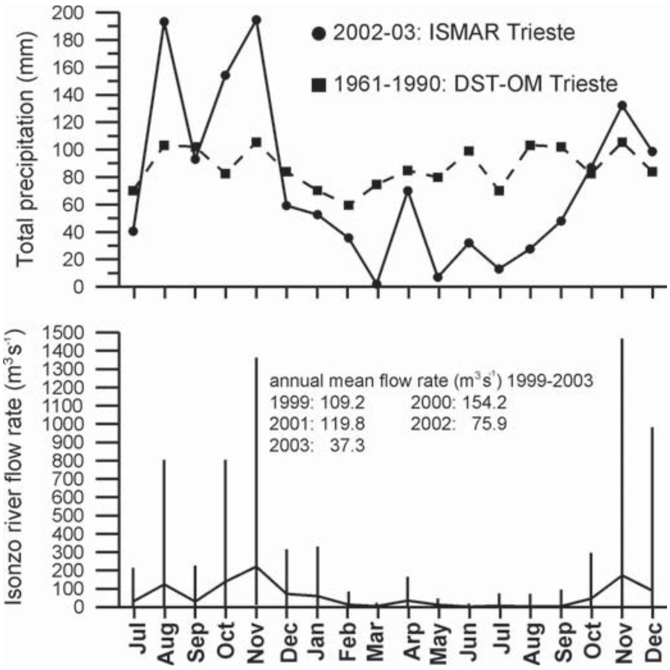

Fig. 5. Total precipitation (ISMAR and DST-OM Trieste) and Isonzo River flow rate (monthly mean, minimum and maximum) (Direzione Regionale dell'Ambiente – Friuli Venezia Giulia) from July 2002 to December 2003. Flow rate is measured at Turriaco station, 15 km north of the river mouth

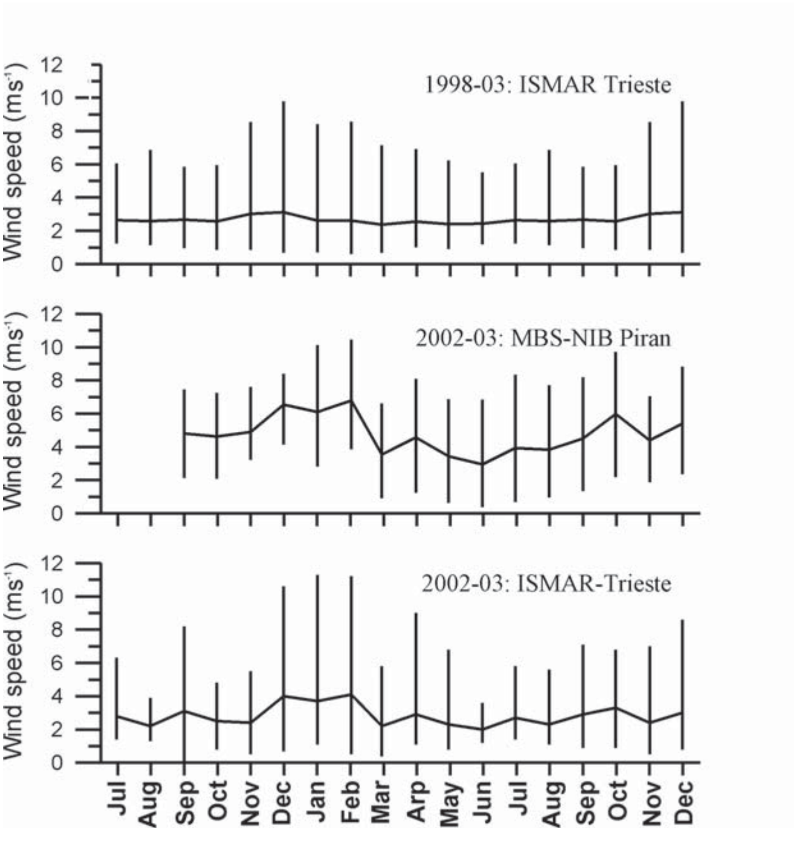

Fig. 6. Wind speed (monthly mean, minimum, maximum) from July-September 2002 to December 2003, and from 1998 to 2003, ISMAR-Trieste and MBS-NIB meteorological stations. See Fig. 1 for the locations of those stations

