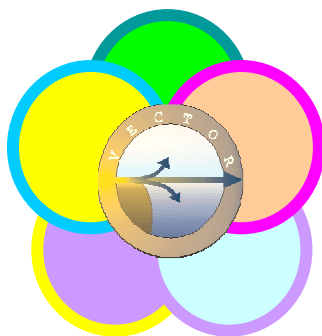


Progetto V.E.C.T.O.R.



Workshop finale
Roma, 18-19 ottobre 2010

Libro degli abstracts

Libro degli abstracts presentati durante il Workshop
di chiusura del progetto V.E.C.T.O.R.

Una copia digitale degli interventi orali e dei poster verrà pubblicata,
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Per maggiori informazioni contattare il Coordinatore del progetto,
il Prof. Cesare Corselli

Dipartimento di Scienze Geologiche e Geotecnologie

Università degli Studi di Milano Bicocca

Piazza della Scienza, 4 - 20126 Milano

Tel. 02 64482081

e-mail: corselli@unimib.it

Segreteria scientifica e organizzativa:

Dr. Simona Tanzarella

Dipartimento di Scienze Geologiche e Geotecnologie

Università degli Studi di Milano Bicocca

Piazza della Scienza, 4 - 20126 Milano

e-mail: vector@conisma.it

Web Site: <http://vector.conismamibi.it/>

Progetto V.E.C.T.O.R.

Vuln**E**rabilità delle **C**oste e degli ecosistemi marini italiani ai
cambiamenti clima**T**ici e loro ruol**O**
nei cicli del ca**R**bonio mediterraneo

Workshop finale

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Introduzione

Con questo workshop si conclude il progetto VECTOR dopo oltre 4 anni di ricerche dal lontano 16 febbraio 2006, data ufficiale di avvio delle attività.

È tempo dunque di parlare di risultati, delle conclusioni raggiunte, e di esporre i bilanci delle nostre ricerche che, nonostante le più svariate problematiche incontrate, ha visto la comunità VECTOR impegnata tra alti e bassi nel raggiungimento di vari obiettivi.

Il 18 e 19 ottobre 2010, in Roma, presso la sede Centrale del Consiglio Nazionale delle Ricerche, che ringrazio fortemente per l'ospitalità concordataci, esporremo i risultati più salienti delle nostre ricerche attraverso 43 comunicazioni orali e 27 poster, apponendo di fatto un tassello importante e fornendo un contributo consistente alla conoscenza scientifica europea ed internazionale.

Nel corso della seconda giornata di workshop, in presenza di tutta la comunità VECTOR riunita, e con la partecipazione di ospiti illustri impegnati come noi nelle ricerche sui cambiamenti climatici in Italia, abbiamo programmato uno spazio "ad hoc" per aprire una tavola rotonda sulle problematiche della ricerca italiana in questo settore e per discutere quale possibile futuro ci attende. La tavola rotonda potrà essere, spero, il "punto di partenza" per cercare di continuare il lavoro svolto, malgrado le ristrettezze economiche che oggi affliggono la Ricerca, e per consentire di mantenere le posizioni così faticosamente raggiunte a livello internazionale, certi che senza un'efficace azione di continuità rispetto al passato si corre il rischio che i risultati raggiunti non vengano adeguatamente valorizzati.

Il progetto VECTOR recentemente, ha fatto un grosso passo in questa direzione entrando ufficialmente a far parte del progetto IMBER che coinvolge le migliori forze internazionali nello studio degli impatti dei cambiamenti climatici sugli equilibri biologici e geochimici degli oceani. Ed in questa direzione cercheremo di muovere i nostri prossimi passi.

Ringrazio tutti gli autori dei lavori presenti in questo volume per il prezioso contributo offerto, la dr.ssa Mariangela Ravaioli per il costante supporto e Simona Tanzarella per l'organizzazione dei lavori ed auguro buon lavoro a tutti i partecipanti al Workshop finale VECTOR.

Il Coordinatore
Cesare Corselli

Sessione: Comunicazioni orali

Trend assessment of Sele Plain coastline (Southern Italy). The 1870 - 2009 time window

Alberico Ines^(1*), Amato Vincenzo⁽²⁾, Aucelli Pietro Patrizio Ciro⁽³⁾, D'Argenio Bruno⁽⁴⁾,
Di Paola Gianluigi⁽²⁾, Pappone Gerardo⁽³⁾

ialberic@unina.it

⁽¹⁾ CIRAM - Centro Interdipartimentale Ricerca Ambiente,
Università degli Studi di Napoli Federico II, Napoli, Italy

⁽²⁾ STAT - Dipartimento di Scienze e Tecnologie per l'Ambiente e il Territorio,
Università degli Studi del Molise, Italy

⁽³⁾ Dipartimento di Scienze per l'Ambiente, Università degli Studi di Napoli "Parthenope", Italy

⁽⁴⁾ Istituto per l'Ambiente Marino Costiero (IAMC)-CNR, Napoli, Italy

Key words: shoreline mapping, shoreline variation, shoreline trend, DGPS survey, granulometric analysis, morphological analysis

In the Mediterranean, the coastal population was estimated at 146 million in 1990 and the urban coastal population alone is projected to rise at 176 million by 2025, with an addition of 350 million of tourists per year. In this zones, to forecast the shoreline location and its change through time, is fundamental to coastal scientists, engineers and decision makers, when planning a reduction of the territorial vulnerability at both long and short terms.

The prediction of coastal evolution is complex because it is related to both the analysed spatial and temporal scales over which coastal changes occur, and to the inter-dependence between different components of the coastal system. Despite these difficulties, this prediction is

necessary to identify the areas that could be more severely hit by erosion over decades to centuries.

The main aim of this paper is to define the shoreline variability of Sele Plain (Southern Italy) occurred in the last 140 years between Salerno and Agropoli towns. To this purpose 170 transects, spaced at 200 m intervals across nine shorelines tracts, were analysed in order to measure the variations in time between two adjacent shorelines and the linear regression trend over 140 years. This analysis has shown that in Sele plain the highest rates of erosion, generally localized at river mouths (Picentino river, mean value: 0.4 m/y; Sele river, mean value: 1.3 m/y), decreased in the last 20 years revealing that the beach system has reached a new stability.

Holocene palaeo-geographical evolution of the Sele river alluvial-coastal plain: new morpho-sedimentary data from Poseidonia-Paestum area

Amato V.¹, Aucelli P.P.C.², D'Argenio B.³, Pappone G.², Petrosino P.³, Roskopf C. M.¹, Russo Ermolli E.³

vincenzo.amato@unimol.it

¹Dipartimento STAT, Università degli Studi del Molise; ²DISAM, Università degli Studi di Napoli "Parthenope"

³IAMC-CNR, Napoli; ⁴Dipartimento di Scienze della Terra, Università degli Studi di Napoli "Federico II"

Key words: Holocene, Sea level rise, Coastal palaeoenvironment, Geo-archaeology, Tephrostratigraphy, Sele Plain, Poseidonia-Paestum, Southern Italy.

Holocene glacio-eustatic sea level rise after the Last Glacial Maximum (LGM) led to a worldwide flooding of shelf areas and controlled strongly the evolution of low coast areas, in particular coastal embayments and alluvial plains, while its significant deceleration in mid-Holocene times and the increase of fluvial sediment yields led to a progressive shoreline progradation of many Mediterranean alluvial coastal plains. Shoreline progradation was more marked during the last 2500 years, and favored by the increase of anthropic impacts on vegetation and, consequently, on sediment yields of fluvial and coastal systems (Vita Finzi, 1969; Bradley, 1999; Messerli et al., 2002; Amato, 2006). Also the Sele river coastal plain was interested by such a morpho-sedimentary evolution and affected by marine transgression during the early Holocene and shoreline progradation from the Middle Holocene onwards (Cinque, 1986; Brancaccio et al., 1987, 1988; Barra et al., 1998, 1999, Cinque, 2008; Amato et al., 2009 and references herein).

Within the Vektor-Vulkost Project (Thematic Line 2), a multidisciplinary approach, based on a detailed sedimentological, stratigraphic and geomorphological characterization of the Sele plain, was carried out in order to reconstruct the palaeoenvironmental and landscape changes that occurred during the Holocene. In particular, stratigraphic data were derived from the interpretation of more than 200 boreholes and from three new cores, one drilled very close to the Sele river mouth, the other two in the area of Paestum, in the sector located between the coast line and the archaeological site of Poseidonia-Paestum.

In this abstract we present main research results for the Poseidonia-Paestum area, concerning in particular its evolution from mid-Holocene to historical times as inferred from collected geomorphological and archeo-tephro-stratigraphic data.

In the area of Paestum, the local response to the Late Upper Pleistocene to Early Holocene sea level rise was the progressive landward migration of the coast line. As examined core data clearly evidence, marine erosion even affected the travertine platform on which the city of Poseidonia successively was built, and generated an abrasion platform and a related sea cliff, part of which is still visible near Porta Marina, the southern entrance of the city.

The change from a transgressive trend to a regressive one in mid-Holocene times is evidenced by a net seaward shifting of the coastline and the early deposition of a first emerging beach-dune ridge (Laura palaeo-ridge, dated to 5.3 ky by Brancaccio et al., 1984) which is located about 0.6 km seawards from the Porta Marina palaeo-cliff. This ridge isolated Fossa Lupata, a large back-ridge depression. Archaeological remains referring to the VI-V century B.C. and the presence of the Averno tephra (3.8 ka, Orsi et al., 2004) within the back-ridge's pelitic fill succession, confirm the existence, during this period, of a barrier-lagoon morpho-sedimentary system, that shifted in time alternatively landward and seaward. The Fossa Lupata depression was probably connected with the sea and used as port of the Greek city.

As confirmed also by archaeological data which highlight the extensive use of the Laura ridge for burials during Greek times (Necropolis of Ponte di Ferro dating to the VI-V century B.C., Amato et al., 2009), about 2500 years ago, the coastline had already moved further seaward for a few hundred meters where a second dune ridge deposited (Sterpina ridge, max. 2.5 ky, Brancaccio et al., 1984). The Fossa Lupata depression, no longer connected with the sea, narrowed progressively due to the deposition of fluvial-marshy deposits and dried definitely up after the deposition of the 79 A.D. Vesuvius pumice fall deposits and during very recent times.

Main goals of line 3 “VARiazioni relative del livello del mare, impatto sulle aree COSTiere”

Antonioli E.¹, Agate M.², Bezzi A.³, Buseti M.⁴, Bisiccia C.⁵, Digrigoli G.², Catenacci M.⁶, Caburlotto A.⁴, Chiocci F.⁷, Devoti S.⁸, Fontana A.⁹, Fontolan G.³, Fachin G.³, Lambeck K.¹⁰, Delli Quadri F.³, Pillon S.³, Ricci E.³, Savelli D.⁵, Silenzi S.⁸, Tessarolo C.¹¹, Tarragoni C.⁷, Tramontana M.⁵, Trivisi C.⁶

fabrizio.antonioli@enea.it

¹ ENEA, Casaccia Roma

² Dipartimento di Scienze della Terra di Palermo

³ Dipartimento di Scienze Geologiche e Ambientali, Trieste

⁴ Istituto Nazionale di Oceanografia e di Geofisica Sperimentale, Trieste

⁵ Dipartimento di Sc. Ambientali di Urbino

⁶ Fondazione Enrico Mattei, Milano

⁷ Dipartimento di Sc. della Terra di Roma

⁸ ISPRA, Roma

⁹ Dipartimento di Geografia, Padova

¹⁰ The Australian National University, Canberra, Australia

¹¹ Dip. Scienze Geologiche e Geotecnologie, Università degli Studi di Milano-Bicocca

Key words: Grado and Marano Lagoon, Metauro and Foglia rivers, Ombrone Plain, Ionian coast Roccella Ionica, Eustatic, Isostatic and tectonic sea level component, Holocene, MIS 5.

Using eustatic, isostatic, tectonic data, and the IPCC 2007 Projections for 2100, we calculated the relative sea level change in the studied Italian Plains. In collaboration with FEEM ENI we evaluated the socioeconomic impact in the Grado and Marano Plain. A complete collection of the used database are contained on the online version

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Quantifying the carbonate production of coralline algae (Rhodophyta): from the plant to the basin scale

Basso D., Caragnano A., Bracchi V.

daniela.basso@unimib.it

Dip.to di Scienze Geologiche e Geotecnologie, Università degli Studi di Milano-Bicocca

Key words: Coralline algae, Alizarin stain, Side-scan sonar, growth rate, cultures, carbonate production.

Marine biogenic calcification will be hampered by acidification and low carbonate saturation state induced by increased dissolution of inorganic carbon and carbon dioxide in surface ocean water. Coralline algae are one of the most important carbonate producer in temperate benthic ecosystems and are common from tropical to polar oceans at all depths within the photic zone. Thus corallines are a key element of carbon and carbonate cycles in shallow water. They respond very sensitively to a lowered pH, by dramatically decreasing their abundance and dissolving the Mg-calcite thallus. Few studies have focused on the quantitative contribution of biogenic carbonate and particularly on carbonate production or accumulation of coralline algae, a major element in the Mediterranean carbon budget.

This work is aimed to achieve a reliable evaluation of the contribution of coralline algae to the biogenic carbonate production in the shelf areas of the Mediterranean, and of their vulnerability to the expected lowering of the carbonate saturation state.

We explored the growth rate of common species of coralline algae using Alizarin-S stained laboratory cultures (tank experiments) and one-year long *in situ* experiments. The tank experiment lasted 15 months and resulted in an inhomogeneous growth of *Lithophyllum stictaeforme* and *Mesophyllum sp.* In *L. stictaeforme* we observed a thallus thickening of 26,25 $\mu\text{m}/\text{y}$ to 74,17 $\mu\text{m}/\text{y}$, and a marginal elongation ranging between 42,5 $\mu\text{m}/\text{y}$ and 1316,25 $\mu\text{m}/\text{y}$. The thickening of *Mesophyllum sp.* ranged from 15 $\mu\text{m}/\text{y}$ to 103,13 $\mu\text{m}/\text{y}$, and the marginal elongation was between 60 $\mu\text{m}/\text{y}$ and 356,25 $\mu\text{m}/\text{y}$.

After the *in situ* experiments at 7 m depth in the Bay of Bonassola (SP) we observed a marginal elongation of up to 2000 $\mu\text{m}/\text{y}$ in *L. stictaeforme*, and up to 5000 $\mu\text{m}/\text{y}$ in *Mesophyllum sp.*, with thickening of about 170 $\mu\text{m}/\text{y}$.

The carbonate factory of the Pontian Islands shelf has been investigated on a basin scale: the biogenic carbonate fraction of the sediment presently on

the sea-floor was measured and the CaCO_3 polymorphs identified by X-ray diffraction. A total of 150 grab samples have been considered in order to define the main sedimentological features of the seafloor between 30 and 100 meter wd. Thin sections have been prepared to identify the biogenic components. Multidimensional statistical analyses have been performed to detect similarities among samples and define the carbonate facies. Two different carbonate facies have been distinguished: the Coralline Algae facies, in the bathymetric interval from 30 m to 70 m wd, and the Carbonate matrix facies, between 70 m and 100 m wd. The areal distribution of the two carbonate facies has been mapped based on available side-scan sonar data, and an estimate of the algal carbonate presently occurring at the seafloor is provided. Our results show that in the bathymetric interval between 32 m and 100 m of water depth (wd), the total carbonates exceed 80% of the recent/actual sediment production. The maximum carbonate production takes place between 40 and 70 m wd, with values ranging between 83,1% and 95,7%.

Coralline algae represent the most important carbonate producer in the studied area, reaching a spatial distribution of about 80% in the bathymetric interval between 40 m and 70 m wd (CA facies). Living free branches and rhodoliths 1-3 cm in diameter form the benthic algal assemblage. The calculated production rate of 329 $\text{g m}^{-2} \text{y}^{-1}$ is an intermediate value between those reported in literature for maërl facies and coralligenous build-ups. In the deepest bathymetric interval (CM facies) calcareous red algae reach a surface coverage of 3,6 km^2 , but in this facies the sediments are characterized by muddy sand in which abrasion, bio-erosion and recrystallization are reported. The biogenic carbonate percentage in this interval reaches a medium value of 66%. The recognized algal contribution is lower than 15% of the total carbonates and the calculated production rate is 38,02 $\text{g m}^{-2} \text{y}^{-1}$.

The northern Adriatic as a long term ecological site: structure and results

¹Bastianini M., ¹Ravaoli M., ¹Paschini E., ²Cataletto B., ³Fonda Umani S., ¹Marini M., ¹Socal G.,
¹Focaccia P., ²Giani M., ⁴Russo A., ¹Raichich F.

mauro.bastianini@ismar.cnr.it

¹ Istituto di Scienze Marine, CNR-ISMAR

² Istituto Nazionale di Oceanografia e Geofisica Sperimentale, OGS Trieste

³ Dipartimento di Biologia, Università di Trieste

⁴ Dipartimento di Scienze del Mare, Università Politecnica delle Marche, Ancona

Key words: Adriatic, carbon cycle, time series.

Pluriannual ecological data series, gathered with minimal interruptions and adequate sampling frequencies, represent an invaluable tool to deal with climate changes in marine ecosystems.

In the framework of the national research program VECTOR (Vulnerabilità delle Coste e degli ecosistemi marini italiani ai cambiamenti climatici e loro ruolo nei cicli del carbonio mediterraneo), a wide array of data-sets have been merged in the effort to a better understanding of ecosystems functions and of their feedback to environmental changes. VECTOR focuses at different sites, in particular the research line CARADRI will study the carbon cycle in the Adriatic given the reactivity of this ecosystem, considered the Mediterranean area with the highest mean primary production. Both research and ecological monitoring of a wide range of variables cover key areas of the basin (Gulf of Trieste, Gulf of Venice, Po Delta, Ancona). One of the key feature of CARADRI is its long-term approach and the presence of automatic data gathering systems which ensures continuity to the collection of data. The ability of buoyed observatories to make long-term measurements of ongoing processes also gives the study the potential to play an important role in oceanographic and climatic studies. They could track the flow of major currents along the adriatic boundaries.

Thanks to the joint effort of a team of researchers, a network of northern Adriatic stations entered the international Long Term Ecological Research

network (LTER-International). The availability of different ecosystem study approaches (e.g. biogeochemical cycles, plankton ecology) entitled the Northern Adriatic Sea as one of the few marine sites of the network.

Three different Institutions collaborate in this LTER site (ISMAR CNR, University of Trieste and INOGS), with ecological studies in four different areas (Gulf of Trieste, Gulf of Venice, Po river pro delta and Susak-Senigaglia transect). In the most recent years the project "VECTOR" contributed significantly to long-term data elaboration and to the carrying on of field activities.

The main ecological investigations concern: i) the carbon pathways in the pelagic food web, ii) patterns and trend in plankton communities, iii) monitoring the trophic state variation of the basin. Moreover, in key areas advanced automatic acquiring systems are operating, as early warning systems for dystrophic events and as a validating centre for numerical models. Furthermore other Process oriented measures have been conducted such as: vertical fluxes, primary production rates regarding both bacterial and plankton systems, isotopic tracers (U/Th), Dissolved, Particulate of inorganic and organic carbon concentration, allow a better comprehension of the origin and fate of the main fractions of carbon flowing through the ecosystem. During the meeting will be presented some results.

Physical and biological processes controlling particle fluxes variability, carbon export and burial in the Southern Adriatic

¹Boldrin A., ¹Turchetto M., ²Langone L., ²Miserochi S.

alfredo.boldrin@ismar.cnr.it

¹Istituto Scienze Marine ISMAR-CNR, Venezia

²Istituto Scienze Marine ISMAR-CNR, Bologna

Key words: Particulate organic carbon, downward fluxes, southern Adriatic.

The efficiency of the biological pump and the transfer of particulate organic material from the surface to the deep sea have been studied in Southern Adriatic (SA), by long-term sediment trap and sediment core studies.

In the framework of the VECTOR Project, downward particle fluxes have been measured in a station located in the centre of SA, from November 2006 to August 2008. Sediment sampling was carried out during two cruises in different seasons (April 2007 and February 2008), and consisted in collecting cores for sediment oxygen microprofiles, porosity measurements, solid phase sub-sampling and pore water studies.

The main goals of this work are to define:

- the variability of particulate matter production, transfer and sedimentation processes in the SA;
- the influence of hydrological and dynamical structures on production and transfer of particulate material to the sea floor;
- the export of particulate organic carbon from the photic zone and the relation with productivity processes;
- the flux of particulate organic carbon to the sediment water interface as the sum of mineralization and burial.

Sediment trap samples were collected at two depths, below the photic layer (168 m) and near the bottom (1174 m), and analysed for total mass flux (TMF), organic carbon (C_{org}), nitrogen, carbonates, stable isotope of organic carbon ($\delta^{13}C_{org}$) and biogenic silica contents.

Solid phase analyses included organic carbon and total nitrogen content, grain size, and radionuclides (^{210}Pb and ^{14}C) measurements to determine sediment accumulation rates and biomixing coefficients.

The results have been integrated and compared with data obtained from previous projects, carried out in the SA in 1994-95 and in 1997-98.

Fluxes of particulate matter showed high seasonal and interannual variability, with maximum values in late winter-spring season. The organic carbon flux showed higher values below the photic zone,

following the same seasonal trend, with peaks in spring, related to blooms of silicates and/or carbonates phytoplankton organism (e.g. diatoms, coccolithophorids).

The C_{org} export from the photic layer was of $5.2 \text{ g C m}^{-2} \text{ y}^{-1}$, and $2.1 \text{ g C m}^{-2} \text{ y}^{-1}$ reached the seabed. The average mineralization rate of was $3.2 \text{ g C m}^{-2} \text{ y}^{-1}$ (without taking account of sediment vertical mixing), while only $0.3 \text{ g C m}^{-2} \text{ y}^{-1}$ are definitively buried in the bottom sediment.

Early significant results from deep time-series sediment trap studies included the discovery of a strong seasonality and interannual variability in deep-ocean particle fluxes and the important role played by episodic events in the rapid transport of biogenic material to depth, mainly due to blooms of large planktonic organisms, both autotrophic and heterotrophic. These processes are driven by autotrophic production processes occurring in the upper euphotic layers and are affected by light and nutrient availability. The latter in turn, in the SA, is subject to physical water mixing that is mainly produced by the winter deep convection process, which brings inorganic nutrients in the upper euphotic zone from deeper layers.

TMF at the bottom trap were twofold those measured below the photic layer, and showed a high lithogenic fraction, highlighting the presence of advective processes, that appear particularly active in the investigated area, and can be correlated with the spreading of dense waters coming from the north and central Adriatic, generally observed in spring.

The elemental and isotopic composition of the bottom trap samples is similar to that found in the slope area, reinforcing the hypothesis that lateral advective contributions from the western Adriatic shelf-slope area other than vertical input were contributing to bottom particle fluxes. The advective transport determines episodic, high-flux events, linked to physical forcings, and to the interaction between water circulation and geomorphological structures.

A large scale survey of functional phytoplankton diversity in the euphotic layer in the Mediterranean sea – summer 2007 (VECTOR Research Program)

Brunet C.¹, Conversano F.¹, Lavezza R.², Margiotta F.¹, Saggiomo M.¹, Santarpia I.¹,
Cerino F.^{3,4}, Percopo I.^{1,3}, Totti C.³, Zingone A.¹, Saggiomo V.¹

christophe.brunet@szn.it

¹ Stazione Zoologica Anton Dohrn, Villa Comunale 80121 – Naples – Italy,

² Istituto di Biofisica – Aria della ricerca di Pisa – Italy,

³ Department of Marine Sciences - Polytechnic University of Marche – Ancona – Italy,

⁴ Biological Oceanography Department – OGS - S. Croce (TS) – Italy

Key words: Phytoplankton, Mediterranean Sea, Primary productivity, Pigments.