Thermohaline features

From October 2002 to mid April 2003 the basin was essentially characterised by the instability of the water column. In some cruises (25/10/02, 27/11/02 and 05/04/03) fresh water inputs were observed, especially at the coastal stations. In October and November to mid December 2002, near the northern Italian coastline, the temperature ranged between 9.79 °C (st. T05, 1 m; 12/12/02) and 20.42 °C (st. T13, 22 m; 03/10/02) (Fig. 7); salinity reached its maximum and minimum values in station T04 with 38.28 (10.5 m; 03/10/02) (Fig. 7) and 24.43 (surface; 25/10/02), respectively. In December a marked decrease of temperature was detected (12/12/02). During winter 2003 the water column was homogeneous both in temperature and salinity. Temperature at shallower stations was rather low: at station T05 a minimum value of 6.02 °C (surface; 24/02/03) was recorded while the maximum was observed at T07 with 10.96 °C (5.5 m; 14/01/03). A weak thermal gradient from the western to eastern coast was evident both in the surface and bottom layers (Figs. 8 and 9). Salinity data did not vary markedly in the subsurface and bottom layers (depth ≥ 8 m), ranging from 37.52 (14/01/03) and 38.18 (24/03/03). In particular, in February (24/02/03) the entire basin had a homogeneous salinity distribution which averaged to 38.16, with a standard deviation of 0.13.

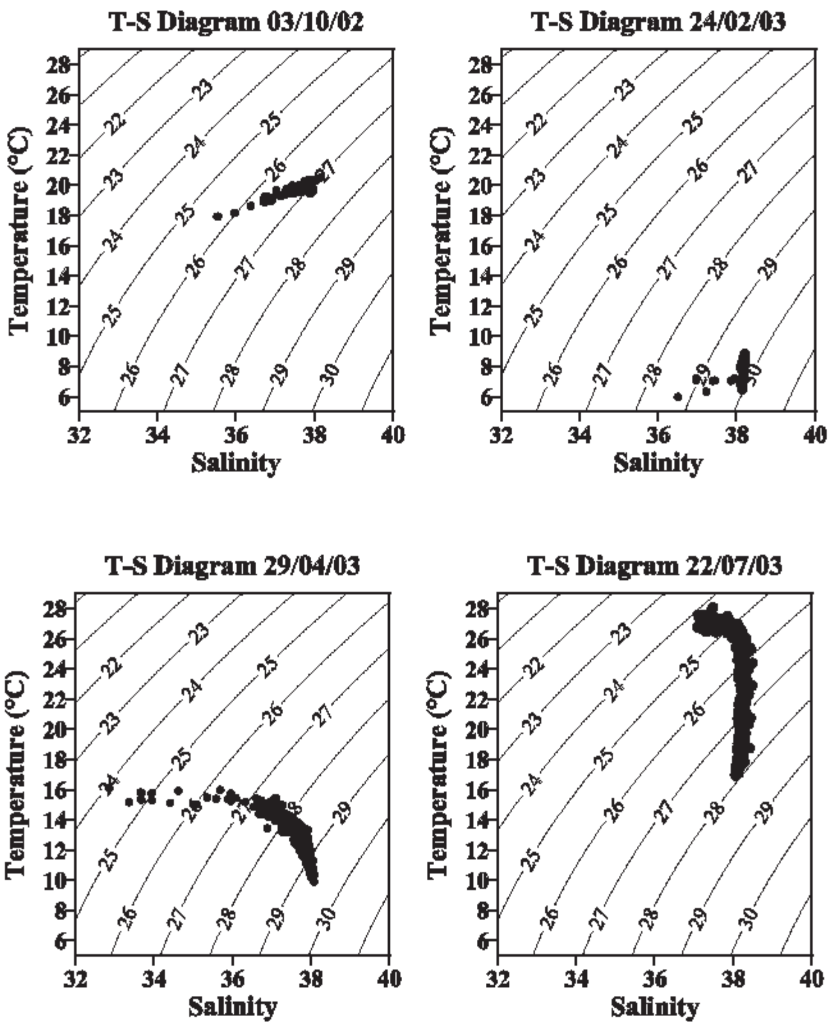

Fig. 7. T-S diagrams

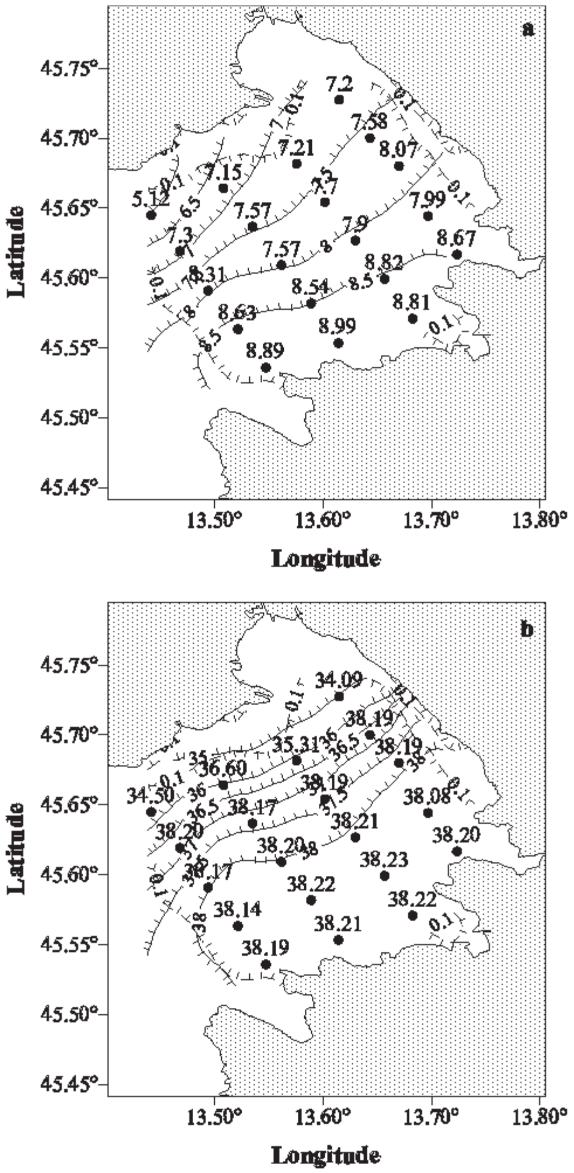

Fig. 8. *Objective analysis of surface temperature (a) and salinity (b) fields and error fields (dashed line) on 24/02/03*

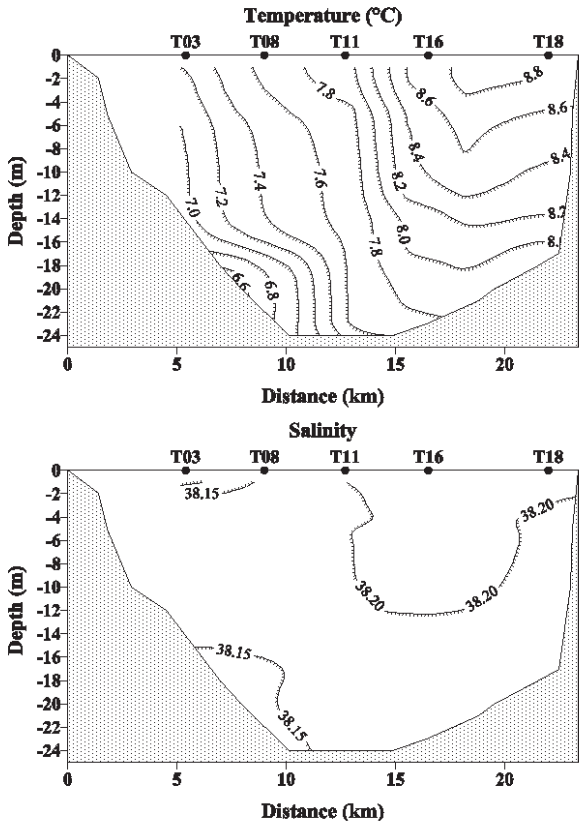

Fig. 9. *Vertical distribution of temperature and salinity fields on 24/02/03. Data interpolated using the kriging method*

In order to better understand the horizontal field distribution of temperature and salinity of the basin in February, a kriging interpolation analysis (Fig. 10) had been performed as well, although the results for the study area did not evidence significant differences between the two interpolation methods.

Between mid- and late April the thermal stratification of the water column became established with a mean vertical gradient of about 6 °C/20 m (Fig. 7). The vertical gradient of temperature increased in May and June, reaching its maximum value of 13.8°C/20 m in early June (09/06/03). During this period fresh water inputs were very scarce and salinity consequently increased to values slightly higher than 38.3.

In summer (June-September 2003) the maximum temperature was 29.09 °C on 11/08/03 (st. T02, surface) and the minimum was 15.58 °C on 07/07/03 (St. T08, 23 m). The thermal stratification lasted until the first week of September with a mean vertical gradient of about 10 °C/20 m. During this period salinity ranged between 34.06 (surface of St. T17, 22/09/03) and 38.39 (depth of 18-19 m of St. T20, 04/08/03). On 22/07/03 salinity in the entire Gulf was high, with the saltiest water lying in front of the Isonzo River mouth (Fig.