The upper layer – from surface to the DCM – of 10 stations along a trans-Mediterranean transect has been intensively sampled in June 2007, in order to investigate the functional diversity of the phytoplankton community in different trophic areas of the Mediterranean sea. Functional diversity was investigated with measurements of phytoplankton pigments and primary productivity in two algal size classes (picoplankton and nano-micro-plankton), phycobiliproteins and absorption spectrum. Phytoplankton diversity was described thanks to traditional microscopy analyses combined with a metagenomic approach (clone libraries of 16S rRNA gene). Vertical profiles of chl.*a* fluorescence, light and hydrological

properties were carried out at each station. A Western to Eastern gradient was revealed for some key-environmental parameters. Depths of the mixed layer and DCM were shallower and deeper in the Eastern basin, respectively, while light penetration was stronger in the Eastern part relatively to the Western part. The hydrological properties and the trophic state of the water masses significantly affected the composition and ecological traits of the microbial community that presented a high diversity both across the basin and along the water column. These results are discussed in term of adaptative ecology of primary producers to environmental conditions.

Geophysical investigation of the Late Pleistocene and Holocene evolution of the Grado and Marano Lagoon (Northern Adriatic)

Busetti¹ M., Baradello¹ L., Caburlotto¹ A., Gordini¹ E., Zanolla¹ C., Accettella¹ D., Antonioli² F. and Paganini¹ P.

mbusetti@inogs.it

¹ Istituto Nazionale di Oceanografia e di Geofisica Sperimentale

Borgo Grotta Gigante 42/c, 34010 Sgonico (Trieste)

² ENEA - Via Anguillarese 301 - 00123 Roma (Italy)

Key words: Grado and Marano Lagoon, Holocene, Thyrrenian, seismostratigraphy.

The Grado and Marano Lagoon, located at the northernmost coast of the Adriatic Sea, is a moderately anthropized system, still having the possibility of natural evolution. For this reason it has been chosen as one of the study sites where to investigate the vulnerability of coastal environment induced by climatic and sea level changes.

The Grado and Marano Lagoon extend between the Tagliamento and the Isonzo Rivers, covering an area of about 160 km², fronted by the sand banks and 1 km northward, by barrier islands distributed in an arch shape separated by inlets. The plain northward of the lagoon is up to 2 m below sea level, and was a wetland reclaimed since the Middle Ages and more extensively between the 1920-1940, and protected from the lagoon by artificial levees.

The Grado and Marano Lagoon is composed by the merging of the Marano lagoon (western part) formed about 5500 ys BP and, and the Grado Lagoon (eastern part) formed about 1000 ys BP (Marocco et al., 1991) due to the eastward diversion of the Isonzo River (Brambati, 1970).

Among the VECTOR project, the aim of the study is the evolution of the Holocene, with the transition from continental to lagoon environment, and of the Late Pleistocene, with possible relationship and/or analogues between the present day marine transgression and the Early Thyrrenian, 125.000 ys BP with a sea level rise of 7±1 m (Antonioli and Silenzi, 2007), and the tectonic subsidence of the area to provide scenarios of increasing relative sea level.

For this purpose were acquired: a) 150 km of high resolution single channel seismic profiles integrated with further 50 km from OGS database; b) three profiles of multichannel seismic of intermediate resolution from land to lagoon, for a total of 25 km; c) morpho-bathymetry in the inlets for a total of 4 km² and 320 km of singlebeam bathymetric profiles outside the lagoon, integrated with 870 km of bathymetric profiles from OGS

dataset. The bathymetric dataset has been merged with onland topographic data of the Friuli Venezia Giulia Regional Technical Chart 1:5.000 to create a DTM of the Marano and Grado Lagoon together with its sea and land surrounding areas.

The geophysical investigation were integrated with stratigraphic information from well data, two of them, about 50 m deep, drilled within the VECTOR project.

The results from seismo-stratigraphy analysis are the identification of: a) the transition from continental to lagoon environment dated ~5000 ys BP in the central part of the lagoon, at about 10 m bsl; b) the base of the Holocene in the external part of the lagoon, being the beginning of the postglacial marine transgression. Holocene sediments are mainly constituted by the Isonzo and Tagliamento delta. Moreover the Isonzo delta migrated eastward of about 10-15 km, favouring the formation of the Grado Lagoon; c) continental environment surface with peaty sediment dated ~20.000 ys BP, present overall the area from 25 m bsl landward to 40 m bsl deep in the external part of the lagoon.

The DTM of the area was used to compute different scenarios in relation to the increase of the relative sea level: a) the Scenario 2050 according to the IPCC 2007 A1FI max indicates that area below sea level will extend landward from 2 to 7 km, increasing of up to 0,5 km the present extent. Most of the sub-aerial zone inside of the lagoon and barrier islands will be below sea level; b) the Scenario 2100 according to the IPCC 2007 A1FI max and Rahmstorf (2007) indicates that area below sea level will extend landward from 3 to 8 km and the sub-aerial zones inside of the lagoon and barrier islands will be almost completely below sea level.

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Long-term variability of thermohaline conditions in the Southern Adriatic Sea with emphasis on the 2006-2008 period

Cardin V., Bensi M., Pacciaroni M.

vcardin@ogs.trieste.it

Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS

Key words: Adriatic Sea, Deep convection, Thermohaline properties, OMP analyses.

Spatially averaged temperature and salinity profiles from individual cruises from 1990 to 2009 were analyzed to outline the temporal evolution of water mass properties in the deep convection site in the Southern Adriatic Pit (SAP). Long-term variability in the hydrographic characteristics waters have been analysed on the basis of temperature and salinity data collected during several cruises covering at almost regular intervals the area of the southern Adriatic.

Particular attention was given to data collected during the last 3 years (2006-2008) when the VECTOR and SESAME cruises were carried out. This allowed us to situate the actual thermohaline properties in the context of the decadal variability. The datasets consists of temperature, salinity and oxygen parameters, the last one collected with an SBE 43 or Beckman/YSI sensor mounted on the CTD and calibrated with independent measurements performed on board by the CNR-ISMAR (Trieste Institute) scientific group.

This last period was characterised by a very low production of dense water in the northern basin during 2007, while from winter 2008 high production of North Adriatic Deep Water and Adriatic Deep Water in the northern and southern basin, respectively, were seen.

Finally, to identify the percentages of different water masses contained in the SAP we used the optimum multiparameter analysis (OMP), which provided a quantitative description of the water masses that reside in the south Adriatic Sea, highlighting some differences between two recent periods studied (2007 and 2008) and the production of dense waters.

The long-term variability in thermohaline conditions has been explained and related to the close feedback mechanism between the Ionian and the Adriatic Sea suggested by Gačić et al. 2010, according to which the Adriatic–Ionian area behaves as a bimodal system (“BIOS”) oscillating between two regimes characterised by cyclonic and anticyclonic upper layer circulation.

Microbial Contribution to Carbon flux in the Northern Adriatic Sea during February 2008 (VECSSES cruise)

Caruso G., Monticelli L.S., Azzaro M., Maimone G., La Ferla R.

gabriella.caruso@iamc.cnr.it

CNR Istituto per l'Ambiente Marino Costiero (IAMC) Messina

Key words: Northern Adriatic Sea, microbial loop, ectoenzyme activities, prokaryotic abundance, heterotrophic prokaryotic production, community respiration.

Microbial community plays a key role in the biogeochemistry in aquatic environments, regulating the turnover of organic matter with consequent nutrient regeneration and Carbon mobilization. Although the significance of microbial processes in organic matter transformation has widely been recognised, current knowledge of the contribution of the microbial metabolism in some Mediterranean basins is still limited. The Northern Adriatic Sea, due to its peculiar hydrological characteristics (shallow depth, Po river inputs, dense water formation in winter), has been selected within the VECTOR project (Task 6.3) as an important investigation site to quantify the flux of Carbon mobilized by microbial activities along the water column and to evaluate the effect of the continental slope on the whole Carbon budget.

An investigation was performed by IAMC – CNR in the framework of the VECSSES cruise during late winter (February 2008), to obtain a snapshot of the amount of Carbon flowing through the microbial community and to evaluate the relative efficiency of microbial activities along the main steps of organic matter transformation: decomposition, production and mineralization by oxidation. Fifteen stations covering an area from the Gulf of Trieste to Ancona were sampled and measurements were carried out to determine the following parameters: microbial decomposition by ectoenzymatic activities [EEA: leucine aminopeptidase (LAP) and beta-glucosidase (GLU)] using specific fluorogenic substrates; bacterioplankton biomass (BB) after DAPI staining and image analysis; Prokaryotic Heterotrophic Production (HPP) using H^3 -leucine incorporation; microbial community respiration (CR) by Electron Transport System assay. EEA: HPP and HPP:R ratios were also calculated to evaluate the coupling between the microbial processes.

Microbial activities showed values ranging from 0.002 to 2.516 and from 0.004 to 1.116 $\mu\text{gC/l/h}$

for LAP and GLU, HPP from 0.012 to 0.492 $\mu\text{gC/l/h}$ and CR from 0.065 to 0.205 $\mu\text{gC/l/h}$, respectively. BB ranged from 10.43 to 72.82 $\mu\text{gC/l/h}$. The microbial community responded to the Po river inputs with significant increases in both activity and biomass values in correspondence of the most coastal, less haline, waters. The importance of fluvial inputs in providing sources for microbial metabolism was suggested by the significant inverse relationships linking salinity with LAP and HPP data ($r = -0.821$, -0.888 , $n=62$, respectively). Vertical profiles of activity rates pointed out the presence of sporadic peaks in deep waters.

EEA by LAP+GLU potentially mobilised, on average, an amount of $11.12 \pm 13.65 \mu\text{gC/dm}^3/\text{day}$; HPP incorporated $1.82 \pm 2.36 \mu\text{gC/dm}^3/\text{day}$, while CR oxidised $2.57 \pm 0.68 \mu\text{gC/dm}^3/\text{day}$. The processes of EEA and HPP were quite reciprocally coupled ($r=0.707$, $n=62$), as the highest microbial hydrolysis and productive rates were measured at the most western coastal stations; conversely, CR was spatially uncoupled with HPP, as mineralisation prevailed at the southern side of the basin. The amount of Carbon released by EEA exceeded that uptaken by HPP, providing a source of DOC available to planktonic organisms. The percentage of monomers incorporated into new biomass ranged from 2.67 to 102.1% *per day*, with a mean value of $24.23 \% \pm 20.30$; the mean percentage of biomass oxidised by CR *per day* was $301.12 \pm 232 \%$. A similar uncoupling between hydrolysis and uptake was observed in the same area and seasonal period during previous PRISMA 1-2 projects (February 1997 and 1998, considering LAP only). The overall analysis of microbial processes pointed out the high heterogeneity of the investigated area, with significant differences between surface and deep layers and the co-existence of sub-basins with different microbiological characteristics.

MACISTE-ICE, an advanced updatable informatic system to visualize and make available oceanographic data collected in Antarctica in the frame of national and international projects

Catalano⁽¹⁾ G., Massa ⁽²⁾ F., Castellano ⁽²⁾ M., Povero⁽²⁾ P.

giulio.catalano@ts.ismar.cnr.it

⁽¹⁾ CNR-ISMAR- U.O.S. di Trieste – Viale Gessi, 2 – 34123 Trieste

⁽²⁾ CONISMA, Università degli Studi di Genova - DIP.TE.RIS. - C.Europa 26, 16132 Genova

Key words: Carbon biogeochemical cycle, C inventory, WebGIS application, Southern Ocean, Ross Sea.

This communication is aimed to present an application of MACISTE-ICE to some data collected in the frame of the Italian National Project of Researches in Antarctica (PNRA). MARine Coastal Information SysTEm (MACISTE) is an advanced informatic system addressed to record, visualize and manage environmental data. This presentation starts with data that we already have, subsequently relying on the single initiatives of the researchers to fill progressively and update the system to obtain a real data bank exploitable for numerous purposes. MACISTE-ICE was developed for the PNRA project “Marine Observatory of Terra Nova Bay (MOA)” and it has been opportunely adjusted to make possible to insert, analyze and manage all the environmental information of carbon biogeochemical cycle of the Southern Ocean.

MACISTE-ICE is composed by Portal WEB - CMS Plone, GeoDatabase - RODBMS PostgreSQL with spatial extension PostGIS, WebGIS Enterprise - GISClient UMN-Mapserver. This system can be utilized to see available data, display data maps, it can also work as a decision supporting system (DSS), being able to make complex researches of heterogeneous data, aggregate results and allow their sharing through the web. MACISTE-ICE offers an advanced authoring tool to create thematic maps and to build query. Query builder allows you to define fields for research, the formatting of data output or to carry out calculations on aggregated data (e.g. total area covered by a certain amount of biotic

communities as areas of individual polygons in the map) and generate dynamic reports and graphs of data extracted. Moreover MACISTE-ICE allows sharing data using OGC Web services (WMS/WFS). Every user will be able to enter through an interface configured according to the web pages (web address – login - password) and utilize the software according to its account.

Geodatabase contains data and metadata relative to the sampling station position, investigated variables, investigated compartments and are populated using an automated procedure or dedicated insert web-form.

Until now it has been inserted in MACISTE-ICE information and dataset collected during the Oceanography and Marine Ecology campaigns (data already published in Ministry of University and Scientific Research and the PNRA Data Report) and collected during multidisciplinary study carried out in the littoral area of Terra Nova Bay. ABIOCLEAR project (PNRA) will guarantee the insertion of the data of marine geology. Moreover, it has been added links to some web sites of international research groups, particularly of the USA, that carried out cruises in the Ross Sea.

We hope that in this way the Italian researchers can be stimulated to put in and make available to the community their own data until kept in the “drawers”, by passing the request of pure “delivery”, that, as occurred in the past, did not seem welcome.

A box-model approach for a snapshot of Carbon biogeochemical cycle in the northern Adriatic Sea during February 2008

Catalano G.⁽¹⁾, Azzaro⁽²⁾ M., Balestra⁽³⁾ C., Bastianini⁽¹⁾ M., Bellucci⁽¹⁾ L., Bernardi Aubry⁽¹⁾ F., Burca⁽⁴⁾ M., Cantoni⁽¹⁾ C., Caruso⁽²⁾ G., Casotti⁽³⁾ R., Cataletto⁽⁴⁾ B., Cozzi⁽¹⁾ S., Del Negro⁽⁴⁾ P., Focaccia⁽¹⁾ P., Fonda Umani⁽⁵⁾ S., Frignani⁽¹⁾ M., Giani⁽⁴⁾ M., Giuliani⁽¹⁾ S., Kovacevic⁽⁴⁾ V., La Ferla⁽²⁾ R., Langone⁽¹⁾ L., Luchetta⁽¹⁾ A., Maimone⁽²⁾ G., Malisana⁽⁵⁾ E., Monticelli⁽²⁾ L., Piacentino⁽⁶⁾ S., Pugnetti⁽¹⁾ A., Rampazzo⁽⁷⁾ F., Ravaoli⁽¹⁾ M., Socal⁽¹⁾ G., Spagnoli⁽¹⁾ S., Ursella⁽³⁾ L.

g.catalano@ts.ismar.cnr.it

⁽¹⁾ CNR-ISMAR- Trieste, Venezia, Bologna

⁽²⁾ CNR-IAMC-Messina

⁽³⁾ Stazione Zoologica "A. Dohrn" - Napoli

⁽⁴⁾ OGS - Trieste

⁽⁵⁾ CONISMA - Università di Trieste- Dip. Di Biologia - Trieste

⁽⁶⁾ ENEA - UTMEA-TER - Palermo

⁽⁷⁾ ISPRA - Chioggia.

Key words: Carbon biogeochemical cycle, box model, continental shelf pump, winter condition, northern Adriatic Sea.

Stocks and fluxes of carbon biogeochemical cycle on the northern Adriatic platform, northwards of the bathymetric of 100m, have been calculated according to a box model approach. Reported estimates are referred to processes occurred in water column in February 2008 after the winter mixing and before the beginning of the spring-summer stratification. This study is mainly based on the parameters measured by a multidisciplinary team during the cruises: VECSES 1, carried out on board of the R/V Urania from 15 to 21 February 2008 in the frame of VECTOR Project Activity 6.3, specifically addressed to obtain a snapshot of carbon cycle in the northern Adriatic Sea.

As far as it concerns the estimates of carbon stocks, they have been subdivided in reservoirs of DIC (dissolved inorganic carbon, in turn subdivided in CO₂, HCO₃ and CO₃ values), DOC (dissolved organic carbon) and POC (particulate organic carbon). The living fraction of this last stock has been further partitioned in phytoplankton (pico-phytoplankton and nano+micro-phytoplankton), bacterioplankton and microzooplankton. Other estimates concern mean values of temperature, salinity, dissolved O₂ and AOU, dissolved inorganic P and N, total

alkalinity, pH of seawater and, air and seawater pCO₂.

With regard to the carbon fluxes between the reservoirs, it has been considered: total primary production (dissolved and particulate primary production), prokaryotic production, community respiration, ectoenzyme activity, POC flux along the water column and its burial into the sediments. All these fluxes were finally compared with the carbon input – output across the borders of our area of interest, i.e. from the coast, at north and westwards, and across the open border with the central Adriatic basin, at south. The input-output balance has been calculated from riverine advection data and utilizing the ROMS circulation model of the northern Adriatic Sea. The model was set up for the Adriatic by A. Russo (CoNISMa – Università Politecnica delle Marche) in the frame of the LIFE EMMA project (Environmental Management through Monitoring and Modelling of Anoxia), coordinated by M. Ravioli.

Other specific considerations and findings regarding the parameters discussed in this communication are reported in posters or other communications presented in this same workshop.

Variability of autotrophic plankton communities in the offshore southern Adriatic Sea

Cerino F.^{a,1}, Bernardi-Aubry^b F., Coppola^b J., La Ferla^c R., Maimone^c G., Socal^b G., Totti^a C.

fcerino@ogs.trieste.it

^a Dipartimento di Scienze del Mare, Università Politecnica delle Marche, via Brecce Bianche, 60131 Ancona, Italy

^b Istituto di Scienze Marine (ISMAR), CNR, Castello 1364, I-30122 Venezia, Italy

^c Istituto per l'Ambiente Marino Costiero (IAMC), CNR, Spianata S. Raineri 86, 98122 Messina, Italy

¹ Present address: Dipartimento di Oceanografia Biologica, Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS), via Piccard 54, 34151 S. Croce (TS), Italy

Key words: phytoplankton size fractions, phytoplankton composition, offshore, southern Adriatic Sea

The southern Adriatic Sea is an area in which a high seasonal variability of both physico-chemical and biological parameters occurs, due to the intermittent pulse of different water masses. In order to investigate the spatial and temporal variability of different phytoplankton size classes, samples collected in the years 2006-2008 (on a ca. seasonal frequency), in three stations along the Bari-Dubrovnik transect were analyzed. The main aims of this study were to characterize the structure of autotrophic community, and to provide a contribution about the standing stocks of the main fractions of autotrophic phytoplankton.

Total autotrophic abundances and biomass ranged from $1.94 \cdot 10^6$ to $1.93 \cdot 10^8$ cells l^{-1} and 8.5 to 80.7 μg C l^{-1} , respectively. Picophytoplankton was generally the most abundant phototrophic fraction (96 and 48% of the autotrophic abundances and biomass, respectively). Nanophytoplankton biomass

exceeded that of picophytoplankton at the deepest sampled depths. Microphytoplankton provided a minor contribution, being more abundant only at surface layer during stratification periods and occasionally also at the deep chlorophyll maximum.

A decreasing gradient from west to east was observed for both total abundance and biomass. Such low biomass values and the dominance of the autotrophic picoplankton fraction in the whole area reflected the marked oligotrophy throughout the considered section. Such oligotrophic conditions characterized even the westernmost station, although located close to the western Adriatic coast. The easternmost station, which presented the lowest abundance and biomass values, was still more oligotrophic probably due to the effects of Ionian Surface Water (ISW), coming northward from the eastern Mediterranean.

Impact of the Adriatic-Ionian feedback mechanism (BiOS) on the marine ecosystem

Civitarese G., Lipizer M., Gačić M.

gcivitarese@ogs.trieste.it

Istituto Nazionale di Oceanografia e di Geofisica Sperimentale – OGS, Italy

Key-words: Circulation, thermohaline properties, nutrient, biodiversity, Adriatic Sea, Ionian Sea.

Analysis of 20-year time-series of the vertically averaged salinity and nutrient data in the South Adriatic shows that the two parameters are subject to strong decadal variability. In addition, nutrient and salinity variations are out of phase. Nutrients in the Ionian and in the Adriatic vary in parallel except that often the nutrient content in the Adriatic is lower than in the Ionian, a fact that has been attributed to primary producer consumption following the winter convective mixing. Horizontal distribution of the nitracline depth in the Ionian suggests that nutrient content in the Adriatic is a function of the circulation pattern in the Ionian that wells up or wells down the nitracline: cyclonic circulation causes a downwelling of the nitracline along the borders of the Northern Ionian Gyre (NIG) and a decrease in the nutrient content of the water flowing into the Adriatic across the Otranto Strait, and vice versa.

The circulation variations are due to the Bimodal Oscillating System, i.e. the feedback mechanism between the Adriatic and Ionian. Inversion of the sense of the NIG results in the advection of Modified Atlantic Water or of the Levantine/Eastern Mediterranean (EMed) waters in the Adriatic. Here, we show that the presence of allochthonous organisms from Atlantic/Western Mediterranean (WMed) and EMed/temperate zone in the Adriatic are concomitant with the anticyclonic and cyclonic circulations, respectively, of the NIG. As a consequence of the NIG inversions, in the Ionian, this highly oligotrophic zone shows annual blooms in its central area only during cyclonic circulation. On the basis of the results presented, a revision of the theory of Adriatic ingressions formulated in the early 1950s is proposed.

Sulfur containing Organic Compounds in the Marano and Venice Lagoons

Joan Coppola^a, Angeles Benitez Macias^b, Andrea Gambaro^{a,b}, Giorgio Socal^c e Paolo Cescon^{a,b}

joan.coppola@alice.it

a – CNR – Istituto per la Dinamica dei Processi Ambientali

b – Università Ca' Foscari di Venezia

c – CNR – Istituto Scienze Marine

Key words: Organic Sulfur compounds, phytoplankton, lagoon, Venice, Marano

Since the 1970's, dimethylsulphide (DMS) has generated much interest because of its possible role in the biological regulation of the climate (CLAW hypothesis)

The main DMS precursor in the marine environment is Dimethylsulfoniopropionate (DMSP), which is synthesized by many micro and macro-algae, it is also metabolised as a carbon source by heterotrophic bacteria both in the water column and in sediments.

A lot of factors regulate the presence of DMS in marine ecosystems such as the production of DMSP by enzymatic cleavage; direct excretion by marine phytoplankton; viral or bacterial attack of phytoplankton, phytoplankton grazing by zooplankton; removal by photo-oxidation to form dimethyl sulphoxide (DMSO); biological consumption; sea-air exchange and adsorption onto sediment particles.

DMSP role in marine algae is not yet fully understood, even if it is thought to act in a similar way to glycine betaine (GBT), as a compatible solute and an osmolyte. It is observed that DMSP is produced by algal cells under stress conditions: when water salinity increases, a growth of DMSP concentration occurs inside the cell in order to balance the external osmotic pressure.

Most of the studies concerning the role of DMS on climate have been made in an oceanic environment. In contrast, the aim of this work is

to estimate the relative importance of biological sources of sulphur containing compounds in two brackish ecosystems, the Venice and the Marano lagoons. These environments are characterized by high primary production and a wide range of salinities and temperatures.

Six stations were sampled in the Venice lagoon from January to December 2007 with an approximately weekly frequency; four stations were sampled in the Marano lagoon from March to October 2009 with an approximately fortnightly frequency. Both sampling campaigns were carried out at neap tide, in order to minimize the effect of tidal hydrodynamics.

Sulfur compounds levels are significantly smaller in the Marano lagoon: the means are respectively for Venice and Marano lagoon: 236 nM and 92 nM for DMS, 587 nM and 142 nM for DMSP and 618 nM and 332 nM for DMSO.

DMSO is the dominant form of sulfur containing compounds, highlighting the importance of the oxidized form in brackish ecosystems, linked with degradation processes.

The relationship between sulphur organic compounds and chemical-physical parameters and phytoplankton distribution have been examined and discussed, and are compared with the oceanic values.

Prokaryotic metabolism in deep-sea sediments of the Mediterranean Sea: implications in C cycling at the basin scale

Dell'Anno A., Pusceddu A., Corinaldesi C., Luna G.M., Danovaro R.

a.dellanno@univpm.it

Department of Marine Science, Polytechnic University of Marche, Via Brecce Bianche - 60131 Ancona, Italy;

Key words: deep-sea sediments, prokaryotic C production, viral lysis.

Deep-sea ecosystems cover about 65% of the Earth's surface and play a key role in biomass production and biogeochemical cycles on a global scale. These processes are pre-eminently mediated by benthic prokaryotes. Therefore, the assessment of microbial processes occurring in the deep sea are crucial for the quantification of C cycling and nutrient flow within the benthic food webs. To date, these processes are still largely unknown especially in deep-benthic ecosystems of the Mediterranean Sea. In the frame of the project VECTOR, sediment samples were collected at 18 deep-sea stations (3000-4000 m depth) crossing the entire Mediterranean Sea and analysed for organic C contents, extracellular enzymatic activities, prokaryotic heterotrophic and autotrophic C production and viral-mediated prokaryotic mortality. Degradation rates of organic carbon were very high in the entire basin and did not differ among eco-regions. The prokaryotic

heterotrophic carbon production was high and increased significantly eastern-ward. The deep-sea sediments of the eastern Mediterranean were characterised by a more efficient conversion of degraded OC into prokaryotic biomass compared to the central and western basins. High values of autotrophic prokaryotic C production were observed at all stations suggesting that chemosynthetic C production in the deep Mediterranean could partially compensate the CO₂ produced by heterotrophic respiration. We estimated that viral infection of deep-sea benthic prokaryotes diverts the major fraction of the prokaryotic biomass into dissolved organic C, thus influencing the whole pathways of C within the deep-sea benthic food web. We suggest that sediments of the deep Mediterranean Sea, acting as an enormous hidden bioreactor, fulfil the basin with huge amounts of dissolved C and provide a major CO₂ source to the overlying deep waters.

**Characterization of water mass structure
and associated processes in the Tyrrhenian Sea (southern sector)
by means of in situ data collected during
VECTOR-TM cruises**

Falco P., Zambianchi E.

pierpaolo.falco@uniparthenope.it

CoNISMa – ULR Dipartimento di Scienze per l’Ambiente – Università di Napoli “Parthenope”.

Key words: Tyrrhenian Sea, deep dynamics, double diffusion.

Starting at the end of November 2006, six oceanographic cruises have been carried out in the area, centered on the so-called VTM station, selected as a test site to study the seasonal and interannual variability of the intermediate and deep hydrology and dynamics of the Tyrrhenian Sea. The VTM point depth is approximately 3450 m, its coordinates are 39°30' N, 13°30' E, approximately 90 nautical miles off the Italian coasts.

Three of the six oceanographic cruises were conducted in a winter month. Thus, in terms of interannual variability, information could be derived only for the winter season. The remaining three campaigns were carried out in Fall (late November 2006), early and late Spring (April 2007 and first decade of June 2008 respectively).

Moreover, in April 2007, a mooring was deployed very close (less than 1 nautical mile) to the point VECTOR-TM and worked up to January 2009. Current measurement at the depths of 1000, 1600 and 2200 meters, collected by means of Aanderaa RCM-9 currentmeters, are available for the period June 2007 –December 2007, whereas a yearly temperature time series (February 2008 – January 2009) at a depth of about 3430 meters is available too.

The analysis of the information derived from this composite data set addressed three main issues: vertical structure of the investigated transect; thermohaline processes along the vertical, especially in the most offshore stations of the transect; intermediate and deep current pattern obtained from the mooring time series.

The analysis of the CTD data collected allows to identify the three major water masses present in

the basin: Atlantic Water (AW), Levantine Intermediate Water (LIW) and Tyrrhenian Deep Water (TDW). In particular, the vertical distribution of temperature and salinity in the upper layer, together with the relative geostrophic velocity field, pointed out that the overall circulation is broadly anticyclonic, as expected. If looked at from the perspective of long term change the data reveal several points of interest: for instance, bottom temperature and salinity values result slightly higher than in the past; at the same time, the observed salinity maximum relative to the LIW is higher than in historical data.

The central Tyrrhenian is notoriously an area where double diffusive processes may be observed. Thermohaline staircase structures have been found in all cruises, and characterized in terms of a number of parameters classically utilized for this purpose. The stability of double diffusive structures in space and time (e.g., in terms of depth, width, gradient) is remarkable. Their associated temperature and salinity fluxes would deserve of further investigations, prolonged in time.

Current data obtained from the mooring shows a relative strong W-NW flow with velocity values up to 10 cm/s at 1000 m whereas, as expected, the velocity slows down to few cm/s at deeper depth where the remaining two currentmeters were located. The direction is less stable with respect to the 1000 m current data but the net displacement is northwestward as well. Also, a diurnal tide signal can be observed from the spectral analysis of the deepest currentmeters whereas it does not appear in the 1000 m depth current measurement.

Interannual variability of the east-west Mediterranean exchanges, as a result of a long-term monitoring

Gasparini G.P., Borghini M., Schroeder K., Sparnocchia S.

gasparini@sp.ismar.cnr.it

CNR-ISMAR, Pozzuolo di Lerici (La Spezia) and Trieste

Key Words: Water mass, interannual variability, Sicily Channel, Tyrrhenian Sea

Recent studies have shown that the Mediterranean Sea is far from being at a steady state. Important and abrupt changes in the stratification and in the thermohaline circulation have occurred both in the eastern basin (since the second half of 80s) and, more recently, in the Western Mediterranean Deep Water production (since 2005). A continuous monitoring of the Mediterranean circulation is necessary to detect possible changes when they happen and to understand their time scales. Long-term monitoring of Mediterranean straits together with repeated observations in deep-basin sites of special interest demonstrated the capability to determine, at a basin scale, the evolution of the water mass characteristics and the transport variability.

In the framework of the VECTOR project, the main objective of the CNR-ISMAR La Spezia team was to characterize the mass exchanges between the eastern and the western Mediterranean Sea in the Sicily Channel, continuing the long-term monitoring of the region active since 1993. To complement the Sicily Channel monitoring, the deployment of a deep-sea mooring has been recently carried out by CNR-ISMAR, jointly with ENEA and University Parthenope, positioned in correspondence of the multidisciplinary Tyrrhenian VECTOR site. This monitoring permits to relate the variability of the Eastern Mediterranean Outflow (EMO) crossing the Sicily Channel with the variability of the deep Tyrrhenian thermohaline properties.

Indeed the EMO, after having crossed the Sicily Channel, enters the Tyrrhenian mainly positioned

between 200 m and 800 m. But, as consequence of the EMT event and for about 10-15 years, its density increased with the consequent cascading and a remarkable deep injection of heat and salt into the deep Tyrrhenian Sea (Gasparini et al., 2005). The changes produced by the EMT in the deep thermohaline circulation of the EMED modified the properties of the EMO and deeply influenced the hydrographic structure of the WMED water. More specifically, an acceleration of the increasing temperature and salinity trends in the deep and intermediate layers has been produced. During recent years, those changes were able to play a key role in modifying the WMED deep water production (Schroeder et al., 2006). The recent abrupt increase of the heat and salt contents in the deep layer of the western basin can be largely attributed to an increased heat and salt lateral advection. As a matter of fact, our long time series coherently show a tendency towards higher heat and salt contents in the layers occupied by waters coming from the Eastern Mediterranean. It is relevant to remark that the EMO is still experiencing an increase in temperature and salinity, suggesting that the eastern basin is far to have recovered the pre-transient condition. One important question that arises from these observations is whether there is any connection with the EMT, with the production of warm and salty Cretan Intermediate Water, or if the LIW formed in the Levantine basin shows similar trends and why.

Ecological relevance and biogeochemical implications of the prokaryotic biomass and microbial activities in a pelagic station (TM) of the Southern Tyrrhenian Sea

La Ferla R., Azzaro M, Caruso G, Giuliano L., Irrera G.P, La Cono V., Maimone G, Monticelli L. S., Yakimov M., Zaccone R., Paranhos* R.

rosabruna.laferla@iamc.cnr.it

CNR Istituto per l'Ambiente Marino Costiero (IAMC) UOS-Messina (Italy)
*UFRJ Instituto de Biologia (Departamento de Biologia Marina), Rio de Janeiro (Brazil)

Key words: Tyrrhenian Sea, Carbon cycle, prokaryotic biomass, ectoenzyme activities, heterotrophic prokaryotic production, community respiration, dark CO₂ fixation, taxonomic characterization.

A synthesis of the studies on microbial biogeochemistry carried out in the Southern Tyrrhenian Sea (TM station: Lat. 39°30' N, Long. 13°30' E) in the frame of VECTOR-Carpel project (task 8.2) is referred. The focus was to investigate the transfer of C matter mediated by the microbial heterotrophic activities along the water column. In particular the studied parameters were: the distribution of the prokaryotic biomass - in terms of cell abundance and volume measurements - and of the microbial activities as community respiration, ectoenzymatic activities and heterotrophic prokaryotic production. In June 2007, the taxonomic characterization and dark CO₂ fixation were carried out. Particular attention was paid to the C deep water column which assumed a key role in the global carbon biogeochemistry and CO₂ sequestration.

The prokaryotic abundance ranged from 6.56E+04 to 2.09E+06 cell ml⁻¹ showing a general decrease with increasing depth. The opposite was found for prokaryotic cell volumes that increased with increasing depth (range 0.03- 0.18 μm³) so that the prokaryotic biomass (range 1.11 - 44.96 ngC ml⁻¹) was modulated by both cell abundances and volumes. Experimental evidences showed that the percentages of cells containing high levels of nucleic acids (HNA) increased with depth in the Tyrrhenian (HNA/LNA=0.3, 0.4 and 0.6 % in the epi-, meso- and bathy-pelagic layers).

Picophytoplankton ranged from 0.94E+01 to 1.67E+05 cell ml⁻¹. As in previous studies in other Mediterranean basins, picophytoplankton was sometimes detected also in the meso- and bathy-pelagic layers (Nov06 and Feb07).

Leucine aminopeptidase –a proteolytic enzyme- varied in the range 0.0095-8.197 nmol l⁻¹h⁻¹. In general, higher activity rates were measured in the epipelagic layer, with exceptions in Nov06 and Jan09, when the max values were registered in the meso- and bathypelagic ones. Beta-glucosidase –a glycolytic enzyme- ranged from 0.0305 to 1.138 nmol l⁻¹h⁻¹. No clear trends with time and space

were found, except for high activity rates in the epi-pelagic layer in Apr07 and in meso- and bathy-pelagic layers in Jan09 as well as low rates along the whole water column in Feb07. Alkaline phosphatase ranged from 0.023 to 4.378 nmol l⁻¹h⁻¹. Its vertical distribution showed higher values in the epipelagos than in the two deeper layers.

Heterotrophic prokaryotic production ranged from 0.013 to 122.76 ngC l⁻¹ h⁻¹ (mean value 13.25 ±2.73 ngC l⁻¹ h⁻¹). Always the upper 100 m of the water column showed the highest rates (38.18 ±38.57 ngC l⁻¹ h⁻¹). Values varied between 0.013 and 3.61 ngC l⁻¹ h⁻¹ (mean value 3.18 ±7.90 ngC l⁻¹ h⁻¹) in the meso-pelagic layer while in the bathypelagic one the range of variation was 0.026 - 5.78 ngC l⁻¹ h⁻¹ (mean value 0.93 ±1.25 ngC l⁻¹ h⁻¹). In Apr07 and June07 higher values than the averaged value were gathered (~ 1.6 ngC l⁻¹ h⁻¹).

Community respiration (range 0.024-3.720 μg C l⁻¹ d⁻¹) generally decreased with increasing depth. However, a seasonal variability was weakly registered till the deepest layer, but in June07, the highest rates were registered in the aphotic waters. The prokaryotic chemoautotrophic primary production measured in June07 varied from 48 to 231 μg C m⁻³ d⁻¹. The abundance of two functional genes of *Crenarchaeota* involved in the CO₂ fixation (*accA*-like) and ammonium oxidation (*amoA*-like) was analyzed at the maximum sampling depth (3580m); the values registered were 12,054 ± 602 copies ml⁻¹ for *amoA*-like gene and 14,904 ± 745 copies ml⁻¹ for *accA*-like gene.

In conclusion, the microbial biomass and activities exhibited high variability in the study site, with changing patterns occurring both along the water column and time scale. This metabolic vulnerability of the microbial community was observed also at the deepest layers that suffered the same variability of the upper layers, also if in a lesser extent. According to its metabolism, the microbial community in the examined area appeared mainly to act as a CO₂ sink.

Sedimentary organic carbon budget in the western Adriatic Sea

¹Langone L., ¹Tesi T., ²Giani M., ¹Miserocchi S., ¹Frignani M., ¹Ravaoli M.

leonardo.langone@ismar.cnr.it

¹CNR-ISMAR, sede di Bologna, via Gobetti 101, 40129 Bologna, Italy
²OGS, Dip. Oceanografia Biologica, via A. Piccard, 54 34151 Trieste, Italy

Key words: Organic carbon, sedimentary budget, northwestern Adriatic Sea

In the ocean, settling particulate organic carbon (OC) escaping post-depositional processes (e.g., bacterial degradation or resuspension) is ultimately buried in marine sediments. Most of this OC burial occurs in shallow sediments that act as a sink for the fraction of CO₂ fixed by primary producer.

The estimate of the OC burial in the western Adriatic continental shelf is the first step toward the calculation of a global carbon budget of the Adriatic Sea. In this regard, a review of all available OC data has been undertaken in the framework of VECTOR project. The final aim to be achieved in the project Subtask 6.1.8 is the coupling between OC contents in surficial sediment and mass accumulation rates in order to estimate the sedimentary OC mass balance.

In the last 20 years, sedimentary OC contents were measured in a suite of studies to assess sediment composition and biogeochemical characteristics, to estimate the effects of eutrophication or to understand the relationships with pollutant concentrations. On the other hands, mass accumulation rates were obtained from ²¹⁰Pb and ¹³⁷Cs activity-depth profiles for radioecological, sedimentological and mass balance purposes. Overall, the dataset consists of 247 values of mass accumulation rates and 429 values of organic carbon and total nitrogen contents. On a subset of surface sediments (330 samples), $\delta^{13}\text{C}$ measurements are also available.

OC contents higher than 1% compose a depocenter developing around the Po delta. Southwards, in the central Adriatic, the OC contents show a narrower variability (0.33-0.97 %), with higher values offshore Ancona and the Gargano promontory.

The pattern of mass accumulation rates almost parallels the OC content distribution, with higher values found in the areas influenced by rivers, as the Gulf of Trieste (Isonzo river), the Adige and Brenta river prodeltas, the Po river prodelta, and the southern zone subject to Apennine rivers discharges. The deposition of fine sediment, which generally has elevated levels of associated OM relative to their coarse counterparts, deeply influences the OC distribution. As a consequence, along the Adriatic shelf, OC values vary from the coastline going offshore, according to grain size: low in coastal sands, higher in the narrow belt of the high-stand mud wedge, low again in the relict sands.

OC accumulation rates were calculated as the product of the average OC contents in the sediment surface mixed layer and mass accumulation rates. According to our calculations, on the western side of the Adriatic basin, the OC annual flux to the seabed amounts to $\sim 373 \times 10^9$ g C, $\sim 17\%$ of which accumulating in two depocenters on the Po prodelta. This quantity must be considered as an upper limit of the CO₂ fixed by primary production because, based on an end-member mixing model from literature, the OC from marine and riverine-estuarine phytoplankton origin only accounts for 10 and 30% of the accumulating OC in the Po River prodelta and Adriatic shelf, respectively. Finally, the benthic remineralization further reduces of $\sim 21\%$ the OC burial in the Adriatic sediments giving a net value of organic carbon burial of marine origin of $\sim 82 \times 10^9$ g C y⁻¹. Comparisons with other long-term storage estimates of anthropogenic CO₂ will be performed in order to understand how significant is the Adriatic sedimentary sink in the global CO₂ budget of Italy.

Effect of climate changes on Mediterranean carbonate producers

Lombardi¹ C., Cocito¹ S., Gambi² M.C., Cupido¹ R., Peirano¹ A.

chiara.lombardi@enea.it

¹ Centro Ricerche Ambiente Marino ENEA S. Teresa (SP)

² Stazione Zoologica Anton Dohrn, Laboratorio di Ecologia Funzionale ed Evolutiva, Ischia (NA)

Key words: bryozoans, corals, carbonate producers, climate changes, Mediterranean Sea

On going increase of atmospheric concentration of carbon dioxide due to anthropogenic emissions is causing significant changes in climate. Ocean their storage capacity takes up one-fourth of the total atmospheric carbon dioxide produced by human activities with consequences on aquatic CO₂ levels and water physicochemistry. Serious concerns are rising about the effects of climate changes on marine organisms and ecosystems, with particular attention to calcifying taxa which use calcium carbonate for built their skeletons. Even though the mechanisms leading to calcification of marine organisms are not clearly understood, the elemental composition and physical chemistry of the external environment interact with biological control in determining the formation of biogenic minerals. These minerals are the bases of the skeletons and shells of different marine taxa such as algae, corals, molluscs, tube worms and bryozoans which form biogenic carbonate constructions worldwide distributed.

Marine bioconstructors are well represented in the Mediterranean Sea, which is characterized by a complex physiography and oceanography. Growth, carbonate productions, calcification rate, mineralogy, geochemistry of these organisms are strictly dependent of hydrology, light, temperature and pH of medium. In the present study, the influence of temperature and pH has been investigated on the skeletal development, growth and calcification rates, mineralogy and carbonate productions of two species of bryozoans and one species of hard coral from the Mediterranean Sea.

Colonies of the bryozoan *P. fascialis* were collected from west coast of Italy and the south coasts of England, whereas the coral *C. caespitosa* samples were collected from Ligurian, Adriatic and Ionian Sea. Distribution and colony size in standard areas (1 m²) were investigated order to calculate carbonate production. Moreover morphological and mineralogical investigations and radiographic analyses for detecting annual growth banding were

realized on the bryozoan skeletons, whereas sklerochronological analyses on recent and fossil samples of the coral were performed. All these data were related to temperature conditions and for *C. caespitosa*, thermal trends were analyzed on the base of annual SST from 1985 to 2004.

Colonies of the bryozoan *M. truncata* collected in Ischia Island (Naples) (Tyrrhenian Sea) were transplanted in an area of natural volcanic CO₂ vents (Castello Aragonese, Ischia Island). Samples were exposed to normal (mean pH= 8.1), medium acidic (mean pH=7.6) and most acidic (mean pH=7.4) conditions for 1 and 4 months. Calcification and dissolution rates, morphology, mineralogy and geochemistry of the species were investigated. All these results were related to temperature and pH conditions experienced by the colonies during the experiment.

The present study revealed that on both *P. fascialis* and *C. caespitosa* seawater temperature can affect skeletal mineralogy and growth rate, with an effect on carbonate production due to seasonal variation in temperature. Moreover seawater temperature affected calcification rate in *M. truncata*, which showed low calcification rates at high temperatures. Low pHs altered skeletal structures inducing modification and corrosion of skeletal structures. The corrosion of the skeletons resulted strictly dependent on the mineralogy of carbonate structures and the enrichment of Mg in outer layers of the skeleton revealed the vulnerability of *M. truncata* to dissolution.

The sensitivity of bryozoans and corals to global warming and ocean acidification make them model organisms for predict future sceneries. Further studies on both fossil and recent species, coupled with transplantation experiments *in situ* and in laboratory will be useful for understanding the role and contributes of the carbonate producers to changes in carbon and carbonate biogeochemical cycles in coastal systems.

With and without the invader: exploring the response of soft-bottom macrofaunal assemblages to the presence of the invasive seaweed *Caulerpa racemosa* var. *cylindracea* in the Gulf of Salerno

Lorenti M., Gambi M.C., Guglielmo R., Patti F.P., Scipione M.B., Zupo V. and M.C. Buia

maurizio.lorenti@szn.it

Stazione Zoologica "A. Dohrn" di Napoli

Key words: *Caulerpa racemosa*, macrofauna, invasive species, biodiversity, long-term comparison.

The spread of the introduced chlorophyte alga *Caulerpa racemosa* (with its variety *cylindracea*) in the Mediterranean Sea has been dramatic in the past decade also due to its capability for covering substantial bottom areas and for modifying invaded habitats. The effects of the introduction of *C. racemosa* on indigenous biota can be substantial. Accordingly, the settlement of the alga on formerly unvegetated or scarcely vegetated soft bottoms is potentially an agent of change in the diversity and structure of macrobenthic communities.

Starting from its first appearance in mid-1990s, *C. racemosa* var. *cylindracea* has proliferated on the bottoms of the Gulf of Salerno (Tyrrhenian Sea), which in its central part were largely unvegetated except for the local presence of the seagrass *Cymodocea nodosa*. In the frame of the VECTOR project, two approaches to the study of the interactions between *C. racemosa* and the structure of macrofaunal assemblages were followed. In a first instance, two habitat conditions (presence vs absence of *C. racemosa*) were tested at two localities of the Gulf, about 20 km apart, characterized by different sediment texture and exposure to land inputs. A detectable effect of the presence of *C. racemosa* on local diversity and on the overall community structure of macrofauna was found at only one location, marked by a higher proportion of sandy fractions, suggesting a modulation of the impact of the alga by the physical environment.

At a second stage, a long-term assessment of the macrofaunal assemblages from an area affected by the current presence of *C. racemosa* was conducted. It was based on the comparison between a historical data set of macrofaunal species and abundances obtained in 1981, before the introduction of the alga, and data sets derived from sampling performed in 2006 and 2007 during the VECTOR project. The aim of the comparison was to explore whether a detectable change occurred in the degree of diversity and in the composition of macrofaunal assemblages and, if occurred, whether such change could be attributed to the *C. racemosa* colonization in the area. While overall local diversity does not result to have significantly changed in the study area, the compositions of the macrofaunal assemblages in 2006/2007 differ from that in 1981. The most conspicuous phenomenon is the change across years in the pool of numerically dominant species. On the whole, the cover by *C. racemosa* does not result to have determined the formation of an assemblage with unequivocal traits of a plant-related community nor to have attracted the presence of other non-indigenous species. At least some of the patterns of change observed may be explained by assuming an allogenic engineering role of *C. racemosa* which, similar to other invasive plants, may affect in a more or less subtle way processes such as larval recruitment/settlement, sediment geochemistry and detritus quality and the efficiency of predators.