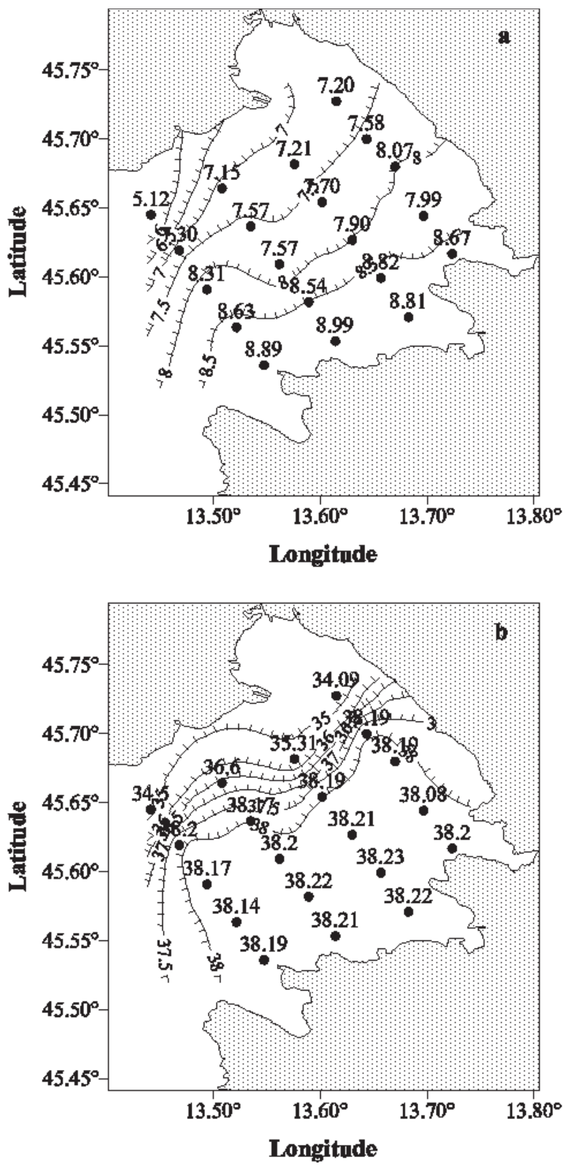

Fig. 10. Horizontal distribution of temperature (a) and salinity (b) fields on 24/02/03. Data interpolated using the kriging method

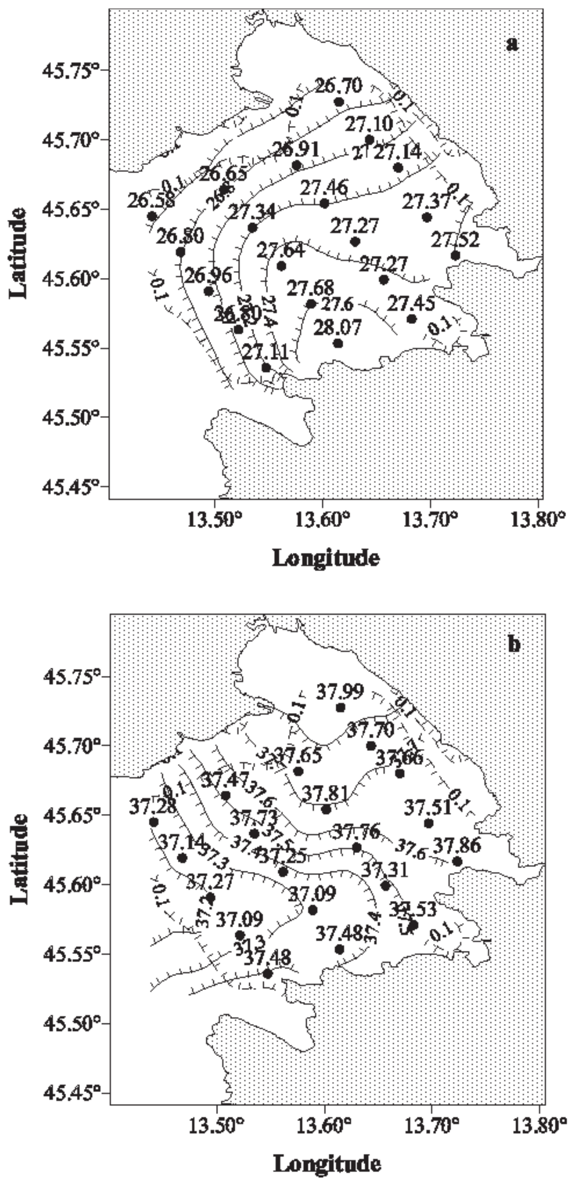

Fig. 11. Objective analysis of surface temperature (a) and salinity (b) fields and error fields (dashed line) on 22/07/03

11). Moreover, an ingression of saltier waters is clearly visible in the south-eastern part of the Gulf at depths of 12–20 m (Fig. 12).