Resilience of coastal zooplankton in the LTER-MC time series in the Gulf of Naples

Mazzocchi M.G.¹, Di Capua¹ I., Dubroca^{1*}L., Garcia-Comas^{1**} C., Licandro² P., Ribera d'Alcalà¹ M.

grazia.mazzocchi@szn.it

¹Stazione Zoologica Anton Dohrn, Napoli

²SAHFOS, Plymouth, UK

*Ifremer Laboratoire Environnement Ressources du Languedoc-Roussillon (LER/LR), Sète, France

** National University of Taiwan, Taipei

Key words: Zooplankton, copepods, species, time-series, coastal waters

In the frame of VECTOR-IA-A1, we analyzed the first two decades (1984-2006) of zooplankton communities in the LTER-MC time-series in the inner Gulf of Naples (Tyrrhenian Sea). The sampling site (st. MC) is located 2 miles from the coastline, between the littoral and the open sea systems, and is characterized by frequent changes in hydrographic properties. Beyond a remarkable variability at short time scale evidenced by the weekly sampling, clear seasonal signals appear in the patterns of environmental parameters and a significant long-term increase in summer temperatures in the integrated water column. Moreover, a significant decrease in the late-winter peaks of chlorophyll *a* has been observed. The present work was aimed at searching if, in such a dynamic and variable environment, the zooplankton communities follow such variability or manifest stability and resilience. Specific aims were: 1) identifying zooplankton associations and their features, 2) detecting homogeneous periods both at seasonal and inter-annual scales based on species associations, 3) characterizing copepod variability in relation to temperature, salinity and chlorophyll *a*, as proxies for environmental scenarios, and 4) highlighting possible changes in standing stocks and species composition in the course of the period under study. Over two decades in such a variable environment, the zooplankton community showed a reduced interannual variance in abundance and also consistent patterns in the regular co-occurrence of some species, which persisted throughout the years. In fact, hierarchical clustering identified as robust associations five zooplanktonic groups of different size and taxonomic composition that persisted throughout the period notwithstanding high variability of local conditions. The time course of these associations was largely shaped by strong seasonal forcing comprising both physical

and biological (e.g., trophic) signals. In the copepod assemblages, step changes did not appear for most of the key representative species (e.g., *Acartia clausi*, *Centropages typicus*, *Paracalanus parvus*, *Temora stylifera*, and juveniles of *Clausocalanus* spp./*P. parvus*) beyond the interannual variability in the abundance patterns. A few indications suggest that st. MC might have acquired less coastal characters (e.g., decreasing chlorophyll *a* concentrations), but the signals from the copepod assemblages appeared only in rare or less frequent species. A significant increase was observed in the occurrence of some calanoids from open sea (e.g., *Neocalanus gracilis*, *Scolecithricella* spp.), while a few species typical of confined areas disappeared (e.g., *Acartia margalefi*, *Paracartia latisetosa*). STATICO analysis showed a significant resilience in the seasonal cycle of the copepod assemblages, even in correspondence of high variability in the environmental parameters. While the changes recorded in the least abundant species may be indicative of long-term variations, we interpret the overall persistence in the long-term of zooplankton associations and of the basic copepod community as providing evidence of resilience in communities thriving in highly variable coastal conditions. Despite the strong observed variability at seasonal and interannual scales, our site did not show evident discontinuities or trends in the water column properties as compared to other Mediterranean sites for the same period, which may be due to the position of st. MC, which is exposed to the influence of a complex climate forcing. In our zooplankton time series, we did not observe so far the significant changes reported in other Mediterranean regions (e.g., Ligurian Sea and North Adriatic), suggesting that in our coastal site, the climate impact might be overwhelmed by the typical variability of the system.

Zooplankton respiratory electron transport system activity (ETS) in the Mediterranean Sea: spatial and diel variability

Minutoli R., Pansera M., Guglielmo L.

rminutoli@unime.it

CoNISMa-ME, Department of Animal Biology and Marine Ecology, University of Messina, Italy

Key words: Electron Transport System, oxygen consumption, carbon consumption, zooplankton, Mediterranean Sea.

Our studies carried out inside the VECTOR project regard the zooplankton carbon demand and its day/night variability in two different sites, the Tyrrhenian and the Adriatic sea. The sampling fixed station were the "VTM-VECTOR" (13°30'00" °E, 39°30'00" °N) 3450 m depth out of Naples, and the "VECTOR AM1" (17°45'E, 41°50'N) 1150 m depth along the Bari-Dubrovnick transect, respectively. Another study was carried out on samples collected during the VECTOR TRANSMED oceanographic cruise, from out of the Strait of Gibraltar to Rhodes island along 10 stations. In order to interpret the ETS data, the species composition, abundance, biomass and their relations were always investigated. During the TM3 cruise carried out in the Tyrrhenian sea, samples were collected with the BIONESS until 2000 m depth dividing the water column into 15 sampling layers. The AM1 and AM3 cruises were done in the Adriatic sea, where was reached the maximum depth of 1000 m, investigating 11 layers. In both the areas the environmental parameters, temperature, conductivity, oxygen, depth, and fluorescence, were measured in real time using a multiparametric probe installed on BIONESS. In the TRANSMED cruise was employed the Indian Ocean Standard Net, sampling the layer 200-0m. In all the areas investigated a nictimeral cycle was followed, sampling each station 4 times (06:00-12:00-18:00-24:00) in 24-h, in order to study if there was a linkage between level of C consumption and changes in zooplankton community structure. In the VTM fixed station high rates of organic carbon flux were measured in April 2007, showing a decreasing trend from the more superficial layer 0-20 m (418.24 mg C/m²/d) to the sea bottom (4.86 mg C/m²/d). The analyses indicated day/night differences in ETS vertical zooplankton distribution. The deeper layers between 300 and 2000 m showed, during all the time samplings, very similar data of C consumption, except in the midday sample that

showed a little higher value. The mean value of C demand from 300-0 m layer was very different during the times. The vertical distribution of C requirement, showed higher values in more superficial layers during the night and morning collection, than during the daytime. The analyses ETS carried out on Adriatic samples did not showed differences in C consumption rates between the AM1 (November 2006) and the AM3 (April 2007), even if lower mean values among all the four time samplings were observed for autumnal samples. For the AM1 samples, the range was from 93,984 ugC/g/d to 288,885 ugC/g/d. In the morning collection the deeper stratum (1000-800 m) showed a value of 106 instead the more superficial (20-0 m) 245,1 ugC/g/d; in the midday samples the highest values of C consumption shifted in the deeper layers; a more omogeneous ETS distribution among layers was showed in the afternoon collection; in the samples collected during the dark time at midnight returns the situation observed in the morning, before the sunrise, with a value of 117,6 in the deeper layer respect 248,6 ugC/g/d in the 20-0 m layer. The AM3 oceanographic cruise samples showed the same pattern of vertical ETS activity along the water column. About the TRANSMED samples, the carbon requirements per unit of zooplankton biomass indicated spatial geographical and day/night differences in the area studied. It was evidenced an increasing gradient from out of the Strait of Gibraltar, going from a mean value of 240.866 µgC/g/d, to the easternmost station near the Isle of Rhodes where there was a value of 419.344 µC/g/d. The relation between zooplankton ETS activity and sea-water temperature was analysed. The higher values in any station for the samples collected between the sunset and the sunrise, than during the daytime, was related to actively migrating organisms that mediate the vertical transport of material in the sea.

Early diagenetic processes and organic carbon burial in deep sediments of the Mediterranean Sea

Miserocchi S.¹, Langone L.¹, Santinelli C.², Azzaro M.³

stefano.miserocchi@ismar.cnr.it

¹CNR-ISMAR, Sede di Bologna, Via Gobetti 101, 40129 Bologna, Italy

²CNR-IBF, Sede di Pisa, Via Moruzzi 1, 56124 Pisa, Italy

³CNR-IAMC, Sede di Messina, Spianata S. Raineri 86, 98122 Messina, Italy

Key words: organic carbon, benthic remineralization, sedimentary burial, Mediterranean Sea.

Early diagenesis refers to the combination of biological, chemical, and physical processes that occur during sediment burial. The early diagenetic processes in the upper sediment layers are generally most important in the benthic pelagic coupling and consequently reflect changes occurring in the pelagic processes. Sedimentary organic matter burial in marine sediment is an important reservoir and represents the predominant long term sink in the global biogeochemical cycle of organic carbon. Dissolved organic carbon (DOC) in pore waters plays a key role in the global carbon cycle, because it is involved in the remineralization and preservation of the sedimentary organic carbon as well as in the control of the sedimentary metal complexation.

During the TransMed cruises with the R/Vs *Urania* and *Universitatis*, in spring-summer 2007, bottom sediments were collected by using an oceanic boxcorer in 18 sites from deep plains along the Mediterranean Sea and Atlantic Ocean with the aim to estimate the mineralization and the burial rates of organic carbon.

On board, box cores were subsampled for different analyses (porosity, grain size, organic and inorganic carbon, total nitrogen carbon stable isotopes and radionuclides). Furthermore, sediments were sampled for the measurement of the respiratory electron transport system (ETS) activity. Oxygen microprofiles in sediment were measured immediately after retrieval on ship using Clark-type microelectrodes. The measured concentration profiles of O₂ have been interpreted by using a numerical modeling technique assuming

steady state conditions. On selected stations, additional sediment cores were subsampled in order to extract pore waters for benthic response and early diagenesis characterization. Pore water was extracted by centrifuging for dissolved nutrient (nitrate, silicate, phosphate), alkalinity and DOC determinations.

DO, DOC and nutrients data in the pore waters together with the measurement of the respiratory electron transport system (ETS) activity in sediments will be presented and discussed.

The consumption rates of oxygen ranged from 0.8 mmol m⁻² d⁻¹ at station VKC (Atlantic Ocean) to 3.2 mmol m⁻² d⁻¹ at station V4C (Almeria-Oran area) corresponding to a carbon mineralization rate of 2.5 and 11.0 g C m⁻² y⁻¹, respectively. A good correlation was found between the estimates of SCOC and ETS activity. Organic carbon and total nitrogen contents mostly showed the highest values at the sedimentary interface, then they decreased downcore. In the western Mediterranean Sea, the averages of the surficial contents (0.64%), are slightly higher than those measured in the eastern Mediterranean Sea (0.55%) and in the Atlantic Ocean (0.44%). DOC exhibited concentrations ranging between 100 and 600 microM with different trends in the different stations. DOC concentrations in pore waters were generally elevated over bottom water values (up to an order of magnitude), implying that there was a net production of DOC within sediments as a result of remineralization processes.

Microbial Contribution to Carbon flux in the Mediterranean Sea during June 2007 (TRANSMED cruise)

Monticelli L.S., Azzaro M., Caruso G., La Cono V., LaFerla R., Maimone G., Yakimov M., Zaccone R., .

luis.monticelli@iamc.cnr.it

CNR-Institute for Marine Coastal Environment (IAMC) Section of Messina, Messina, Italy.

Key words: Mediterranean Sea, exoenzymatic activities, prokaryotic bulk, heterotrophic prokaryotic production, community respiration, dark production.

In this study, we examined the longitudinal and vertical dynamics of exoenzymatic activities (EEA) (leucine aminopeptidase-LAP and \square -glucosidase- \square Glu), net heterotrophic prokaryotic production (nHPP), community respiration (CR), net Archaea dark production (nADP) and prokaryotic bulk (PB) under late spring - early summer period, crossing the Mediterranean Sea from Alboran - ALB to Eastern Basin -EB provinces (July 2007, VECTOR-TRANSMED Cruise). Our objectives were to quantify the flux of Carbon mobilized by microbial activities in the photic and aphotic (>200 m depth) zones and to characterize the Carbon transfer mass balances mediated by microbiological processes that occur in the two main sub-basins (Eastern -E-MED and Western -W-MED).

As integrated values, longitudinal and vertical variations in all microbiological parameters were observed. PB averaged 5.52 (CV 41%) and 19.79 (CV 54%) gC m^{-2} in photic and aphotic environments respectively. In the whole water column, the highest PB was observed in ALB (49.36 gC m^{-2}) with a decreasing trend towards the Ionian Sea. In the aphotic zone, the PB recorded in EB was 2-3 times higher than in the Ionian Sea. Average potential EEA (LAP + \square Glu) was 0.39 (CV 71%) and 5.01 (CV 63%) $\text{gC m}^{-2}\text{d}^{-1}$ in photic and aphotic zones, respectively. In E-MED the amount of C mobilized by EEA was two times higher than in W-MED.

Average potential net HPP was 0.085 (CV 38%) and 0.067 (CV 132%) $\text{gC m}^{-2}\text{d}^{-1}$ in photic and

aphotic zones respectively. Referred to the entire water column the average values were 0.096 and 0.198 $\text{gC m}^{-2}\text{d}^{-1}$ at W-MED and E-MED respectively.

Average potential CR was 0.39 (CV 29%) and 0.15 (CV 30%) $\text{gC m}^{-2}\text{d}^{-1}$ in photic and aphotic zones respectively. The average value for the entire water column was 0.55 $\text{gC m}^{-2}\text{d}^{-1}$ in both sub-basins with peaks in ALB, Tyrrhenian Sea and EB.

In the aphotic W-MED, CR provided only 30.7 % of C of the Dissolved Inorganic Carbon (DIC) potentially required to sustain nADP. The amount of DIC needed by nADP for the production of new cellular structures (Particulate Organic Carbon) reached 0.48 $\text{gC m}^{-2}\text{d}^{-1}$.

Analyzing the relationships between the DOC produced and consumed by microbial activities [EEA- (CR/2 + nHPP) in photic, and EEA- (CR + nHPP) in aphotic zones] different patterns were observed with positive and negative imbalances. The aphotic zones of each sub-basin were potentially able to produce DOC, mainly the E-MED (W-MED 2.54 and E-MED 6.60 $\text{gC m}^{-2}\text{d}^{-1}$, t-test, $p < 0.05$). The photic W-MED was negatively imbalanced (-0.11 $\text{gC m}^{-2}\text{d}^{-1}$) differently from E-MED (0.26 $\text{gC m}^{-2}\text{d}^{-1}$) [t-test, and $p < 0.05$]. In the late spring - early summer studied, the enhanced heterotrophic processes that took place in the photic W-MED needed necessarily other sources of DOC (dissolved primary production, upwelled waters, coming from E-MED or allochthonous origin).

From plankton to benthos and back: diversity and germination patterns of diatom resting stages

Sarno D., Montresor M., Di Prisco C., Kooistra W., Zingone A.

marina.montresor@szn.it

¹Stazione Zoologica Anton Dohrn, Villa Comunale 80121 Napoli

Key words: diatoms, resting stages, LTER.

Diatoms – as other phytoplankton groups - include the formation of benthic resting stages in their life cycle. Resting stages constitute a ‘seed bank’ that can periodically inoculate planktonic blooms or persist alive in the sediments for years.

With the aim of understanding the relationships between planktonic and benthic stages of diatoms in the sea, we studied water samples and sediments gathered at the LTER station MareChiara in the Gulf of Naples (Mediterranean Sea) from April 2007 to July 2008. Plankton samples were collected weekly by Niskin bottles and enumerated at the inverted microscope. Surface sediment samples were collected with a gravity corer at bimonthly intervals. Diatom resting stage abundance and diversity were assessed through the germination of serially diluted crude sediments. The same sediment samples were incubated several times at two month intervals to identify possible temporal variations in the germination outcomes. Germination success under different daylength conditions was also estimated. The investigation provided several clonal cultures of species of the genus *Chaetoceros* – that includes a considerable number of spore-forming species – that were used to assess a preliminary phylogeny of the family Chaetocerataceae. Morphological characters of vegetative cells and resting cysts were examined and the genetic diversity and phylogenetic relationships was assessed

Over the studied period, diatoms dominated phytoplankton in terms of total abundance, with peaks (up to $36 \cdot 10^6$ cells L⁻¹) in the periods of maximum phytoplankton development. Of the 110 species identified in plankton samples, 29 were recovered from the germination of the sediments. These included ca 12 species not known so far to form resting stages. Most resting stages belonged to the genus *Chaetoceros*, with *C. curvisetus*, *C. diadema*, and *C. socialis* as the most abundant. The

respective vegetative stages were also abundant in surface waters. Other dominant species of the plankton community such a *Leptocylindrus danicus* and *Skeletonema* spp. were also frequently recorded in the benthos, and with high concentrations. However, there were mismatches, e.g. in the case of *C. tenuissimus*, which was abundant in the plankton but not in benthic samples. The remarkable absence of any *Pseudo-nitzschia* species, which are instead an important component of the plankton of the area, confirms the hypothesis of an exclusively planktonic life-style for these pennate diatoms.

While most diatom species have a clear and recurrent seasonality at LTER-MC, no evident seasonal pattern in resting stage germination was recorded in our experiments. In addition, there were no significant differences in germination success tested under different daylength conditions. Overall, this study highlighted diatom seed beds are a highly dynamic system which has continuous relationships with the above water column, although the formation of benthic resting cells and spores seem not to be a mandatory feature of planktonic diatoms.

Molecular phylogeny based on the hypervariable region (D1–D4) of the LSU rRNA gene and a consensus cladogram reconstructed from states associated with morphological characters demonstrated monophyly for the subgenus *Chaetoceros*; whereas, the subgenus *Hyalochaete* was found to be paraphyletic. We gathered evidence for cryptic or pseudocryptic diversity in several *Chaetoceros* species, such as *C. curvisetus*, *C. debilis*, *C. diadema*, *C. lorenzianus*, *C. peruvianus* and *C. socialis*. This calls for further studies aimed at testing possible differences in life cycle features, including capability of resting stage production, amongst the different genotypes.

Non-indigenous species (NIS) of macroalgae and climate change: can we forecast the fate of NIS by the trend of temperature?

Petrocelli A., Alabiso G., Portacci G., Cecere E.

ester.cecere@iamc.cnr.it

Istituto per l'Ambiente Marino Costiero (IAMC) - CNR

Key words: Mar Piccolo of Taranto, Mediterranean Sea, Non-indigenous species, Seaweeds

The introduction of non-indigenous species is one of the worst threaten for the biodiversity and the productive activities in coastal marine environments nowadays. Often, many species are introduced by means of imported molluscs for aquaculture activities.

In the Mar Piccolo of Taranto, the imported Japanese oyster *Crassostrea gigas* Thunberg, 1793 seems to be the principal vector of introduction of a few macroalgae.

Within the VECTOR Project, the distribution and the phenology of 4 NIS were studied: *Hypnea cornuta* (Kützinger) J. Agardh, from Africa warm-waters, settled in the Second Inlet, *Undaria pinnatifida* (Harvey) Suringar and *Codium fragile* (Suringar) Hariot v. *fragile*, *Grateloupia turuturu* Yamada, all of them from Japan cold-temperate seawaters and collected in the First Inlet in the vicinity of mussel markets along the quay of the Old Town of Taranto.

Hypnea cornuta (Rhodophyta, Gigartinales) was collected for the first time in December 2000. It was observed to be present from May to December both in the attached and the unattached form. In almost ten years, it widened out in the Second Inlet of the Mar Piccolo, but only in the inner part of the basin, without becoming either invasive or dangerous for the local aquaculture activities. Specialised multicellular propagules, which are characteristic of the species, were found as means of vegetative reproduction. In December 2008, for the first time tetrasporangia were found in stichidial branchlets, also on thalli bearing propagules. Gametophytes were never collected; therefore, tetraspores are probably apomeiotic.

For *Undaria pinnatifida* (Ochrophyta, Laminariales), collected for the first time in April 1998, an initial widening of the settled population was observed near the zone of the first finding and then a progressive decline up to its disappearance.

Codium fragile v. *fragile* (Chlorophyta, Bryopsidales) was found only in July 2002 and 2003, with a few scattered thalli. Successively, in June 2009, few

thalli were observed again, which probably represent a secondary introduction.

Grateloupia turuturu (Rhodophyta, Halymeniales) was collected for the first time in February 2007. Monthly observations were carried out on both artificial and natural hard substrata. Erect thalli were present from October to June, while in summer only crusty bases remain. Reproductive thalli were not observed on artificial substrata, while on natural hard substrata tetrasporophytes were collected in February and March and gametophytes from March to June. In two years of observations, an increase in the density of recruitments was recorded as well as a widening of both the presence period and settlement zone. So, at the moment, it seems to be established and slightly spreading in the Mar Piccolo of Taranto.

The observations carried out on seaweed NIS were interpreted in the light of the trend of seawater temperature values (mean, minimum and maximum values) recorded in the last 13 years in the Mar Piccolo. In this period, both mean and minimum values showed a slight increasing trend. Therefore, it is possible to hypothesize that the reduction and the following disappearance of the populations of the cold-temperate seawater NIS could be due mainly to the increase of minimum temperature values which, most probably, inhibited the development of the reproductive structures, especially in *U. pinnatifida*. Therefore, *G. turuturu* will have probably the same destiny.

At the same time, the increasing trend could justify the spread of the warm-water species *H. cornuta*, which can be considered an established species in the basin by now; also the formation of tetrasporangia could be interpreted as an adaptation of the species to the current environmental conditions of the Mar Piccolo.

Therefore, on the basis of these results, it seems possible to foresee the destiny of the NIS, when both their eco-physiological features and the temperature trend of the introduction locality are known.

Estimates of carbon sequestration in the Adriatic Sea during cold and warm years

Querin S., Cossarini G., Solidoro C.

squerin@ogs.trieste.it

Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS)

Key words: dense water formation, carbon fluxes, Adriatic Sea, 3D coupled model.

Continental shelf areas, despite being only a minor part of the oceans, are of great importance for air/sea CO₂ exchange, due to their strong hydrodynamic and biologic variability. The Adriatic Sea is considered to be a key area for the sequestration of atmospheric carbon in the interior of the Mediterranean Sea.

Indeed, nutrient input from rivers and relatively mild water temperature sustain active primary production, which uses the carbon -DIC- taken up through air/sea exchanges. The sinking of particulate organic material (biological pump) and the horizontal transport out of the shelf and into deeper water of dissolved organic (DOC) and inorganic (DIC) carbon (enhanced by downward fluxes related to dense water formation), foster the transport of carbon in the intermediate and deep layers of the sea preventing the backward flow of DIC to the air-water interface.

This study presents the results obtained by running a numerical model of the Adriatic Sea for the period november 2006 - august 2008. The simulations aim at understanding the dynamics and quantify the fluxes of the biogeochemical properties of the basin, paying particular attention to the formation and transport of dense water masses (~7°C, 38 psu, 1030 kg/m³), which originate in the Northern Adriatic Sea in winter and spread southward along the basin.

The simulations are carried out customizing the MITgcm, a three-dimensional, finite volume, non-hydrostatic, general circulation model. The physical model is coupled with a medium complexity biogeochemical model specifically developed for the Adriatic Sea and a model which solves the carbonate chemistry system. The computational domain spans north of the Otranto strait (from latitude 40.3° N to 45.9° N), with a horizontal resolution of 1/32° (~3.4 × 2.4 km) and 51 unequally spaced levels. Initial and open boundary conditions are obtained from the 1/16°

operational model of the Mediterranean Sea run by INGV. Surface atmospheric forcing is interpolated from high resolution atmospheric models (ETA006 and ALADIN). The physical model reproduces the mesoscale seasonal variability correlated with the thermohaline properties of the water column. Short term (a few days) response to the major atmospheric forcings (Bora and Scirocco wind) also show a good agreement with experimental observations.

The biogeochemical model simulates carbon and phosphorus cycles paying particular attention to production, sinking and recycling processes.

Results show very strong interannual variability of CO₂ fluxes, especially for the winter/spring period. In particular, during winter/spring 2006/2007 anomalous weather conditions did not trigger any relevant dense water flux, which, instead, has been measured for the 2007/2008 period. It is interesting to note that winter 2006/2007 has been particularly mild, and could represent a possible condition that might be expected in a global warming scenario.

The results of the simulations also show different biogeochemical properties and different air/sea CO₂ exchange rates for the Northern, Central and Southern Adriatic Sea. In particular, CO₂ sequestration rates are higher in the Northern area (annual mean: 5.5 mmol/m²/d) compared to the other two (annual mean: 4.1 and 4.0 mmol/m²/d, respectively), showing the importance of continental shelf processes. These values agree with the most recent estimations for temperate marginal seas.

Furthermore, the comparison between the winter/spring seasons of the two years shows lower CO₂ solubility in the continental shelf during the warmer period (2006/2007: -20%), suggesting that the global warming process could weaken the mitigation of the greenhouse effect performed by the Northern Adriatic Sea.

Comments on the role of the water-sediment fluxes in the Northern-central Adriatic Sea (VECTOR632 Cruise)

Ravaioli M.¹, Spagnoli F.², Focaccia P.¹, Giordano P.¹, Albertazzi S.¹, Campanelli A.², Nisi M.², Giani M.^{3,4}

mariangela.ravaioli@bo.ismar.cnr.it

¹ Consiglio Nazionale delle Ricerche - Istituto di Scienze Marine (ISMAR), Sede di Bologna

² Consiglio Nazionale delle Ricerche - Istituto di Scienze Marine (ISMAR), Sede di Ancona

³ Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS –
Dipartimento di Oceanografia Biologica – Trieste

⁴ Istituto Superiore per la Protezione e la Ricerca Ambientale- ISPRA- Brondolo, Chioggia

Key words: North-central Adriatic Sea, oceanographic cruise, early diagenesis, reactive organic substance.

In the context of the studies about the role of the Northern Adriatic continental shelf in the Mediterranean carbon cycles, on October 2008, an oceanographic cruise was carried out on board of Dallaporta oceanographic vessel. The cruise, related to the 6.3 work activity of the Project VECTOR, aimed to: determination of benthic fluxes of Dissolved Inorganic Carbon (DIC) and of other dissolved substances involved in early diagenetic processes, characterization of the diagenetic environments which produce benthic fluxes, definition of the dissolution and/or precipitation carbonate rates, implementation of numerical models able to explain the investigated processes.

The first results of VECTOR632 cruise allowed the identification of some areas with different biogeochemical characteristics which are causing of early diagenetic processes for degree and type distinguished. Mainly, these differences were depending on the input intensity of reactive organic matter, on sedimentation rate and chemical/physical conditions of the water column. In particular has been highlighted the existence of:

an area located near to the Po River mouths characterized by intense and anoxic processes of early diagenesis that lead to a high recycling of the reactive organic matter reaching the seabed, and to dissolved nutrients and DIC intense fluxes towards the water column; an area in front of the Emilia-Romagna coast identified by inputs of partially decomposed organic matter that generates weak diagenesis processes and low water-sediment fluxes; an area, in the Meso-Adriatic Depression, distinguished by very low inputs of solid matters and reactive organic matter which are causing of very weak and oxic early diagenesis with benthic fluxes near to zero values.

Furthermore, a previously undefined area has been individuated south of the Conero mount marked by more intense processes than those reported in the northern and southern areas. These processes seem to be depending on the more intense input of suspended solid and organic matters of Apennine origin that accumulate for the less hydrodynamic energy present in the south-east area of the Conero mount coast.

Marine climatology of the northern Adriatic Sea and analysis of oceanographic data from cruises and buoys offshore the Romagna coast during the 2006-2009 period

Russo^{1,2} A., M. Ravaioli², G. Bortoluzzi², F. Falcieri¹, M. Krzelj^{1,3}, M. Bastianini²,
P. Focaccia², F. Grilli², A. Coluccelli¹, G. Stanghellini²

a.russo@univpm.it

¹DiSMar-UnivPM CoNISMa

²ISMAR-CNR

³Univ. di Split

Key words: Adriatic Sea., LTER, time series, fixed sites, monitoring, climatology.

The northern Adriatic Sea is a relevant area of the Mediterranean Sea under several aspects, in particular it receives a high river runoff and the related nutrient loading, sustaining a relevant biological production. Moreover, dense waters eventually forming in winter are important contributors to the Eastern Mediterranean Deep Water. For such reasons, the northern Adriatic plays an important role in the Mediterranean carbon cycle, and climate change could have major effects on this area (being the northernmost area of the Mediterranean Sea, and climate studies evidence that climate change effects are more intense in poleward areas). Being also the most sampled sub-basin of the Mediterranean Sea, the northern Adriatic Sea represents an optimal area where to assess effects of climate change on water masses properties; such aspect is made challenging by the relevant higher frequency variability of this sub-basin (due to its peculiar characteristics: a shallow epicontinental basin with huge river runoff).

Thermohaline properties of over 19'000 oceanographic stations collected in the northern Adriatic Sea during the period 1970-2007 have been analyzed. Data collected during the period 1970-1989 have been used to define the reference bimonthly climatologies. Bimonthly climatologies during the period 1990-2007 vary sensibly in respect to the reference. Relevant variations are evident in the surface haline field (at least partially explainable by variations of the Po river runoff), while very limited variations are detected at intermediate and bottom layers. Marine

temperatures at surface show a strong warming from November to June, while summer period does not exhibit relevant changes; the behavior is variable at deeper layers.

Climatologies are also compared to recent data collected in the 2007-2009 period. CTD data were collected during 7 oceanographic VECTOR cruises held with R/V "Urania" and R/V "Dallaporta", and meteo-oceanographic data were continuously measured at S1 and E1 sites (managed by ISMAR-CNR, with support from the Emilia-Romagna Region, the Italian Ministry for Environment through the ADRICOSM project, the EU DG Environment through the LIFE EMMA project, the Rimini Municipality). The S1 buoy, deployed in 2004, is located about 5 km south of the Po delta with 22 m bottom depth, and E1 buoy, deployed in 2006, is located about 6 km offshore Rimini with 10.5 bottom depth. The two buoys have similar configurations, measuring near surface atmospheric (temperature and pressure, wind speed, gust and direction, net radiation), near surface marine (temperature and salinity, plus dissolved oxygen, pH, fluorescence, turbidity, current speed and direction at S1, at 1 m depth) and near bottom (temperature, salinity and dissolved oxygen, plus pH at S1 and current speed and direction at E1) parameters at 5-30 min interval. Data are downloaded every 4 hours in average through cellular phone and Internet connection, and displayed in near real time on the dedicated website.

The role of DOC in C export in the Mediterranean Sea

Santinelli C., Lavezza R., Nannicini L., Seritti A.

chiara.santinelli@pi.ibf.cnr.it

CNR, Istituto di Biofisica (IBF), Pisa

Key words: Dissolved organic carbon, Carbon export, mineralization rate.

Dissolved organic carbon (DOC) represents the largest, the most complex and the less understood reservoir of organic carbon on the Earth. The difficulty to describe and quantify marine DOC dynamics and cycles is due to the very scarce information on its numerous source and sinks and to its variable and unknown composition.

The DOC data collected in the framework of VECTOR Project were studied together with seven years (2001-2008) of dissolved organic carbon (DOC) vertical profiles, in order to assess the role of DOC in C cycle in the Mediterranean Sea. As expected, DOC showed high and highly variable values in the surface layer (57-68 μM , average values in the layer 0-100 m), and a decrease to concentrations of 44-53 μM at 200-500 m. In the deep waters, DOC distribution was strongly affected by deep water formation, with a significant increase to values of 76 μM in recently ventilated deep waters and low concentrations, comparable to those observed in the open oceanic waters (34-45 μM), where the oldest deep waters occurred. In the intermediate layer, the main path of the Levantine Intermediate Water (LIW) was followed in order to estimate the DOC consumption rate in its core. Multiple regression

between DOC, apparent oxygen utilization (AOU) and salinity indicated that 38% of the oxygen consumption was related to DOC mineralization when the effect of mixing was removed. In deep waters of the southern Adriatic Sea a DOC decrease of 6 μM , together with an AOU increase of 9 μM , was observed between the end of January 2008 and the end of June 2008 (5 months). These data indicate a rate of microbial utilization of DOC of about 1.2 $\mu\text{M C month}^{-1}$, with 92% of the oxygen consumption due to DOC mineralization. These values are surprisingly high for deep waters and represent a peculiarity of the Mediterranean Sea. Finally in order to quantify the DOC export from the surface below the mixed layer, the DOC data collected in the Southern Adriatic Sea in 6 months from the 2006 to the 2008 were studied. Surface DOC distribution was strongly affected by the stratification of the water column. The highest DOC values were observed in the late summer/fall. The DOC that escapes remineralization and accumulates in the mixed layer is exported from the surface the following winter. This export was estimated to be of 258-436 mmol C m^{-2} (3-5 g C m^{-2}) each winter in the southern Adriatic Sea.

POC fluxes in the Mediterranean Sea

Antonio Schirone^a, Fabio Conte^a, Stefano Salvi^b, Roberta Delfanti^a

antonio.schirone@enea.it

- a) ENEA, Marine Environment Research Centre, P.O. Box 224, 19100 La Spezia, Italy
- b) ENEA, Research Centre Brasimone, 40032 Camugnano (BO), Italy

Key words: ^{234}Th ; $^{234}\text{Th}/^{238}\text{U}$ disequilibrium; particle reactive tracers; POC vertical fluxes.

We have estimated POC fluxes at the limits of the epipelagic, mesopelagic and batipelagic layers in several regions in Mediterranean Sea characterized by different trophic regimes.

We have treated three different sources of data:

- a. experimental data obtained by ENEA CRAM laboratory during the TRANSMED 2007 cruise and the time series collected at fixed stations in southern Adriatic and southern Tyrrhenian seas during the VECTOR project, integrated with Sesame It4 2008, MEDOC 2005, and TRENDS 2004 results, derived using the Thorium/Uranium disequilibrium. We sampled the ^{234}Th deficit from the surface to a depth ranging from 100 to 500 m, so we can estimate POC fluxes at these depths. All the cruises were performed in the late spring - early summer period and due to the ^{234}Th lifetime, they are determined by the fluxes during two months before the campaigns. The two time series instead followed at least one annual cycle.
- b. bibliography: data collected are produced

by disequilibrium Thorium/Uranium or sediment traps.

- c. calculated: in order to fill the gaps in data we derived fluxes according to the Martin relationship, a power law dependence of fluxes with depth. We have compared the profiles obtained during TRANSMED cruise with the shape obtained using the Martin and they were compatible, so we have used this value in every region.

Several works based on satellite data in the last decade have identified different regions in the Mediterranean Sea, according to their trophic regimes. We reserved the main efforts to the western sub-basins, because of their higher productivity. Some regions have been more intensively investigated, such as the Ligurian sea, due to the presence of the fixed station DYFAMED, while others have much less data.

The results show that fluxes leaving the epipelagic layer have average values that ranges between 5 and 70 $\text{mg C m}^{-2} \text{ d}^{-1}$ moving westward, of the order of 10% of the primary production.

Statistical analysis and extreme distributions of significant wave height in the Mediterranean basin and along the Italian coasts

Sclavo¹ M., Carniel¹ S., Martucci² G. and Lionello³ P.

mauro.sclavo@ismar.cnr.it

1- CNR, ISMAR;

2 - National University of Ireland, Galway, Ireland;

3 - Univ. del Salento, CMCC

Key words: climate change, extremes statistic, Mediterranean Sea, Adriatic Sea.

An accurate analysis of the wave fields in the Mediterranean Sea over several years has been carried out in order to study the climate variability of significant wave height and its trend. The SWH fields were produced by the third-generation wave model, WAM (WAVE Model), at 0.25° lat-lon resolution. The two sets of forcing wind fields used were provided by the ERA-40 reanalysis and the HIPOCAS project. The simulations are validated against satellite altimeter data. Several mid-latitude patterns are linked to the SWH field in the Mediterranean. Considering the mean monthly SWH values, EA (Eastern Atlantic pattern) exerts the largest influence, while NAO and other patterns have a smaller but comparable effect. Severe SWH conditions have been characterized using the 50 and 95percentile of daily SWH maxima. In general, both SWH high and mean values are modulated by several patterns, with an important variability in space and at monthly level so that no single pattern can be attributed a dominant role along the whole annual cycle and all the mentioned patterns are important for at least few months in the year. Trends of both SWH_{50p} and SWH_{95p} are negative for both Western and Eastern Mediterranean, with isolated exceptions.

As a second step, a thorough statistical analysis of sea states timeseries derived using the wave model WAM forced by the ERA-40 dataset in selected areas in front of the Italian coasts has been performed, spanning more than 40 years. For the period 1958 -1999 the analysis results were: (i) the existence of a negative trend in the annual- and winter-averaged sea state heights; (ii) the existence of a turning-point in late 70's in the annual-averaged trend of sea state heights at a site in the Northern Adriatic Sea; (iii) the overall absence of a significant trend in the annual-averaged mean durations of sea states over thresholds; (iv) the assessment of the extreme values with return periods up to 1000 years by means of two methods to obtain extreme values from the independent sea states: the r-largest annual maxima and the peak-over-threshold. The two methods showed statistical differences in describing the wave field. The r-largest annual maxima method provides more reliable predictions of the extreme values especially for small return periods (< 100 years). Finally, the study statistically proves the existence of decadal negative trends in the significant wave heights and by this it conveys useful information on the wave climatology of the Italian seas during the second half of the 20th century.

FISR VECTOR Project: a survey on the CNR-ISMAR modelling activity

Mauro Scavo, [Sandro Carniel](mailto:sandro.carniel@ismar.cnr.it), Andrea Bergamasco

sandro.carniel@ismar.cnr.it

CNR - Istituto di Scienze Marine – Venice Italy

Key words: climate change, coupled models, Adriatic Sea.

Within the framework of activities of the FISR funded Project “VECTOR”, CNR-Institute of Marine Science coordinated the WP1 “CLICOST”, dealing with effects of climate variability on wind-wave dynamics; within this task several numerical studies have been performed to assess the climate-change related effects and modifications on the wave climate and circulation in the Adriatic region.

Contributing to recent improvements in the theoretical background and benefiting from recent advances in the computer performances (that allowed higher-resolution, long-term integrations and a growing availability of large forcing outputs from meteorological and sea-state numerical models), CNR-ISMAR moved to the direction of employing complex, integrated numerical tools to model coastal dynamical processes. The final aim is that of providing estimates of the tendency of coastal erosion and vulnerability, and to forward hypothesis on the effects that likely climate change related scenarios may have on the Adriatic Sea region.

The capability of employing complex, integrated hydrodynamic-wave-sediment numerical models to correctly simulate coastal ocean dynamics is highly linked to the possibility of correctly accounting for processes related to atmosphere-ocean

interactions, turbulent mixing and bottom-boundary layer interactions. Several items are therefore needed to take into account with particular care; examples are given by a high-fidelity description of wave-currents interactions, sediment resuspension and transport. These issues are an actual challenge for the scientific community, and are relevant both for research and practical applications, mostly welcome for a variety of applications ranging from beach protection to search and rescue activities and support to operational and engineering operations, up to the level of climate change related scenarios.

The talk addresses some of the achievements and results in the field of integrated numerical models and in-situ measurements carried out during the VECTOR activity coordinated by CNR-ISMAR, presenting a survey of these scientific themes with appropriate links to the state-of-the-art and to the open issues that will be the challenges for the next decades. Particular attention will be given to some results from numerical climate simulations of the Adriatic sea at high resolution ($1/25^\circ$), performed during two time-slice integrations: the periods covering years between 1961-90 and 2071-2100, the latter reflecting “A1b” scenario as defined by IPCC.

Early diagenesis and benthic fluxes in the Adriatic and Ionian seas

Federico Spagnoli¹, Mariangela Ravaoli², Patrizia Giordano², Michele Giani^{3,4}, Gabriella Bartholini¹

mariangela.ravaoli@bo.ismar.cnr.it

¹ Consiglio Nazionale delle Ricerche - Istituto di Scienze Marine (ISMAR), Sede di Ancona

² Consiglio Nazionale delle Ricerche - Istituto di Scienze Marine (ISMAR), Sede di Bologna

³ Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS – Dipart. Oceanografia Biologica – Trieste

⁴ Istituto Superiore per la Protezione e la Ricerca Ambientale- ISPRA- Brondolo, Chioggia

Key words: Early diagenesis, benthic fluxes, Adriatic Sea, Ionian Sea.

Various research projects investigated early diagenesis and benthic fluxes in Adriatic and Ionian seas in the past (IGM-CNR Bologna projects, MAST, EUROMARGE, PRISMA1, PITAGEM and VECTOR). In these projects early diagenesis were investigated by pore water analyses, while benthic fluxes were determined by direct measurements (benthic chamber deployments and on deck incubations) or pore water modelization. From the integration of these previous data different diagenetic environments and benthic fluxes have been identified: they resulted from different particulate and dissolved continental inputs, different distances from sediment sources (mainly the Po River), different bottom sediment (carbonatic or silicoclastic) and organic matter (fresh marine or old continental organic matter) composition, different depths (increasing reworking and pressure with depth), different oxygenation of water column.

In the Northern Adriatic it is possible to distinguish: 1) the central area on the North of the Po River, characterized by carbonate sediments, low upward phosphate fluxes, due to authigenic apatite precipitation, low ammonia fluxes and downward DIC fluxes due to low reactive organic matter inputs and carbonate precipitation; 2) areas in front of northern rivers, characterized by terrigenous and low reactive organic matter inputs that produce low phosphate, ammonia and DIC fluxes by oxic and suboxic or even anoxic (in lower oxygenated waters) organic matter mineralization; 3) areas in front of the Po River mouths, characterized by high ammonia, phosphate and DIC fluxes due to the high sedimentation rate and reactive organic matter inputs that degrade in anoxic and even sulphidic environments. In this area, when bottom waters reach anoxic conditions, also Fe, Mn and phosphate fluxes increase due to the dissolution of Fe and Mn oxo-hydroxide surface layer; 4) the Po River prodelta distal area, South of the Po River until Ancona offshore, where partially degraded organic matter and

silicate inputs originate weak diagenesis processes and nutrient benthic fluxes.

In the Central Adriatic it possible to discriminate: 1) the coastal Western muddy area, characterised by sediments and partially degraded organic matter coming from Po and Appennine rivers that generate higher DIC and ammonia fluxes, mainly by sub-oxic mineralization; 2) the Mid-Adriatic Depression area, characterized by oxic mineralization due to the low reactivity of already degraded organic matter and low accumulation rates; this produces low upward fluxes of all nutrients, with the exception of nitrate flowing into the sediment; 3) a central area, extending also in the northern Adriatic, characterized by low sedimentation rate, no sedimentation or even erosion, with low and irregular benthic fluxes of organic matter degradation products.

As regard the Southern Adriatic and Ionian seas only some regional differences can be highlighted. The Gulf of Manfredonia is characterized by high benthic fluxes of nutrients indicating consistent inputs of reactive autochthonous organic matter attributable to local high primary productivity. The Southern Adriatic basin, characterized by oxic and suboxic-non sulphidic organic matter degradation with higher strength occurring in the Otranto Channel.

Calculated benthic fluxes in these areas show weak oxygen fluxes into the sediments and weak DIC fluxes outside the sediments while ammonium and nitrate fluxes are complicated by nitrification/denitrification processes occurring in the oxic zone.

In the Ionian Sea sediments remineralisation processes takes place mainly by oxic reactions consequent to refractory organic matter inputs, for the low productivity of the basin, the greater water column thickness and the higher distance from riverine inputs. In the Ionian Sea higher nutrient benthic fluxes are encountered in basin area with respect to slope ones due to higher accumulation rates of partially reactive organic matter.

Modelling coupled physical-biogeochemical processes in ice-covered oceans

Letizia Tedesco ^{1,2,3,4}, Marcello Vichi ^{1,5}, J. Haapala ⁶, T. Stipa ⁶

marcello.vichi@bo.ingv.it

1 Centro Euro-Mediterraneo per i Cambiamenti Climatici, Bologna, Italy

2 Centro Inter-dipartimentale di Ricerca per le Scienze Ambientali, University of Bologna, Ravenna, Italy

3 *now at* Finnish Environment Institute (SYKE), Helsinki, Finland

4 *now at* Marine Systems Institute, Tallinn University of Technology, Tallinn, Estonia

5 Istituto Nazionale di Geofisica e Vulcanologia, Bologna, Italy

6 Finnish Meteorological Institute, Helsinki, Finland

Key words: Sea ice, biogeochemical model.

This presentation aims to summarize the most relevant results achieved during the project, focusing on the development of new concepts and scientific tools for the modelling of coupled physical and biogeochemical processes in ice-covered regions. The main idea behind the coupling is the definition of a dynamical time-varying Biologically-Active Layer (BAL) in sea ice. The BAL concept, assumptions and features will be introduced. The advantage of this new formulation in comparison to standard formulation of a prescribed BAL will be showed. The generality of the BAL concept and the potentialities to apply the BAL theory to other models will be described. The BAL development allows a direct coupling with a new biological model implemented in sea ice (BFM-SI), directly derived from an already existing and widely used model (BFM). Model results at two different ice sites - one in the coastal Baltic and one in the coastal Greenland - will show that algae growth is

primarily controlled by light availability, followed by nutrient replenishment and competition. Several experiments on different forms of light adaptation and acclimation will show that rapid changes in light conditions may lead to different community structure. The ability of organisms to down-regulate their internal chl:C ratio becomes crucial in ice-covered regions where it may result in different contributions in terms of biomass. The direct coupling between the sea ice and the oceanic ecosystems also

allows a new modelling approach at the study of the sinking versus seeding effect of the sympagic and pelagic communities. Some final speculations will be made on the evolution of the polar ecosystems in a climate change scenarios: model results suggest that shorter ice seasons and thinner sea ice may support higher production rates and diversity of the sea ice biological community in a warming ice-covered ocean.

VECTOR Project on the Ionian Calabrian margin: results

Chiara Tessarolo, Alessandra Savini, Cesare Corselli

chiara.tessarolo1@unimib.it

Università degli Studi Milano Bicocca

Key words: Geomorphology, continental margin, Canyons, sediment transport.

6 coastal zones were studied by WP2 and WP3 of the VECTOR Project. Among these zones the Ionian Calabrian margin represented a distinct location in which recent and present-day geomorphic processes shaped a peculiar system formed by a complex of intertwining canyons in the submerged part, strictly associated to deeply eroded valleys on land. Indeed in this region, the geo-tectonic evolution, coupled with sea-level oscillation and climate influence, shaped an high graded margin, characterized by relieves that directly face the coastal zone. Differently from almost all the central and northern regions of Italy, the tectonic and geodynamic evolution of the Calabrian Arc made the southern regions part of an active margin, still subjected to compressional-estentional processes and to consequent uplift trend, that is evaluated between 0,9-1.1mm/year on the Ionian side. In addition, the prominent relieves, that characterize the emerged sector of the margin, result affected by a peculiar hydrographic system that is under the control of short but high energy and seasonal rivers (*Fiumare*); while the submerged sector shows a slightly extended shelf and a complex topography, widely shaped by different size seafloor features, that document the wide erosion and the relevant sediment transport that take place on the slope.

The studies carried out during the three years of the VECTOR project focused the research on three domains: the onshore sector, the coastal zone, and the offshore area.

On the onshore sectors, the relief controls the precipitation distribution and the shape of the hydrographic basins, that are elongated along slope. Precipitation is subjected to climate seasonality and is mainly represented by daily extreme events that reaches 400mm/day. Consequently the amount of sediments delivered

to the coastal zone (and that can reach and pass the shelf, shaping the submerged zone) varies during the year and seems under the control of the occurrence of intense rainstorms.