At the end of August and in September there were three storms with strong westerly and easterly (bora) winds. These events caused cooling of the surface layer by about 4°C and thermocline breakdown. In particular, on 16/09/03, a strong westerly wind event with a fresh water input from Isonzo River forced the mixing of the surface layer of lower salinity with the layers below (Fig. 13).

Climatology of the Gulf of Trieste

The results obtained applying the objective analysis interpolation to the LBM and MBS-NIB climatological dataset (1991-2001) confirm the typical features described in the literature (CARDIN & CELIO, 1997; FRANCO, 1989; FONDA

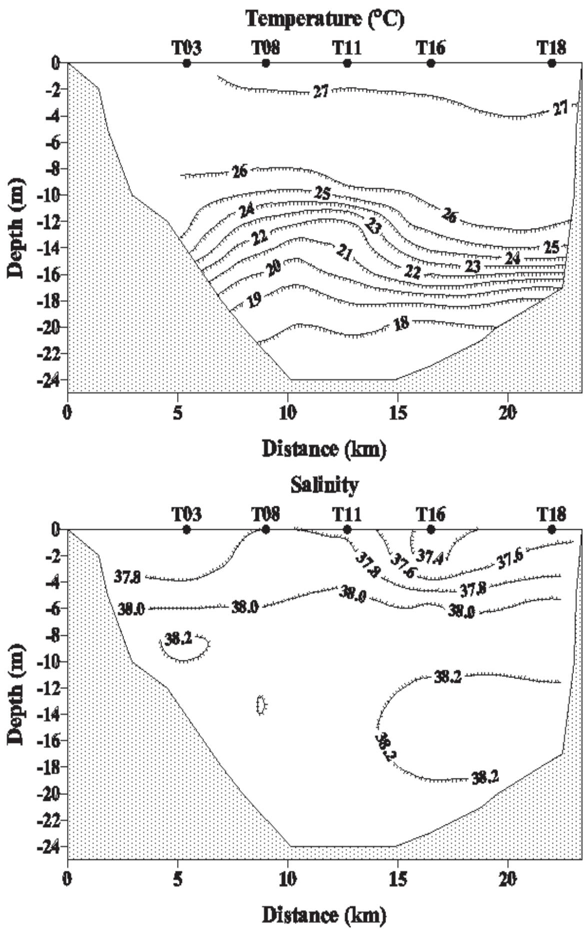

Fig. 12. Vertical distribution of temperature and salinity fields on 22/07/03. Data interpolated using the kriging method

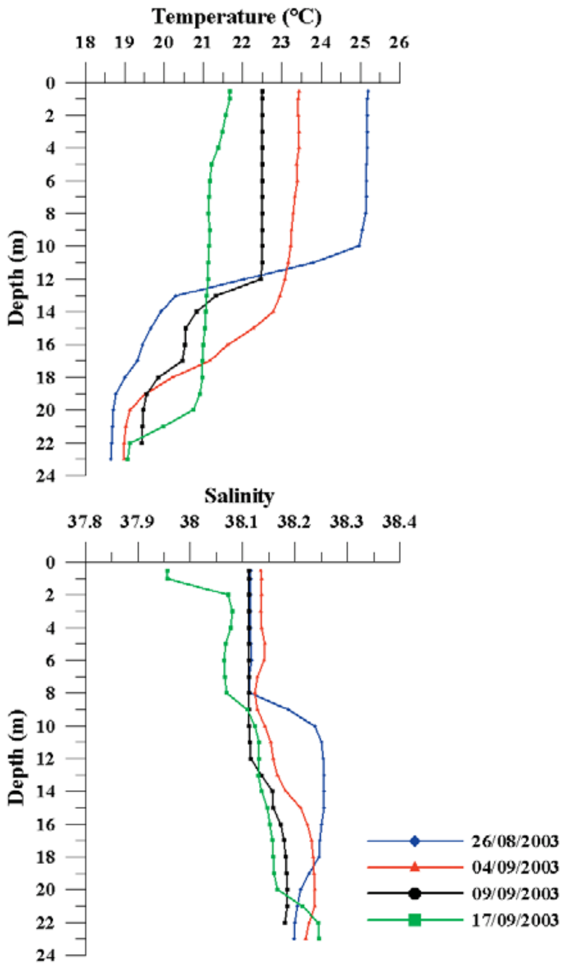

Fig. 13. Abrupt changes of the thermohaline structure of the water column induced by gales at the end of summer 2003

UMANI *et al.*, 1990; MALAČIČ, 1991; MOSETTI, 1984; STRAVISI, 1983, 2000).