The coastal zone is characterized by different widths and evolution trends, from north to south, passing respectively from retreating, to advancing and established beaches. The latter trend results mainly due to the human activity of the summer period, as it has been evaluated from the spring profiles collected in June 2008.

On the submerged shelf and slope sedimentary processes result controlled by the dynamics of the hydrographic system that characterize the on-land sector. Indeed incisions of different sizes, partially mapped on the 2006 VECTOR Oceanographic Cruise (RV *Universitatis*), are widely distributed on the slope. From 50m to 1850m of water depth, Multibeam data showed the occurrence of two main canyon systems: Caulonia and Gioiosa. Their heads extend really close to the shoreline, and a number of genetically associated seafloor morphologies occur such as gullies and small scale incisions. Failure scars, slumps and creep-like features are also present documenting the local instability.

According to the VECTOR Project purposes, the realized studies allowed to map and observe the three described domains, focusing the attention on the observed geomorphologies and on the processes that could have been responsible for their shaping. This study also highlighted how the human activity can affect (and probably already affected) the sedimentary dynamic of this peculiar margin and so that the associated geomorphic processes, influencing the whole progradation of the margin.

Hydrodynamics and Climatology of the Venice lagoon in the project CLIVEN

G. Umgiesser¹, D. Bellafiore¹, M. Ghezzi¹, S. Carniel¹, L. Zaggia¹, R. Zonta¹, M. Bajo¹, S. Donnici¹, R. Serandrei Barbero¹, A. Mazzoldi¹, C. Amos², A. Tomasin³, P. Canestrelli⁴, L. Zampato⁴, A. Massalin⁴

georg.umgiesser@ismar.cnr.it

¹ISMAR-CNR Venezia

²NOCS, Southampton, UK

³Università Cà Foscari, Venezia

⁴ICPSM, Venezia

Key words: Venice Lagoon, hydrodynamics, climatology, water level.

The basic objective is the reconstruction of extreme events that characterize the lagoon and, most importantly, the city of Venice. Past data has been sighted, catalogued and reorganized. Numerical models have been implemented for the production of future scenarios according to the VECTOR scenarios.

Several variables have been analyzed such as water levels, discharges at the inlets, temperature and salinity, and the meteorological component. The idea was to find information about the seasonal variability of the high waters and to define tendencies for the actual phenomenology.

This preliminary analysis of the wind forcing allowed the spatial and temporal reconstruction of the trend. What has been found is a progressive attenuation from the open sea (CNR platform) to the inner areas of the lagoon (Tessera). Moreover, a high variability in the direction has been found.

The results from the model SHYFEM, forced with varying meteorological data, have been compared to the observed water levels in the Adriatic Sea (Platform CNR). The wind fields LAMI are more intense than the ECMWF fields and have a higher resolution (7 km) and succeed in producing a realistic water level in the simulations of Scirocco winds. But also in the case of Bora the LAMI winds, due to the better-resolved orography, show better results than ECMWF. Therefore, high-resolution wind fields are important for the

simulation of realistic results and should be used also for future scenarios.

The analysis of the sediment samples shows a drastic change in their characteristics due to the anthropic interventions in the inlets. The chemical and physical changes in the lagoon and coastal waters, however, do not show significant changes. These results show how inside the inlets the changing granulometry influences the transport and resuspension of material in suspension.

The comparison between two years has shown how the variability in salinity depends on the meteorological situation during the year. A zonation of the lagoon based on the simulated salinity has been proposed.

A model on the larval dispersion has been implemented and calibrated for the year 2005. Several scenarios have been tested and the effect of climate change in the year 2030 has been hypnotized from IPCC scenarios. A lower production of larvae has been seen in the IPCC scenarios, compared to the actual situation.

The first version of the water level forecast has become operational in 2007 and carries out one forecast per day. A new version has been created that allows for 4 forecast per day. Due to this technique the accuracy has been improved for the next days.

Mesoscale eddy activity in the deep layers of the Strait of Otranto (Adriatic Sea)

Laura Ursella, Vedrana Kovačević and Miroslav Gačić

vkovacevic@ogs.trieste.it

Istituto Nazionale di Oceanografia e di Geofisica Sperimentale – OGS, Trieste, Italy

Keywords: Adriatic Sea, Currents, Eddies, Mesoscale.

The footprints of mesoscale eddies propagating through the Strait of Otranto are documented from current meter records, and their formation mechanism is hypothesized. Data within a 100 m of the water column above the sea bed were obtained from three moorings with bottom-mounted upward-looking Acoustic Doppler Current Profilers. They were positioned for five months (November 2006 – April 2007) at a section in the core of the outflowing Adriatic Dense Water (AdDW). Records from all three moorings reveal energetic events that manifest as vertically uniform current vector rotations on a time scale of about 10 days. Current vectors at the two adjacent moorings close to the center of the strait rotated in the opposite senses. This is evidenced by correlation coefficients and by rotary spectra. Simulation of the passage of an idealized cyclonic or anticyclonic rigid circular eddy confirms that these opposed rotations could be associated with passages of eddies in the southward direction. Characteristic eddy parameters were estimated according to Lilly and Rhines (2002): event duration was several days; the edge velocity was around 10-20 cm/s, and advection velocity smaller than 15 cm/s was prevalently in the southwestward direction. Cyclones were bigger (diameter of 30-36 km) than anticyclones (14-24 km), and they traveled at greater depths. Thermohaline properties above the sea bed at the three moorings showed that the passage of cyclones is associated with higher density (lower temperature and lower salinity) that was explained in terms of upwelling in their centres. Not only, the density increase can also be partly attributed to entrainment of denser waters residing upstream of the transect area and their southward advection by eddies. On the other hand, anticyclones were associated with the downwelling in their centres and consequently with the presence of lower density waters (higher temperature and higher salinity). Cyclonic events were also seen in the turbidity properties and this is probably due to sediment resuspension by

strong currents and to the advection of the suspended particles through an adjacent canyon.

Two mechanisms responsible for the eddy formation are hypothesized. The first one acts through the stretching of the high potential vorticity water column at the sill where the outflow occurs, a mechanism similar to that observed in the Denmark Strait overflow (Spall and Price, 1998). On the basis of that hypothesis, we estimate the spatial and temporal scales of the eddies as a function of the density difference between the intermediate and bottom layers, as well as of the bottom slope. The density difference between the AdDW and the intermediate layers as obtained from experimental *in situ* data at the Otranto sill had a value of 0.06 kg/m^3 . This value, according to theoretical calculations by Spall and Price (1998), corresponds to an eddy length scale of about 30 km and a time scale of about seven days. The same scales are obtained with the value of the local bottom slope of 1.2×10^{-2} , calculated to the north of the measurement section.

The baroclinic instability of the overflow layer as presented in Kida et al. (2009) may also possibly be responsible for the eddy formation in the Strait of Otranto. This instability then gives rise to the eddy variability over the entire water column. Our measurements covered only the overflow layer or a part of it, and thus we cannot conclude anything about the vertical extension of eddies over the rest of the water column.

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Response of the ocean carbon cycle to an aggressive mitigation scenario

M. Vichi^{1,2}, L. Patara¹, E. Manzini^{1,2}, PG Fogli¹, A. Alessandri¹, E. Scoccimarro²,
S. Masina^{1,2} and A. Navarra¹

marcello.vichi@bo.ingv.it

1. Centro Euro-Mediterraneo per i Cambiamenti Climatici (CMCC)

2. Istituto Nazionale di Geofisica e Vulcanologia

Key words: global carbon cycle, climate model, Earth System model, ocean biogeochemistry, climate change.

According to observational and modelling estimates, oceans have been capable to uptake about one third of the anthropogenic emissions of carbon dioxide during the industrial era. Under future scenarios of business-as-usual emissions, the ocean storage of atmospheric carbon is anticipated to decrease because of ocean chemistry constraints and negative feedbacks in the carbon-climate dynamics, whereas it is still unknown how the oceanic carbon cycle will respond to more aggressive mitigation scenarios. A set of centennial simulations, performed with the CMCC Earth System model forced with the SRES A1B scenario and with a 450 ppm stabilization scenario, have been used to evaluate the response of natural carbon pools to prescribed atmospheric “target” concentrations. End of century ocean uptake with the mitigation scenario is projected to return to the same magnitude of carbon fluxes as simulated in 1960 in the Pacific Ocean and to lower values in the Atlantic. With A1B, the major ocean basins are instead projected to saturate the capacity for

carbon uptake globally as found with simpler carbon cycle models, while at the basin level the response is contrasting. The model indicates that the equatorial Pacific may increase carbon uptake rates in both scenarios, owing to enhancement of the biological carbon pump evidenced by an increase in Net Community Production (NCP) after changes in the subsurface equatorial circulation and enhanced nutrient availability. NCP is a proxy of the bulk organic carbon made available to the higher trophic levels and potentially exportable from the surface layers. In the northern hemisphere there are indications that this component may be less reactive to mitigation actions. In fact, as a consequence of alteration of vertical mixing driven by ocean changes over the 20th century and independently of the choice of aggressive mitigation or business-as-usual scenarios, NCP of lower trophic levels in the northern Pacific and Atlantic oceans is projected to decrease substantially at the end of the 21st century.

Impact of the sea level rise on vulnerable spots of coastal erosion and on the longshore currents forced by surface waves in the northeastern Adriatic Sea

Dino Viezzoli, Massimo Pacciaroni and Emiliano Gordini

dviezzoli@inogs.it

Ist. Naz. di Oceanografia e di Geofisica Sperimentale - OGS

Key words: climate change, sea level rise, surface waves, radiation stress, longshore current, motion of sediment, Adriatic Sea.

This study aims at predicting the impact of sea level rise on the coastal erosion evaluating the change of longshore currents (LSC) induced by radiation stress of surface waves and the consequences on the sediment movement. The study area is offshore the Marano-Grado lagoon, north eastern Adriatic Sea: here tidal currents reach ~ 0.3 m/s, close to tips, whereas records of two storm events in October 2002 evidence that LSC, induced by waves forced by Sirocco (SE) wind, exceed 1 m/s in 3 m water depth.

We have submitted to multivariate analysis a catalogue of statistical wave parameters obtained processing time series measured by Datawell Directional Waveriders (Stat. DWR1: $45^{\circ}34'N$, $013^{\circ}15'E$, depth 17m) since 2001 to 2007, producing percentages of occurrence, mean and standard deviations of parameters inside equally spaced 2D classes of wave energy and direction.

Our work is based on the generation of a *lookup table* (LUT) of scenarios imposing mean parameters to the forcing spectra, in order to perform a feasible number of model runs on our workstation, instead of producing every exact field pertinent to each record of our catalogue. We employed the third-generation numerical wave model SWAN on two bathymetric grids different in orientation of 30° , both 50×20 km wide and with a 50×50 m cell size. The forcing side of both grids crosses the point DWR1, where we imposed JONSWAP spectra; lateral variations of direction and wave height were inferred by averaging and interpolating scaled results of WAM simulations, 10 years long, performed by Lionello (2003). In order to improve accuracy, we performed SWAN runs for every class with three values of the peak period T_p : the mean, an upper and a lower value such to divide its distribution, assumed normal, in three equivalent parts.

We implemented the approach by Lentz *et al.* (1999) in a novel Fortran code named LENTZ to compute longshore accelerations exploiting the results of SWAN. We compared the results of LENTZ with LSCs obtained by Goda (2006) on a planar beach. We performed another validation and tuned the linear drag coefficient comparing modelled setup and current versus experimental data of October 2002.

Simulations accounted for the sea level of today and the one raised of 0.5m. Then, considering two sea levels, we performed a total of 432 runs of the models SWAN and LENTZ. The results filled our LUT, whose core information consist of estimated scenarios of longshore accelerations. Another program, named TOT was implemented for exploiting the LUT: given an arbitrary sequence of wave parameters as input, it integrates acceleration into current, zeroing current velocity when wave height is < 1 m; it evaluates the bed shear stress under combined wave and current considering sediment size data from geological literature for the study area; then it compares the Shields parameter to its *threshold for initiation of motion of sediment*, and accumulates the time over threshold in each point. We employed TOT for producing the *total times over threshold of incipient motion of sediment* (TOTIMS) for two different sea levels and two grids, using 2001-2007 catalogue as an input in any case.

The map of anomaly shows vulnerable coastal strips and spots. The sea level rise shifts the wave breakers and the LSC toward coast, but, since wave refraction is affected too, the results are non trivial around bathymetric features like holes, channels and bumps. Important processes like sediment transport, morphodynamics, waves generated by Bora (NNE) wind and heterogeneous currents were not considered in this work.

Surface dynamics and water exchanges in the Gulf of Naples – results of studies carried out in the framework of the VECTOR project

Enrico Zambianchi, Stefano Pierini, Berardino Buonocore, Daniela Cianelli,
Pierpaolo Falco, Marco Uttieri, Giovanni Zambardino

enrico.zambianchi@uniparthenope.it

CoNISMa – ULR Dipartimento di Scienze per l'Ambiente – Università di Napoli "Parthenope"

Key words: Gulf of Naples, Tyrrhenian Sea, surface circulation, dispersion processes.

In this presentation we report on the activities carried out within the VECTOR project on the hydrology and dynamics of the Gulf of Naples. The project has provided a new framework, encompassing the former knowledge of the dynamics of the area, which represents a solid foundation for a series of future studies which will contribute to answer the question on the role of that area, and more in general of coastal areas, in the Mediterranean carbon cycle.

The main portion of the studies on the dynamics of the Gulf is linked to the utilization of a remote sensing apparatus for the measurement of surface currents in the area: it is a high frequency coastal radar providing surface current data, relative to the upper meter of the water column, over the whole Gulf of Naples, with a spatial resolution of 1 km and a temporal resolution of 1 hr. Such a radar allows for a synoptic, high resolution assessment of the surface dynamics of the area.

Within the VECTOR project, we have carried out a continuous observation of the Gulf of Naples, showing that its dynamics is dominated by the presence of circulation structures developing at different scales, from the basin- to the meso- and submesoscale (of the order of very few kilometers), many of them never observed in the past, which play a complex role in the distribution of surface waters of different origins in the interior of the Gulf.

The analysis of the time series of circulation data has shown the recurring presence of a relatively limited number of basin-scale structures, characterized by: i) offshore-oriented currents, facilitating the renewal of coastal waters; ii) inshore-oriented currents, yielding stagnation and causing the entrapment of river runoff inside the Gulf, with negative consequences on the marine ecosystem quality; iii) situations dominated by the water response to strong breeze regimes, mainly during the summer months; iv) currents induced by the offshore, alongshore-oriented flow in the Tyrrhenian Sea. The above patterns, affected by

the bottom topography, have been studied in their correlation with the typical wind regimes in the area of the Gulf of Naples, and the results suggest that the basin-scale circulation is indeed strongly influenced by the meteorological forcing (this is the case, in particular, for the first three patterns). At smaller scales, the dynamics is more free, possibly associated with instabilities, and shows a very high degree of variability.

In order to evaluate the effectiveness of the water renewal mechanisms in different subareas, we carried out lagrangian simulations on the basis of the surface currents measured by the coastal radar, starting in different zones within the Gulf. Given the very high variability of the field at meso and small scales, the analysis of trajectories has been complemented by an evaluation of integral descriptors of the dispersion processes, such as the residence time of surface waters inside individual subbasins. The results have shown a series of non-trivial effects, suggesting how the combined effect of wind and circulation structures at different scales may strongly affect the mechanisms of water exchange within a coastal system even of relatively limited dimensions, as is the case of the Gulf of Naples.

In addition to the observations, a modeling activity has been carried out as well. It has made use of two complementary circulation models, a layer model and the Princeton Ocean Model, that have both been applied to a domain that includes the gulfs of Naples, Gaeta and Salerno with forcing given by ECMWF momentum flux data. The advection-diffusion equation has been coupled to those models in order to simulate transport processes of passive tracers. Experimental validation has been successfully carried out in several time-dependent scenarios. Such a modeling apparatus provides a valuable descriptive and interpretative tool for assessing the role played by the dynamics of coastal waters in the Mediterranean carbon cycle.

Sessione: Posters

A fourteen year study of the chemical-physical characteristics of the Taranto Seas systems. (Northern Ionian Sea)

Giorgio Alabiso¹, Mauro Giacomini², Milillo Matteo¹, Patrizia Ricci¹

g.alabiso@iamc.cnr.it

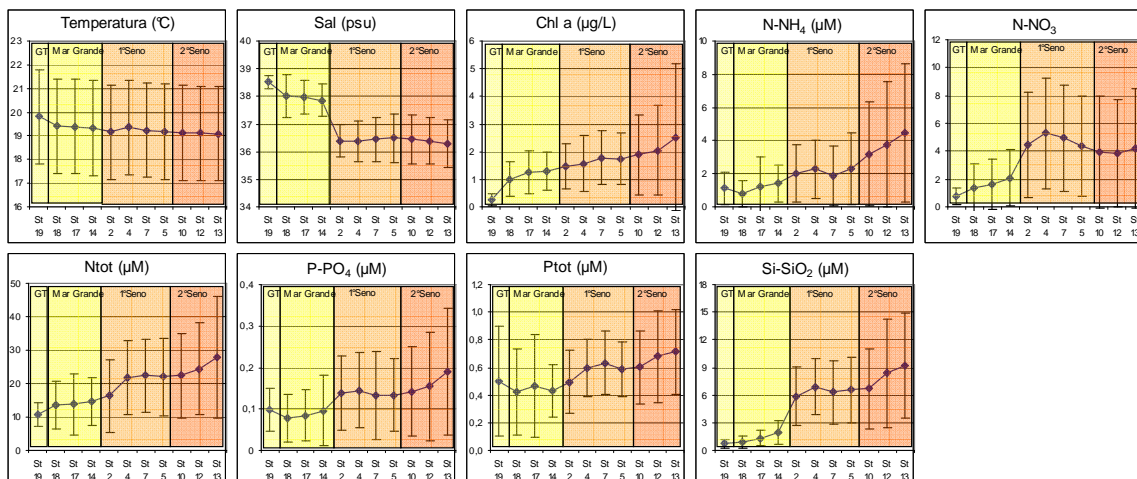
1 IAMC CNR – U.O.S. di Taranto - via Roma, 3 - 74100 Taranto,
2 DIST, Università di Genova, Via Opera Pia, 13 - 16145 Genova

Key Words: Chemical-physical variables, chlorophyll-*a*, nutrients, Mar Grande and Mar Piccolo of Taranto

The present paper is part of a project which aims to construct a mathematical model for both the seasonal and spatial variations of the chemical-physical characteristics of seawater from the basins forming the system of the Taranto Seas: the Mar Grande basin (MG) and the Mar Piccolo basin (MP), which is divided into two smaller inlets: 1° Seno (1°S) and 2° Seno (2°S). The model purpose is to detect their changes caused by the anthropogenic impact. The main goal of the present study is to highlight, by several years of observations, both possible seasonal trends of the considered variables and zones with similar features.

Since 1996 till now the area was continuously monitored. Samplings of seawater were carried out twice a month at seven stations in the Mar Piccolo (four in the 1° Seno and three in the 2° Seno), three stations in the Mar Grande and one station outside the Mar Grande that is in the Gulf of Taranto (GT). The variables examined were the followings: temperature, salinity, chlorophyll *a*, transparency, ammonia, nitrite, nitrate, phosphate, silicate, total nitrogen, total phosphorous. A statistical elaboration was performed on the data of each variable at every station to detect both possible seasonal trends. To single out probable homogeneous station clusters, after eliminating the factor seasonality from the data series, these were compared by the ANOVA followed by the Duncan test. The trend analyses were performed with the Cox-Stuart test. Seasonal trends were

detected for temperature, transparency, salinity and for ammonia only in the Mar Piccolo basins; for nitrate, nitrite and silicate only in the 2° Seno. No trend was observed for chl *a*, P-PO₄, P_{tot} in all the stations. The ammonia showed a not seasonal trend probably due to the different growth phases of the cultivated mussels. In the 1° Seno, from 2000 up to date, analyses showed a negative trend for the N_{tot} concentration and a positive trend for transparency, pH and silicate probably due to the closure of some sewage outfalls. The results obtained showed that these basins are characterized by different levels of confinement (see figure). Such a confinement is evident for some variables (silicate, nitrate, phosphate and total nitrogen) and let to immediately single out the three basins (i.e. MG, 1°S, 2°S), as the variables values change abruptly moving from the GT to the 2°S. Concerning transparency, chlorophyll *a*, ammonia, nitrite, confinement is less clear, since their values progressively change. Along the same direction, besides the confinement, an evident progressive increase of all the variables fluctuations is observable (except for total P), which points out a noticeable instability of the most confined basins. This probably depends not only on their morphological characteristics but also on human activities, such as mussel culture and agriculture carried out in the surrounding lands.



Prokaryotic dynamics and heterotrophic metabolism in the Southern Adriatic Pit

Azzaro M.^a, La Ferla R.^a, Maimone G.^a, Monticelli L.S.^a, Zaccone R.^a, Civitarese G.^b

maurizio.azzaro@iamc.cnr.it

^a CNR-IAMC, Institute for Marine Coastal Environment Section of Messina, Italy .

^b OGS, Istituto Nazionale di Oceanografia e di Geofisica Sperimentale, Sgonico (Trieste), Italy.

Key Words: Prokaryotic abundance and biomass, prokaryotic activities, biogeochemical cycles, deep-convection site, Southern Adriatic Pit.

We report on investigations of prokaryotic abundance, biomass, extracellular enzymatic activity, heterotrophic production and respiration in the full water column (~ 1200 m) of a deep convection site (the Southern Adriatic Pit), carried out on six cruises in 2006-2008. The main aims of this study is i) to study the microbial dynamics in a area of dense waters formation where the organic matter pool in meso- and bathypelagic should be less recalcitrant, ii) to understand the microbial contribution to carbon and phosphorous biogeochemistry in the three phases of the open-ocean convection (pre-conditioning, deep convection and post convection) and in the period of stratification of the water column (summer). The vertical water column structure was subdivided in three layers: i) the upper layer (UL), down to 100 m depth, ii) the intermediate layer (IL), from 100 to 800 m, and iii) the deep layer (DL), down to the maximum depth of about 1200 m.

Vertical distribution of prokaryotic abundance (PA) varied vertically and temporally and ranged from 1.2 to 20.4 x 10⁵ cell ml⁻¹. Cell volumes, generally increased with depth and along the water column oscillated between 0.044 and 0.121 μm³, 0.059 and 0.280 μm³, 0.069 and 0.223 μm³, in UL, IL and DL, respectively. Prokaryotic biomass, as function of PA and cell volumes, oscillated from 3.4 to 41.3 μg C l⁻¹, decreasing with depth. The water column > 100 m deep contained the largest pool of integrated prokaryotic biomass (IL: 56%;

DL: 27 %) while only the 17 % was confined in the UL. The picophytoplankton ranged in UL from 0.089 to 10.71 x 10⁴ cell ml⁻¹ and cells were also recorded till 500 m depth in Feb-08. This finding could be linked to the water convection occurred in SAP in that month. Leucine-aminopeptidase (LAP), β-glucosidase (β-glu) and Alkaline Phosphatase (AP) oscillated along the water column between 0.024 and 188.8 nM d⁻¹, 0.067 and 90.0 nM d⁻¹, 0.071 and 767.1 nM d⁻¹, respectively. The LAP/β-glu ratio showed a seasonal trend probably linked with the productive processes of the photic layer. An inverse relation between AP and phosphate concentrations was found and the decreasing trend of AP versus PO₄ from the surface to deep waters was well described by an exponential curve ($AP = 0.0003 PO_4 - 1.7714$, $R^2 = 0.333$). Such evidence is related to deep water formation in the study site that carries a larger amount of labile dissolved organic carbon and reduces the need for a high recycling activity by prokaryotic community. The prokaryotic heterotrophic production (PHP) and the potential carbon dioxide production rates (CDPR) ranged from 0.048 to 141.8 nM C d⁻¹ and between 12.7 and 291.6 nM C d⁻¹, respectively. Generally Cell-specific extracellular enzymatic activity increased with depth as did Cell-specific CDPR, while Cell-specific PHP had an opposite trend. Speculations have been made to estimate the carbon budget in UL and throughout the water column.

Picoplankton composition and dynamics at MareChiara station, a coastal site of the Mediterranean Sea (Gulf of Naples)

Cecilia Balestra and Raffaella Casotti

cecilia.balestra@szn.it

Stazione Zoologica A. Dohrn di Napoli, Italy

Key words : Picoplankton, heterotrophic bacteria, growth, grazing rates.

The composition and dynamics of picoplankton and their flow along the first steps of the microbial food web were investigated at the Long Term Ecological Research Station MareChiara in the Gulf of Naples from January 2007 to February 2008. Discrete samples were taken, monthly, from 0, 2, 5, 10, 20, 30, 40, 50, 60 and 70 m depth for picoplankton. Cell concentrations were estimated by flow cytometry for three main groups of autotrophs (*Synechococcus* spp, *Prochlorococcus* and picoeukaryotes, the latter represented by several clusters in the cytograms), and the heterotrophic bacteria. Vertical distribution was generally homogeneous in winter, as consequence of strong seasonal mixing of the water column, and stratified during spring-summer, as consequence of heat fluxes.

At surface *Synechococcus* abundances increased from July to September with the highest peak in August (1.52×10^5 cell ml⁻¹). Within the autotrophs, *Prochlorococcus* was the most abundant group along the water column during the winter period with a peak in March in the upper layer (9.00×10^4 cell ml⁻¹). At the surface Picoeukaryote abundances increased in spring and peaked in August (1.29×10^4 cell ml⁻¹). At the surface the heterotrophic bacterial concentration presented one peak in summer with the highest concentration in July (3.00×10^6 cell ml⁻¹) and a second peak in abundance, even if lower than the other one, in October (1.82×10^6 cell ml⁻¹).

Grazing experiments were realized in February, May, July and December 2007 and February 2008 in order to estimate specific grazing and growth rates for bacteria and the different groups of picoplankton, including phototrophs and heterotrophs.

In 2007 1.96×10^4 , 2.66×10^4 , 1.56 and $2.49 \cdot 10^4$ cell ml⁻¹ of heterotrophic bacteria per day were grazed at surface in May, July, December and February 2008, respectively, accounting for 0.39, 0.53, 0.31 and 0.50 $\mu\text{g C l}^{-1} \text{d}^{-1}$. Within the autotrophic picoplankton, *Synechococcus* spp.

showed mortality rates due to grazing of 0.24, 0.18, 0.21 d⁻¹, accounting for 0.60, 0.87 and 0.79 $\mu\text{g C l}^{-1} \text{d}^{-1}$ at surface in February 2007, May 2007 and February 2008, respectively. This converts to 86, 38 and 42 % of *Synechococcus* spp. cell numbers lost by grazing. *Prochlorococcus* spp. showed a similar pattern though the regressions were never significant. Grazing losses of the picoeukaryotes could be estimated only for May 2007 (0.41 d⁻¹, corresponding to 3.57 $\mu\text{g C l}^{-1} \text{d}^{-1}$ and February 2008 (0.27 d⁻¹, corresponding to 3.04 $\mu\text{g C l}^{-1} \text{d}^{-1}$). This converts to 108 and 26 % of picoeukaryotes cells lost by grazing, indicating a less strong top-down control in May for this group of algae and probably a stronger dependence on abiotic or biotic environmental factors.

At 10 m depth *Synechococcus* was grazed less than at the surface. The grazing rates values were 0.38, 0.10 and 0.10 d⁻¹ accounting for 8.65, 0.43 and 0.45 $\mu\text{g C L}^{-1} \text{d}^{-1}$ in July 2007, December 2007 and February 2008, respectively. *Synechococcus* spp. cells lost by grazing were in percentage 154, 42 and 42% of the initial concentrations. *Prochlorococcus* growth and grazing rates were significant only in July 2007 0.50 and 0.32 d⁻¹ respectively corresponding to 1.6 $\mu\text{g C L}^{-1} \text{d}^{-1}$ *Prochlorococcus* cells consumed by grazers, which represented 64 % of the initial cells lost. Picoeukaryote rates were significant only in December 2007 and February 2008. Growth rates were 0.10 and 1.64 d⁻¹ in December and February respectively, which, in terms of C produced, represented 0.35 and 6.10 $\mu\text{g C L}^{-1} \text{d}^{-1}$. Mortality rates were 0.13 and 0.50 d⁻¹ accounting for 0.45 and 1.85 $\mu\text{g C L}^{-1} \text{d}^{-1}$ in December and February respectively. Picoeukaryotes cells lost by grazing were 129 and 31% .

As a general consideration, it appears that picoplankton distribution, abundance and biomass is modulated and controlled by the resource supply (bottom up) but, in some periods of the year, is also controlled by grazing pressure (top- down).

Biomixing coefficients in deep sediments of the Mediterranean Sea

Barsanti M.^{1*}, Schirone A.¹, Delbono I.¹, Salvi S.², Langone L.³, Miserocchi S.³, Delfanti R.¹

mattia.barsanti@enea.it

¹ ENEA, Marine Environment Research Centre, La Spezia, Italy

² ENEA, Research Centre Brasimone, Camugnano (BO), Italy

³ CNR-ISMAR, U.O.S. di Bologna, Italy

Keywords: ²¹⁰Pb, ¹³⁷Cs, biomixing, inventories, primary production.

Different pelagic areas of the Mediterranean Sea have been investigated in order to quantify biological mixing processes (bioturbation) in deep sea sediments (>2000 m). Herein, results of eleven sediment cores sampled at different areas of the Western and Eastern Mediterranean Sea are presented.

The process of bioturbation results from the burrowing and feeding of benthic macrofauna so that particles are mixed and redistributed within a column of sediment or, alternatively, they are resuspended and redeposited or washed away. Bioturbation enhances interactions between sediments, interstitial waters and the overlying bottom water, thereby greatly influencing early sediment diagenesis. Consequently, characterising and quantifying bioturbation processes is of primary importance to define the complex mechanisms that control benthic ecosystem functioning and carbon cycling at different spatial and temporal scales.

²¹⁰Pb_{xs} and ¹³⁷Cs downcore profiles are used to identify the sediment processes characterising the different areas and, finally, controlling mixing depths (SML) and bioturbation coefficients (D_b).

The radionuclides profiles and their fluxes indicate that at most stations biological processes are responsible for surface sediment mixing. In particular, results show that primary production is the main factor controlling variability in the sediment mixing parameters. Infact, results indicate significant differences in sediment mixing depths and bioturbation coefficients among areas of the Mediterranean Sea characterized by different trophic regimes. In particular, near the Oran Rise, where the Almeria-Oran Front induces frequent phytoplankton blooms, we calculate high values of sediment mixing layers (13 cm) and bioturbation coefficients ($0.187 \text{ cm}^2 \text{ yr}^{-1}$). Intermediate values ($\sim 5 \text{ cm}$ and $\sim 0.035 \text{ cm}^2 \text{ yr}^{-1}$) characterise the mesotrophic Algero-Balearic basin, while in the Southern Tyrrhenian Sea mixing parameters (3 cm and $0.011 \text{ cm}^2 \text{ yr}^{-1}$) are similar to those calculated for the oligotrophic Eastern Mediterranean (2 cm and $\sim 0.006 \text{ cm}^2 \text{ yr}^{-1}$). In general, D_b and SML values follow the same pattern as average annual of the Primary Production.

Responses of the invasive green alga *Caulerpa racemosa* var. *cylindracea* to changes in temperature and light: the Gulf of Salerno as a key study.

Maria Cristina Buia, Maurizio Lorenti, Maria Monia Flagella

mcbuia@szn.it

Stazione Zoologica Anton Dohrn of Naples, Villa Dohrn, Ischia (Naples)

Key words: *Caulerpa racemosa* var. *cylindracea*, season anticipation, temperature, photosynthesis, irradiance.

The green alga *Caulerpa racemosa* var. *cylindracea*, introduced from southwestern Australia in the Mediterranean Sea, is considered a major invader of this basin for its colonization success in a variety of marine habitats. Starting from its first appearance in the Gulf of Salerno in mid-1990s, this species has widely proliferated (about 12 km²) on the bottoms of the gulf, which in its central part were, up to mid 1990s, largely unvegetated except for the local presence of the seagrass *Cymodocea nodosa*. Visual surveys conducted in the Northern and middle gulf in 2006-2008 confirmed the broad distribution of the alga, mainly between 12 and 25m depth, although characterized by a marked seasonal variability.

Given that temperature and light are the master environmental factors influencing seaweed geographic boundaries, the responses of a shallow population of *C. racemosa* var. *cylindracea* to the temperature and light regimes were investigated in laboratory, under controlled conditions, at ranges slightly wider than those normally experienced in the mid Tyrrhenian Sea at shallow depths.

Results have pointed out a relevant plasticity of this species both in growth and photosynthetic patterns.

With respect to water temperature, the responses from laboratory cultured plants suggest algal characteristics of a season anticipator, in view of the change in tolerance limits occurring in advance of seasonal minima and maxima. Only in early winter plants patterns in thallus growth are not affected by low temperatures (10°C) and an appreciable stress is imposed by high temperature; on the opposite, early summer plants show a high tolerance respect to higher temperatures (26-30°C). As related to the seasonal scenario and to the water temperature range of the Gulf of Salerno (13.6-25.2 °C between 5 e 10 m depth -SIDIMAR 2001-2006), maximum production rates estimated in the laboratory would occur at those temperature

values recorded *in situ* between June and October whereas minimum rates would occur at seasonal temperatures lower than 18°C (late autumn to late spring). The occurrence of marked seasonal differences and growth at temperature below 18°C seem to discount a tropical character of the alga and may explain the high colonization success in terms of speed of acclimation to the Mediterranean basin.

The study on the light response of *C. racemosa* var. *cylindracea* was further carried out. The effect of different irradiance level and photoperiod on *Caulerpa* thalli under controlled conditions over a period of one month have been assessed in the laboratory. Data obtained point to a significant acclimative response of the plant on the short to medium term: the invasiveness of this species is supported by both a photoprotective response to excess light levels and a shade-adaptation capability at the lowest light levels, maintaining adequate growth rates at different light conditions. The application of a simple H_{sat} model suggests that *in situ* irradiance values equalling or exceeding the estimated photosynthesis saturation value potentially occur all the year round at shallow depths in the Tyrrhenian Sea, with maximum theoretical values in May-June and minimum values in November-December. This would indicate that *Caulerpa*, although able to sustain production in all seasons, is exposed to minimum and maximum light conditions in periods which precede the substantial reduction and the peak of biomass and cover, respectively.

The high physiological and morphological plasticity, the successful vegetative propagation by fragmentation and the short-term acclimation can explain the rapid and extensive spread of this species under the present environmental conditions of the western Mediterranean basin and its adaptation potential to climatic changes.

The carbonate system in the Gulf of Trieste: a two years time series at PALOMA station

Carolina Cantoni¹, Anna Luchetta¹, Stefano Cozzi¹, Massimo Celio², Renato R. Colucci¹, Giulio Catalano¹, Fabio Raicich¹, Fulvio Crisciani¹

carolina.cantoni@ts.ismar.cnr.it

¹ CNR ISMAR – Istituto di Scienze Marine, U.O.S. Trieste, viale R. Gessi 2, 34123, Trieste, Italy
² Osservatorio Alto Adriatico, ARPA Friuli Venezia Giulia, via Cairoli 14, 33057, Palmanova, Italy

Key Words: Seawater pH; time series; carbon dioxide, North Adriatic, Coastal ecosystems.

In the framework of VECTOR project (activity 6.2.2), pH, Total Alkalinity (A_T) and physical/chemical parameters were acquired on a monthly basis since January 2008, in the water column at the PALOMA site (Advanced Oceanic Laboratory Platform for the Adriatic sea, Gulf of Trieste, 25m depth).

The pH was measured by the spectrophotometric method (precision ± 0.003) and the results expressed on “total scale” at 25°C ($pH_T@25^\circ C$). A_T was measured by potentiometric titration at 25°C (precision $\pm 3 \mu\text{mol/kg}$) and the results were checked against sea water certified as reference material. The other parameters of the carbonate system ($p\text{CO}_2$, DIC, CO_3^{2-} , Ω_{Ar} , Ω_{Ca}) were computed from pH, A_T , salinity, temperature, SiO_2 , PO_4 .

To our knowledge this is the first time series of these parameters collected in the North Adriatic Sea. These data allowed an initial identification of roles played by biological and physical factors in controlling the carbonate system dynamics and the pH annual cycle.

During the stratified period (April to September), CO_2 uptake by primary producers in the upper layer (DO sat > 100 %, Fig 1) determined the highest annual values of $pH_T@25^\circ C$ in both years (Fig 1). By contrast, remineralization processes generally prevailed in the deeper waters undersaturated of oxygen (DO down to 48%, Fig 1) and the minima annual values of $pH_T@25^\circ C$ were reached.

From January to March of both years the water column was homogeneous and cold, reaching the lowest annual temperatures (down to 8.8 °C). The $pH_T@25^\circ C$ values were generally low and constant and the oxygen saturation was around 100 %. These characteristics indicated that biological processes were playing a minor role in determining the observed values of $pH_T@25^\circ C$ while physical factors as temperature induced CO_2 solubilization were more important.

A_T concentrations (median value 2633 $\mu\text{mol/kg}$) were higher than in open Mediterranean sea ($\sim 2600 \mu\text{mol/Kg}$) due to the inflow of rivers with a carbonatic drainage basin. A_T variability was mainly modulated by riverine inputs with variable A_T concentrations and by the occurrence of strong remineralization processes in the bottom layer (Aug.- Nov. 2008, up to 2658 $\mu\text{mol/kg}$, $S=37.5$) as shown by the relationship with AOU.

The seasonal evolution of in situ $p\text{CO}_2$ was deeply influenced by the variations of temperature that modulated not only CO_2 solubility but also the chemical equilibria between carbonate species. Despite the production processes in the upper water column during summer, $p\text{CO}_2$ values were higher than 400 μatm on the whole water column, from July to December 2008 and from August to October 2009. During these months the Gulf of Trieste was thus acting as a potential CO_2 source. In contrast, from January to June of both years, $p\text{CO}_2$ values were always lower than 400 μatm and the Gulf was a CO_2 sink (up to $-19.0 \text{ mmol C m}^{-2} \text{ d}^{-1}$, on 14 Jan 2009) especially during high wind events. An exception to this trend were the high $p\text{CO}_2$ value (up to 606 μatm) observed in April 2009 and May 2008, in surface low salinity waters (S down to 27.6 psu), which were ascribed to the ventilation of CO_2 from supersaturated riverine waters.

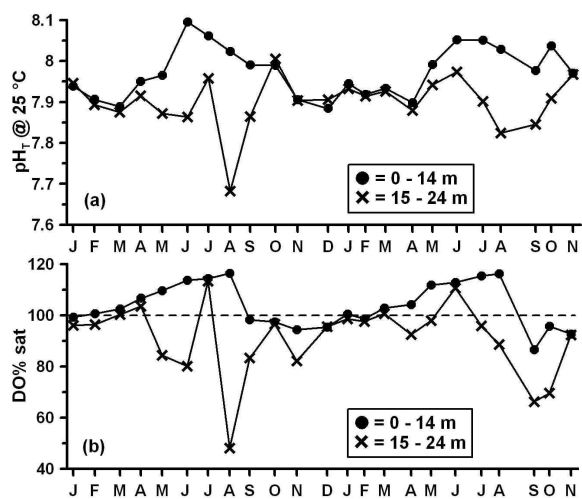


Fig.1 Average pH_T@25°C (a) and oxygen saturation (b) values for the upper layer (0 – 14 m) and for the lower layer (15 – 24 m) from January 2008 to November 2009 at PALOMA station.

New observations of CO₂ – induced acidification in the northern Adriatic Sea.

Carolina Cantoni¹, Anna Luchetta¹, Giulio Catalano¹, Stefano Cozzi¹.

carolina.cantoni@ts.ismar.cnr.it

¹ CNR ISMAR – Istituto di Scienze Marine, U.O.S. Trieste, viale R. Gessi 2, 34123, Trieste, Italy

Key words: Ocean acidification, seawater pH, north Adriatic Sea, carbon dioxide.

In the Mediterranean area the North Adriatic is one of the most suitable sites for studying the response of marine pH to increased atmospheric CO₂ levels because of its shallow depth and being exposed to strong cold winds during winter.

During VECTOR VECSES 1 cruise (15 to 19 February 2008), pH and total alkalinity (A_T) were measured over the North Adriatic basin. These data were compared with that collected during ASCOP 2 cruise (30 April to 8 May 1983), 25 years before.

During ASCOP 2 cruise pH was determined at 25 °C using a potentiometric method in NBS scale (pH_{NBS}) while during VECSES 1 cruise it was measured by the spectrophotometric method (precision ± 0.003) and the results expressed on “total scale” at 25°C (pH_T).

To allow a comparison the pH_{NBS} values were converted into the total scale and the reliability of the conversion was checked. Comparable North Adriatic dense water bodies were identified according to T, S and AOU data from both the datasets and the carbonate system parameters were compared.

Results at 25°C showed an acidification of -0.063 pH_T units from 1983 and 2008 and a decrease in carbonate ion concentration (-19.6 μmol kg⁻¹), whereas total alkalinity (+ 74 μmol kg⁻¹), dissolved inorganic carbon (+ 110 μmol kg⁻¹) and CO₂ (+ 108 μ atm) exhibited a net increase over the same period.

The drivers of these changes were analyzed and the increase in atmospheric CO₂ concentration was identified as the main forcing that determined the acidification observed. It would correspond to an acidification rate of -0.0025 pH units/year, that is of the same order of magnitude of the rate measured in other oceanic regions.

This study, even if it was based on the comparison of only two datasets spanning 25 years is the first published work (Luchetta et al., Chem. and Ecol., 2010, vol. 26, 1-17) assessing the ocean acidification process in the Mediterranean region and one of the few based on the analysis of experimental data.

The nitrogen cycle in the South Adriatic: insights by isotopic tools

Carolina Cantoni¹, Valeria Ibello^{1,2}, Giuseppe Civitarese^{1,2}, Maren Voss³, Margherita Turchetto⁴, Iris Liskow³.

carolina.cantoni@ts.ismar.cnr.it

1 CNR ISMAR – Istituto di Scienze Marine, U.O.S. Trieste, Italy

2 OGS – Istituto Nazionale di Oceanografia e Geofisica sperimentale, Sgonico (TS) Italy.

3 Leibniz Institute for Baltic Sea Research (IOW)-Warnemuende, Seestr. 15,18119 Rostock, Germany.

4 CNR ISMAR – Istituto di Scienze Marine, Venezia, Italy

Key words: Nitrogen cycle, nitrate isotopes, particulate organic nitrogen, South Adriatic.

The Southern Adriatic is a site characterized by a cyclonic circulation and deep convection events triggered by atmospheric forcings. These characteristics make this site very sensitive to meteorological and climatic changes that can easily influence CO₂ sequestration and organic carbon production. The study of ¹⁵N isotopic abundance in particulate suspended matter ($\delta^{15}\text{N-PN}$) and in dissolved nitrate ($\delta^{15}\text{N-NO}_3$) can provide new information on nitrogen sources and on nitrogen cycle in this sub-basin.

In the framework of the VECTOR project isotopic data were collected during four oceanographic cruises in the Southern Adriatic along the Bari – Dubrovnik section, from November 2006 to September 2007. The measures of nitrogen isotopic abundance on dissolved nitrate were performed at station AM1, in the centre of the basin and were the first acquired in the Adriatic, and among the few available for the entire Mediterranean.

At station AM1, the $\delta^{15}\text{N-PN}$ values in the euphotic zone were analyzed as a function of nitrate consumption following Rayleigh fractionation models (Fig 1 a).

These analyses suggested that during November 2006 the euphotic zone was working mainly as a “closed system”, with little new nitrate supplied from below and long residence times of particles before their export in the lower water column. On February 2007, a winter mixing event occurred that supplied new nitrate to the euphotic zone. In this case the $\delta^{15}\text{N-PN}$, low and independent to nitrate consumption, clearly indicated that the euphotic zone was working as an “open system” with new nitrate continuously supplied and a fast particle export.

The average $\delta^{15}\text{N-PN}$ values in the euphotic zone presented a decreasing trend from the coasts towards the centre of the basin (Fig 1 b), even in the two opposite environmental conditions of November 2006 and February 2007. The $\delta^{15}\text{N-PN}$, in the studied site, is hence a good tracer of

riverine nitrogen loaded by the WACC along the Italian coast, that fuels most of the phytoplankton production in the coastal area. It is important to note that biological fractionation processes introduce seasonal variations in isotopic data of almost the same amplitude so they cannot be neglected in studies on nitrogen sources.

The $\delta^{15}\text{N-NO}_3$ in the lower water column (mean value 2.0 ‰) was on average lower than what reported for open Mediterranean waters (2.4 ‰ East Med, 3.2 ‰ West Med.) and did not show any clear signature in different water masses. Surprisingly it was significantly variable on seasonal time scale: in particular it decreased from 2.8 ‰ in February to 1.0 ‰ in April.

Results from a simple mass balance model and the analysis of $\delta^{15}\text{N-PN}$ and PN data indicated that that shift was connect to the fresh locally produced organic matter. The sinking along the water column and the subsequent remineralization of the organic matter with a low isotopic signature produced in February combined with fractionation processes contributed to lower the ¹⁵N content of dissolved NO₃.

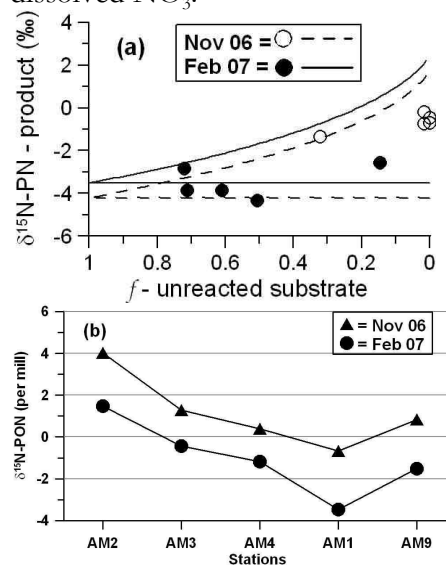


Fig 1. (a) Isotopic fractionation: the curves are the “closed system” equations with accumulate product, the horizontal lines the “open system” equations. The circles are the experimental data. (b) Average $\delta^{15}\text{N-PN}$ values in the euphotic zone along Bari – Dubrovnik section in November 2006 and February 2007.

Modeling double diffusive mixing in the ocean

Sandro Carniel¹, Mauro Sclavo¹, Lakshmi Kantha^{1,2}

sandro.carniel@ismar.cnr.it

1 - CNR - Istituto di Scienze Marine; 2 - University of Colorado, Boulder, USA

Key words: Double-diffusion; Turbulence; Mixing in the ocean; Salt fingers; Diffusive convection; Tyrrhenian Sea.