During the winter period a frontal system forms along the Italian coast that can be approximately identified by the 36.5-37.0 isohalines. The fresh water inputs, confined by the frontal system, flow outward along the NE-SW axis of the gulf; a strong salinity gradient from the Italian to the Slovenian coast is evident. The temperature signal suggests the presence of a possible gyre located in the south-western part of the gulf (Fig. 14).

In April the surface temperature field is rather homogeneous (12.0 °C- 13.0 °C). At the end of April the onset of the heating process, particularly of the surface layer, causes the beginning of the vertical stability. The fresh water inputs are still confined near the Italian coast.

The months between May and September are characterised by strong thermal stratification with a temperature gradient of about 10-12 °C/20 m. The maximum value of temperature is recorded in the surface layers in July (Fig. 15) and August (24.0 °C-26.0 °C) while in the bottom layers the maximum value is measured in September (19.5 °C-20.5 °C); the temperature of the western side of the basin is generally higher than that of the eastern side. A horizontal gradient is still evident for surface salinity in July, but it is weaker than that observed in April. The comparison between climatology and July

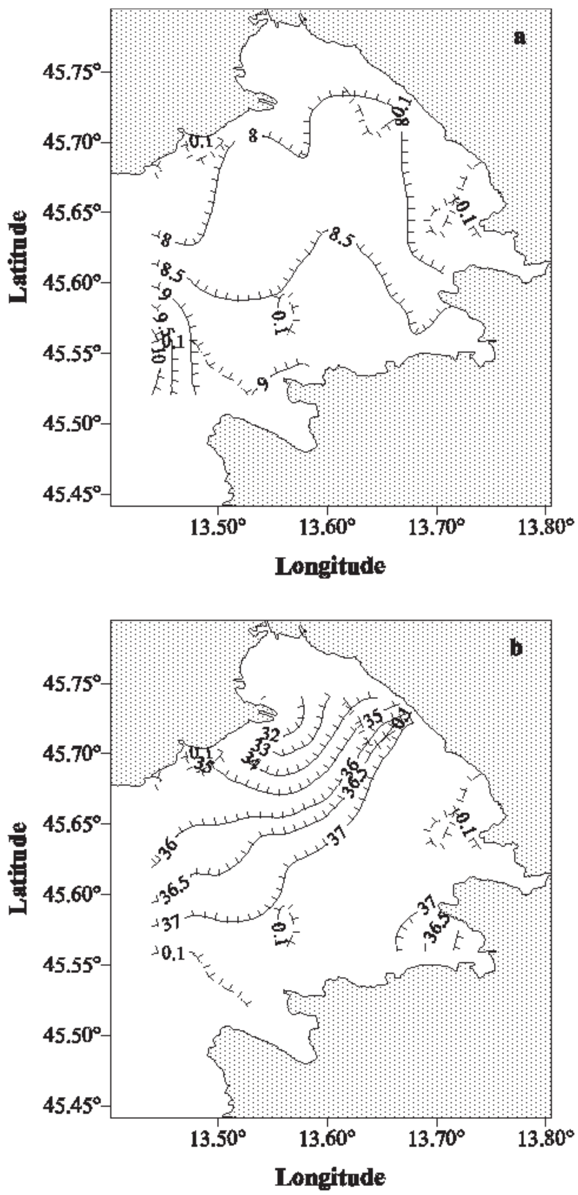

Fig. 14. Objective analysis of surface temperature (a) and salinity (b) fields and error fields (dashed line) for February from climatological data (1991-2001)

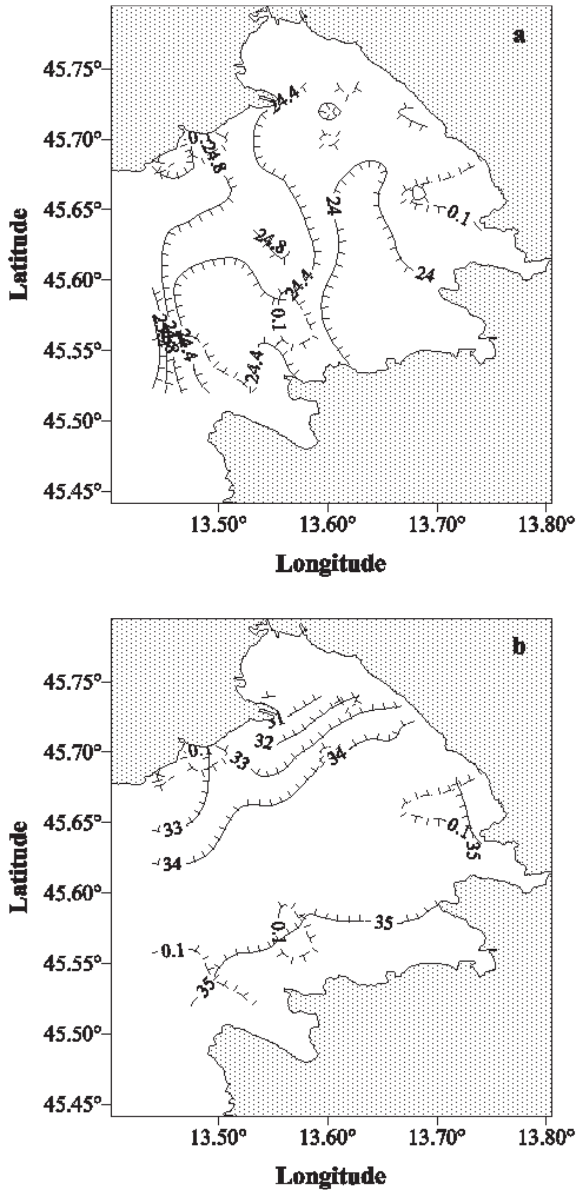

Fig. 15. Objective analysis of surface temperature (a) and salinity (b) fields and error fields (dashed line) for July from climatological data (1991-2001)

2003 shows a different pattern for the horizontal distribution of temperature and salinity at the surface: the climatology presents a higher core temperature in the central part of the basin and a NW-SE salinity gradient (Fig. 15), while in July 2003 the highest temperature values were observed close to the Slovenian coast. Also, salinity shows an anomalous gradient northward with the highest values in the inner part of the Gulf (Fig. 11). This is the reverse of what was expected.

In October, due to the increase in precipitation that usually occurs in this month and the consequent increase of the Isonzo River outflow, low salinity (< 35) water masses are evident along the Italian coast. The onset of the convective and mechanical mixing of the surface and subsurface layers of the water column is noted and a pycnocline separates the subsurface layers from the bottom layers. The mixing of the water column continues in November and December when a decrease in fresh water inputs occurs. At the end of the year the surface and bottom temperatures are 9 °C - 13 °C and 11.4 °C - 13.8 °C respectively.

In October-November, the increase in easterly winds reinforces the cyclonic circulation of the Gulf of Trieste which favours the flow of the water masses along the Italian coast and the setting up of a high salinity (>37.5) bottom countercurrent which enters the gulf (MALAČIČ & PETELIN, 2001).

CONCLUSIONS

The ADRICOSM project has enabled the collection of the CTD data over the entire Gulf of Trieste by means of one day cruises, providing a quasi-synoptic description of the hydrographic features of the basin.

The comparison between the climatological data set (1991-2001) and the 2002-2003 observed data shows that from October 2002 to April 2003 the temperature field was similar to that obtained by OA, though slightly colder waters were observed at the sea surface. During these months, the values of the salinity field ranged between 37.5 and 38.2, i.e. generally greater than the climatological values (36.7-37.7).

During the summer period (June-September 2003) exceptionally high values of temperature were recorded (max 29.09 °C) with a strong vertical gradient (13.8 °C/20 m), while the OA provides climatological values of 26.5 °C and 10 - 12 °C/20 m, respectively. Due to extremely low river inputs that occurred during the spring and summer periods, in July and August the entire basin dilution was very scarce and salinity reached unusually high values (38.4) in the bottom layer. Moreover, the establishment of a reversed horizontal salinity gradient along the SE-NW direction suggests a possible modification of the typical distribution of the water masses in the Gulf with peak salinity in front of the Isonzo River mouth.

Results demonstrate the strong interannual variability of the hydrological characteristics of the Gulf of Trieste and suggest that long time series of accurate and quality-checked CTD data are necessary in order to thoroughly understand modifications to the temperature and salinity fields of the basin. Moreover, it emerges that the climatological analysis of the hydrological characteristics of the Gulf can be a useful tool to detect and assess quantitatively the annual thermohaline deviations that occur in the basin.

REFERENCES

BRETHERTON, F., R. DAVIS & C. FANDRY. 1976. A technique for objective analysis and design of oceanographic experiments applied to MODE-73. Deep-Sea Res., 23: 559-582.

BUSSANI, A., M. CELIO & C. COMICI. 2003. Climatological analysis (1991-2002) of the thermohaline characteristics in the Marine Reserve of Miramare (Gulf of Trieste). Boll. Geofis. Teor. Appl., 44 (1): 11-17.

CARDIN, V. & M. CELIO. 1997. Cluster analysis as a statistical method for identification of the water bodies present in the Gulf of Trieste (Northern Adriatic Sea). Boll. Geofis. Teor. Appl., 38: 119-135.

CELIO, M., C. COMICI & A. BUSSANI. 2002. Thermohaline anomalies in the spring and early summer of 2000 in the Gulf of Trieste. Mar. Ecol., 23: 100-110.

FONDA UMANI, S., P. FRANCO, E. GHIRARDELLI & A. MALEJ. 1990. Outline of oceanography and plankton of the Adriatic Sea. In: The Adriatic Sea. 25th European Marine Biology Symposium. University of Ferrara, pp. 25-43.

FRANCO, P. 1989. Osservazioni sull'oceanografia fisica e chimica dell'Adriatico (Observations on physical and chemical oceanography of the Adriatic Sea). In: Sogesta-Ministero degli Affari Esteri (Editors). Lo stato di salute dell'Adriatico. Problemi e prospettive, Urbino, Italia, 23-24 Maggio, pp. 21-29.

MALAČIČ, V. 1991. Estimation of the vertical eddy diffusion coefficient of heat in the Gulf of Trieste (Northern Adriatic). Oceanol. Acta, 14: 23-32.

MALAČIČ, V. & B. PETELIN. 2001. Regional studies. Gulf of Trieste. In: Cushman-Roisin, B., Gačić M., Poulain P. M. & Artegiani A. (Editors). Physical Oceanography of the Adriatic Sea. Past. Present and Future. Kluwer Academic Publishers, Dordrecht The Netherlands. pp. 167-181.

MOSETTI, F. 1984. Caratteristiche fondamentali dell'idrologia dell'Adriatico (Hydrological foundamental characteristics of the Adriatic Sea). Boll. Oceanol. Teor. Applic., 2: 169-194.

MOSETTI, F. & P. MOSETTI. 1990. Measurements on wind driven circulation in the North Adriatic Sea. Boll. Oceanol. Teor. Applic., 8: 251-261.

NAUDIN, J. J., V. MALAČIČ & M. CELIO. 1996. Hydrological characteristics of the Gulf of Trieste (Northern Adriatic) during high fresh-water input in early summer. In: T. S. Hopkins, A. Artegiani, G. Cauwet, D. Degobbis & A. Malej (Editors). Ecosystem Research No. 32. The Adriatic Sea (EUR 18834). European Community, pp. 71-81.

STRAVISI, F., G. PIERI & P. BERGER. 1981. Golfo di Trieste: risultati delle misure correntometriche 1951-1954 (Gulf of Trieste: Results of current measurements from 1951 to 1954). Boll. Soc. Adriat. Sci., 65: 23-35.

STRAVISI, F. 1983. The vertical structure annual cycle of the mass field parameters in the Gulf of Trieste. Boll. Oceanol. Teor. Applic., 1: 239-250.

STRAVISI, F. 2000. La temperatura del mare a Trieste (Sea temperature in Trieste). Hydrores Inf., 20: 7-16.

VOLLMER, M. K. 1991. Sharpening and matching response signals for finescale sensors. WP 630 MV, Centre for Water Research, University of Western Australia, Perth.

ZAVATARELLI, M. & N. PINARDI. 2003. The Adriatic Sea modeling system: a nested approach. Ann. Geophys., 21: 345-364.

Opažanja u obalnom području u okviru ADRICOSM projekta: Tršćanski zaljev

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SAŽETAK

U okviru projekta ADRICOSM, od listopada 2002. do rujna 2003. godine, provedeno je 36 krstarenja tijekom kojih se uzorkovalo CTD sondom na 19 postaja u Tršćanskom zaljevu. Posebna pažnja je posvećena kvaliteti podataka. Tijekom ljeta 2003. godine opaženi su nagli skokovi vrijednosti saliniteta i gustoće (tzv. “spikes”) u području izražene termokline. U proljeće i ljeto 2003. godine vrijednosti saliniteta bile su izrazito visoke. Polja temperature i saliniteta određena za to razdoblje uspoređena su s postojećim podacima ne bi li se utvrdilo koliko odstupaju od prosjeka.

Ključne riječi: Tršćanski zaljev, hidrografske karakteristike, rijeka Soča, višegodišnji prosjeci, objektivna analiza, CTD sonda