Double diffusive mixing has been largely ignored or poorly represented in the models of turbulent mixing in the ocean and in 3-D ocean models, until recently. Salt fingers occur in the interior of many marginal seas and ocean basins, the Tyrrhenian Sea being a typical example. Diffusive convection type of double diffusion occurs in the upper layers of many sub-polar seas and polar oceans due to cold melt water from sea ice. Consequently, it is important to be able to properly parameterize double diffusive mixing in basin scale and global ocean models, so that the water mass structure in the interior of the ocean can be properly simulated.

Microstructure measurements carried out during 2006 near the Gargano promontory displayed classic double-diffusive layers and staircase structures resulting from the relatively colder and fresher wintertime Po river outflow water masses overlying warmer and more saline water masses from the Adriatic Sea. We report on the water mass and turbulence structure measurements made both in the double-diffusive interfaces and the

adjoining mixed layers in the water columns undergoing double-diffusive convection. Measured turbulence diffusivities are consistent with those from earlier theoretical and experimental formulations, suggesting that the wintertime Po river plume is a convenient and easily accessible place to study double diffusive convective processes of importance to mixing in the interior of many regions of the global oceans.

Within the framework of activities of the FISR funded Project "VECTOR" and taking advantage of the experience gained in the aforementioned measurement campaign, a model for double diffusive mixing in the presence of background shear has been devised. The model is based on Mellor-Yamada type second moment closure, following *Canuto et al.* (2008a) and employing a different strategy for modeling the pertinent terms in the second moment equations. The resulting model is suitable for inclusion in ocean general circulation models and is of potential impact in modeling the hydrodynamic along the Italian coast.

Dynamic of picoplankton and temperature in a semi-enclosed basin: the case of the Mar Piccolo in Taranto (Northern Ionian Sea)

Carmela Caroppo¹, Giorgio Alabiso¹, Loredana Stabili¹⁻²

carmela.caroppo@iamc.cnr.it

¹ IAMC CNR – U.O. S. di Taranto - via Roma 3, 74100 Taranto,

² DiSTeBA, Università del Salento, Lecce.

Key words: Picoplankton; Temperature; Mar Piccolo of Taranto; Ionian Sea.

Picoplankton is a key component of the marine microbial food web and is composed of both < 2 μm pico-sized heterotrophic bacteria and autotrophic pigmented organisms. In particular, small autotrophs, which contain chlorophylls and phycobiliproteins, are important contributors to total primary production in several systems where they are superimposed on the classical pathway based on the larger phytoplankton. Furthermore, they liberate a variety of monomeric and polymeric organic compounds utilized by the heterotrophic picoplankton which, by taking up dissolved organic matter, make it available for the higher trophic levels. The microbial assemblages (e.g. heterotrophic and autotrophic picoplankton) due to their very high turnover rates are assumed to respond rapidly to any environmental change and have been recently proposed as tools for monitoring the functioning of aquatic ecosystems. In this framework we determined autotrophic and heterotrophic picoplankton abundances and their relationships with the temperature in the Mar Piccolo of Taranto a semi-enclosed basin subjected to anthropogenic pollution. From September 2006 to August 2008 monthly samplings were carried out in two stations. Water samples were collected at 0.5 m below the surface using a 5 - l Niskin sterile bottle. In order to estimate the picoplankton abundances, water samples were preserved with formaldehyde (2%) and kept at 4°C until they could be counted. Sub-

samples were filtered through a 0.2 μm Nucleopore membranes, coloured by DAPI in the case of heterotrophic bacteria, and the cell counts were made by using a Zeiss Standard Axioplan microscope equipped with a halogen (Hg 100) light. Temperature values were measured by a multiparametric probe Idromar IM52. The mean abundance of heterotrophic picoplankton was $30.3 \pm 3.6 \times 10^5$ cells ml^{-1} and the maxima values were recorded in July in both the examined years. The values of autotrophic picoplankton abundance varied in a wide range and were high in the summer period of both years. A positive relationship was observed between the temperature and both autotrophic and heterotrophic picoplankton. Our results evidenced that:

- picoplankton abundances were comparable to those of other polluted coastal environment subjected to anthropogenic inputs (e.g. Coffin and Sharp 1987; Maugeri et al., 1992; Acosta Pomar and Giuffrè, 1996; Caroppo, 2002).
- temperature confirmed its role in the dynamics of the picoplanktonic components in Mar Piccolo, like in other coastal environments (e.g. Agawin et al., 2000).

Potentially pathogenic vibrios and microbial pollution indicators in Mar Piccolo of Taranto (Linea 4 attività 5.2)

R.A. Cavallo, M.I. Acquaviva, R. Lo Noce, M. Narracci, L. Stabili

rosanna.cavallo@iamc.cnr.it

CNR-IAMC-Taranto

Key words: *Vibrio*, microbial pollution indicators, Mar Piccolo, water, sediments, mussels.

The genus *Vibrio* includes a large number of species, that are ubiquitous in many environments and can be readily isolated from seawater, sediments and seafoods such as oysters, mussels and coastal fish. Among the known *Vibrio* species, twelve occur in human clinical specimens. Other vibrios, including *V. vulnificus* and *V. harveyi*, are fish or shellfish pathogens and have major economic impact. Several studies have demonstrated that the occurrence of *Vibrio* species is not related to the presence of the microbial pollution indicators. In this framework we studied the dynamic of potentially pathogenic vibrios and the density of the microbial pollution indicators over three years (September 2006-July 2009) in water, sediment and mussel samples collected in the Mar Piccolo of Taranto. During the summer periods the maximum values of abundance as well

as the major diversity of *Vibrio* strains were evidenced. An interesting issue is the finding, especially in warmer period, of *V. alginolyticus* and *V. parahaemolyticus* that could represent a public health hazard as these bacteria are considered potential agents of intestinal and cutaneous infections cases (otitis, pharyngitis, wound infections) especially for frail people. Also *V. vulnificus* was recovered in all samples during the entire period of study, and this bacteria can be considered responsible of symptoms as vomiting, diarrhea, abdominal pain and blistering dermatitis. In all the summer periods examined the densities of the microbial pollution indicators were high in the mussels, low in the water samples and absent in the sediments. By contrast, in winter these microbial parameters showed the maximum values in sediment samples.

Measures of *Posidonia oceanica* metabolism by means of benthic chamber

F.Cinelli, M.L.Grippa, S.Acunto

fcinelli@biologia.unipi.it

Università di Pisa, URL CoNISMa

Key words: *Posidonia oceanica* metabolism, benthic chamber, La Maddalena Archipelago (Italy).

The benthic chamber is an instrument which may be used to measure benthic community metabolism; for example seagrasses and coralligenous metabolisms.

Measures concern *Posidonia oceanica* (L.) Delile grassland in La Maddalena Archipelago (Italy) between 5 and 20 m (S.I.) of depth and between July and October 2009.

Search object is evaluate the net primary

production community of O₂ and CO₂ into the time considered, both respect O₂ and CO₂ entry/exit current to benthic chamber.

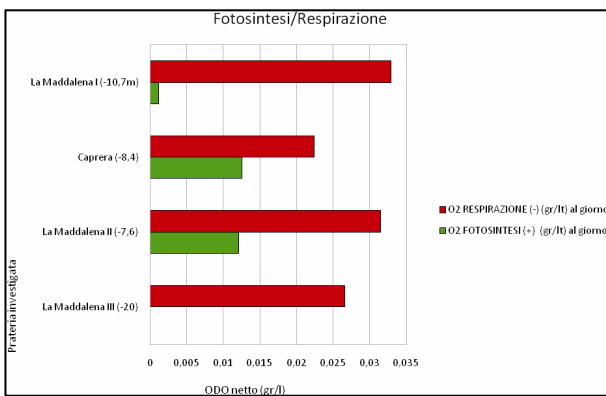


Fig. 1

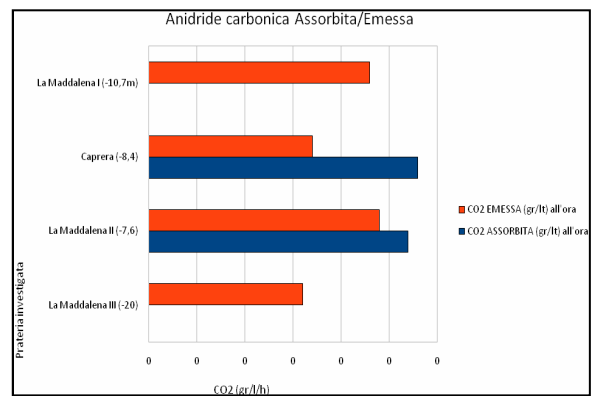


Fig. 2

Fig. 1 - Oxygen product/consumed concentration bar graph in the course of photosynthesis and respiration steps. Fig. 2 - CO₂ absorb/release concentration in the course of photosynthesis and respiration steps.

Structure and functioning of the pelagic Southern Tyrrhenian Sea

Fabio Conversano¹, Christophe Brunet¹, Federico Corato¹, Iole Di Capua¹, Rosario Lavezza²⁻¹, Francesca Margiotta¹, Maria Grazia Mazzocchi¹, Augusto Passarelli¹, Isabella Percopo³⁻¹, Maurizio Ribera d'Alcalà¹, Immacolata Santarpia¹, Maria Saggiomo¹, Vincenzo Saggiomo¹, Ferdinando Tramontano¹, Adriana Zingone¹

fabio.conversano@szn.it

¹Stazione Zoologica Anton Dohrn, Villa Comunale, 80121 Napoli

²Istituto di Biofisica - Area della Ricerca di Pisa, Via G. Moruzzi 1, 56124 Pisa

³Dipartimento di Scienze del Mare – Università Politecnica delle Marche - Via Breccie Bianche, 60131 Ancona

Key words: Plankton, Nutrients, Hydrology, Mediterranean Sea, Tyrrhenian Sea.

Since 5 years, oceanographers, biogeochemists and biologists of Stazione Zoologica Anton Dohrn (SZN) in tight collaboration with other Italian Research Institutes are focusing part of their field activity, on Southern Tyrrhenian Sea. Sampling campaigns had been carried out in the framework of both CIESM field activities (2005) and the Italian program Vector (2006-2009) to study of seasonal and interannual variability of processes related to the exchange of carbon between the atmosphere and the open Mediterranean Sea and its possible segregation along the water column. In particular, we investigated the response of pelagic community to environmental forcing throughout the water column from the surface to the meso- and bati-pelagic layers in different seasons. The Southern Tyrrhenian Sea is poorly known with respect to other areas of the Mediterranean basin, although it plays a key role in the complex dynamics of water masses in the Mediterranean Sea. Exchange and transformation of water masses between Eastern and Western basins, take place in the Tyrrhenian Sea. Hydrographic sampling has been carried out seasonally and a mooring has been positioned intermittently since 2007. SZN contributes to this national research effort with

measurements of dissolved oxygen, nutrients, phytoplankton, primary production and zooplankton in relation to the local physical dynamics.

This area appears to be of great scientific interest due to its oligotrophy, despite being part of the Western Mediterranean sea, and hydrological traits, such as the presence of a persistent anticyclonic eddy, and a nutricline deeper than the pycnocline, since early summer. Another peculiar feature is the presence of a clearly defined “step structure” in the deep layer, that is characteristic of the double diffusion processes, whose role in the vertical distribution of nutrients and tracers in the South Tyrrhenian Sea, has still to be assessed. Those features impact, to a certain extent, on the structure and functioning of the planktonic communities.

Due to the scientific relevance and the possible “sensitivity” of the area to climate change, the scientific and sampling efforts do continue presently in collaboration with other Italian Institutes and French groups (MerMex French project).

Retrospective analyses of zooplankton: results, hypotheses, future prospects

Alessandra Conversi (1), Tiziana Peluso (1), Serena Fonda Umani (2), Alessandra Micheletti (3),
Daniela Morale (3), Alessandro de Gregorio (3)

a.conversi@ismar.cnr.it

(1) CNR, ISMAR-La Spezia, Forte S.Teresa, 19032 Pozzuolo di Lericci (SP), Italy

(2) Dept. of Life Sciences, University of Trieste, Via A. Valerio, 28/A, 34127 Trieste, Italy

(3) Dipartimento di Matematica, Università di Milano, Via C. Saldini 50, 20133 Milano, Italy

Key words: zooplankton; clima; retrospective analyses; regime shifts; SDE models.

The activity 2 of Line 4 (DIVCOAST) focused on statistical and probabilistic methodologies to identify relationships between plankton variability and climate forcing. Object of the investigation was the 36 yr long (1970-2005) copepod time series in the Gulf of Trieste, North Adriatic, one of the longest time series in the Mediterranean. Two lines of investigation were pursued: statistical analyses, and probabilistic models.

The results of the statistical analyses indicated several changes in the zooplankton community of the Gulf of Trieste in the late 1980s, possibly related to changes in the circulation and to a general warming of the area. A literature survey indicates that the Mediterranean circulation underwent a change in this period, which led to suggest the hypothesis of a regime shift (meaning, an abrupt change in biota and abiotic properties) in the Mediterranean Sea in the late 80s. Such shift fits within a pattern seen in all European Seas during the same time, leading to the hypothesis of a larger, hemispheric phenomenon.

Another line of work investigated the impact of climate changes on the abundance of copepod

populations utilizing a non linear approach. This was done by modelling the phenomenon via stochastic differential equations (SDE). These probabilistic models make no assumption on the underlying distributions, and can identify non-linear relationships. Several models were evaluated, and their use for forecasting of zooplankton abundance from climate variations seems promising.

Future prospects:

Refining the SDE models with the purpose of forecasting zooplankton abundance in function of climate. Since zooplankton is an essential component of the marine ecosystem (most marine animals belong to it, or feed on it, during some stage of their life), predicting its variability is very important in view of climate change.

Comparative analysis of synchronous regime shifts across the marine environment, since this may provide the key for distinguishing local (i.e. basin) anthropogenic drivers, such as eutrophication or fishing, from larger scale (hemispheric) climate drivers.

River loads of freshwater and nutrients in the continental shelf area of the Northern Adriatic Sea

Stefano Cozzi¹, Michele Giani²

stefano.cozzi@ts.ismar.cnr.it

¹CNR – Istituto di Scienze Marine, Sede di Trieste, Italy

²Istituto Nazionale di Oceanografia e di Geofisica Sperimentale – OGS, S. Croce (Trieste), Italy

Key words: rivers, nutrients, total nitrogen, total phosphorus, suspended matter, Adriatic Sea.

River discharges have a great effect on oceanographic properties and production processes in the marine ecosystem of the Northern Adriatic Sea. The combination between meteorological forcings and the spreading of river waters, mainly from the Po River, determine formation and dynamics of the coastal fronts in the Western and Northern part of this continental shelf area, through the generation of alternated vertical and horizontal density gradients that drive the circulation of surface waters and the pattern of Southward flowing West Adriatic Current. High inputs of river borne nutrients sustain the peaks of production in this marine system, in particular during spring and autumn. However, they may also cause hypoxic or anoxic crises in the deeper waters, in case of weak circulation. Strong density gradients coupled to alternate ambient conditions experienced by plankton communities in the coastal area, due to the dynamics of low and high salinity waters, are also at the basis of dystrophic events that have often occurred in this area, such as the appearance of large dinoflagellate blooms and mucilage phenomenon.

Despite its basic importance, the role of river loads in the Northern Adriatic Sea has been poorly studied, to date. A number of studies were published in the literature, mostly for Po and Adige rivers, as a result of the efforts addressed to the mitigation of eutrophication problems in the coastal zones carried out during the 1970' and the 1980', while the comparison of river loads at sub-regional scale still remains largely incomplete.

In the framework of VECTOR research project (sub-task 6.1.3. Compilation of river load data, loads of nutrients and dissolved and particulate organic matter), the analysis of the current importance of river discharges in the Northern Adriatic Sea has been carried out, as a part of the study of carbon biogeochemical cycle in this basin, taking in account monitoring data provided by several environmental agencies and scientific institutions of Italy, Slovenia and Croatia.

From 2004 to 2007, water load by Po River ($20.54 - 45.30 \text{ km}^3 \text{ y}^{-1}$) constituted, on the average, 66% of

the total river load in the basin, Adige River (10%), Brenta River (7%) and Livenza River (6%) being the other important sources of freshwater. Despite Po is an highly significant proxy of the total river load in the Northern Adriatic, the inputs from the rivers located along the Northern and Eastern sections of the coast were not negligible (11 and 6% of the total, respectively) and often not in phase with the regime of Po River. As shown by distinct peaks of discharge and by prolonged drought periods that often occurred in the minor rivers differently from Po River, because of their more pronounced flashy flow regimes.

During the same years, total nitrogen ($86,000 - 262,000 \text{ t N y}^{-1}$) and total phosphorus ($3,840 - 9,500 \text{ t P y}^{-1}$) loads of Po River were highly variable, mainly as a consequence of the oscillations of annual integrated water discharges. The transport of TN and TP was constituted by dissolved inorganic nitrogen for 69% and by reactive phosphorus for 47%, whereas a high load of reactive silicon was also estimated ($64,400 - 137,500 \text{ t Si y}^{-1}$). The rivers located in the Northern and Eastern areas of the coast contributed respectively for 8% and 4% to the total load of TN in the basin, but only for 4% and 1% to the total load of TP. This finding pointed out that the strong decreasing gradient from West to East of nutrient supply in the Northern Adriatic might be further exacerbated in case of a selective reduction of the flows of minor rivers, due to oncoming natural changes or to larger anthropogenic usage of the continental waters.

River loads estimated in this study do not strongly differ from the available data published in the scientific literature during the last decades, but they showed that the ecosystem of the Northern Adriatic Sea may experience a strong reduction ($\approx -50\%$) of the supply of land borne nutrients during dry years, like in 2005. Recurring years characterised by extremely low discharges could have a great impact on the biogeochemistry of the whole Northern Adriatic basin.

Ocean acidification effects on the spore of *Lithophyllum incrustans* Philippi (Corallinaceae, Rhodophyta)

Cumani E., Bradassi F., Di Pascoli A., Bressan G.

francescocumani@libero.it

University of Trieste – Dept.Life Sciences

Key words: Ocean acidification, spore, Corallinaceae, microcosm.

During the last few years the effect of the increase of CO₂ was studied on mature calcareous red algae (Kuffner *et al.*, 2008; Hall-Spencer *et al.*, 2008). Little currently is known on the effect of the “ocean acidification” – when atmospheric CO₂ is solved in seawater its pCO₂ increases, and this reduces both the pH and the concentration of carbonate ions – on the reproduction rates and surface increase of the Corallinaceae. For this reason a study on the production and on the growth of Corallinales spores was realized in microcosm. The calcareous red algae were submitted to different concentrations of CO₂ ([CO₂]) in three different tanks (15 lt each). We carried out three “mono-phase cultures” (May and October 2008, May 2009) during which the values of pCO₂ and of pH (“control” tank pCO₂ = 370 ppm and pH = 8,2; “intermediate” tank pCO₂ = 550 ppm and pH = 8,0; “acid” tank pCO₂ = 760 ppm and pH = 7,8) (IPCC, 2007), were maintained constant in each tank during the entire period of insemination; we made three “three-phase culture” (July 2008, October 2009, March 2010) during which the pCO₂ was progressively fitted step by step in three phases at the values described above. Calcareous encrusting red algae, *Lithophyllum incrustans* Philippi (Corallinaceae), were sampled in the gulf of Trieste (north Adriatic, Mediterranean Sea) to a depth of 3-4 m. Two census of the disks of growth were carried out within the first week from the beginning of the insemination and at the end of insemination. At the beginning of “mono-phase culture”, even if developed in different seasons, a decrease in the presence of the thallus was observed as the [CO₂] increased (Fig. 1 – grey column). In “three-phase culture” and in “mono-phase culture” at the end of insemination a new census of the thallus was carried out. In all the cases an increase in the mortality of thalli was recorded with pCO₂ increase (Fig. 1 – white point). To study the surface growth rates of disk of growth, some selected thallus were marked randomly and photographed weekly (Image Pro

Plus 6.0). The rate of growth of the germinated disks was expressed as difference between the surface of the thallus on their last day of culture and their measured surface after a week from the beginning of the insemination (ΔS). In “mono-phase culture” (Fig. 2 – black points) and “three-phase culture” (Fig. 2 – white points) the thallus show a smaller growth at the increase of seawater acidity. The data of thallus surface was submitted to ANOVA; the F value (p-value<0.05) confirmed that the different [CO₂] influence the growth rate of *L. incrustans* young thallus in both methodologies culture. In “mono-phase culture” the value of F was 7.1611 (p-value=0.02), 24.9268 (p-value=1.3e-3), 19.26 (p-value=2.1e-4) in May 2008, October 2008 and May 2009 respectively. In “three-phase” culture the value of F was 7.581 (p-value=0.01), 6.01 (p-value=0.01), 76.632 (p-value=5.7e-15) in July 2008, October 2009 and March 2010 respectively. The results seems therefore to underline that the increasing of [CO₂] could have a negative influence on the colonization of the *L. incrustans* calcareous algae not only at level of species, but at an ecosystemic level too as different authors refer (Kuffner *et al.*, 2008; Hall-Spencer *et al.*, 2008).

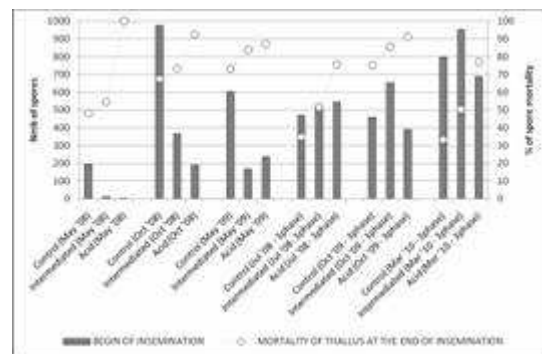


Fig. 1: Numbers and % mortality of spores in “mono-phase” and “three-phase” culture.

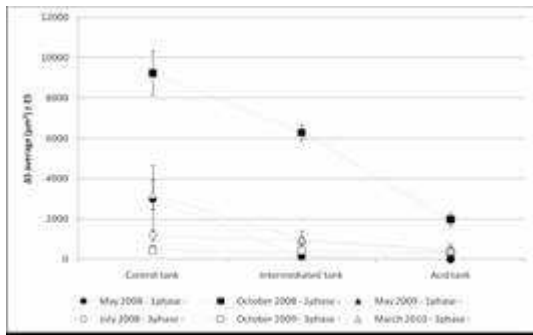


Fig. 2: average spores growth (ΔS average) in “mono-phase” and “three-phase” culture.

Possible effects of the Mediterranean Sea regime shift at the end of the 1980s on the demersal species assemblages in the Ionian Sea

D'Onghia G., Giove A., Maiorano P., Carlucci R., Minerva M., Capezzuto F., Sion L., Tursi A.

g.donghia@biologia.uniba.it

Dipartimento di Biologia Animale ed Ambientale, Università di Bari; ULR CoNISMa di Bari

Key words: Species assemblages, environmental variables, fishing effort, multiple regression, multivariate analysis, Mediterranean.

Data were collected during seventeen trawl surveys carried out in the north-western Ionian Sea, from 1985 to 2005, as part of a national study project on the assessment of the demersal resources. A trawl net with a stretched mesh of 40 mm in the codend was used and the experimental hauls were carried out according to a random-stratified sampling design at depths between 10 and 800 m. The following species were considered: *Eledone cirrhosa*, *Illex coindetii* for cephalopods, *Aristaeomorpha foliacea*, *Nephrops norvegicus*, *Parapenaeus longirostris* for crustaceans, *Merluccius merluccius*, *Micromesistius poutassou*, *Mullus barbatus* and *Phycis blennoides* for teleost fish. The density (N/km²) and biomass (kg/km²) indices were computed for each species and survey. The recruitment index was calculated for *I. coindetii*, *A. foliacea*, *N. norvegicus*, *P. longirostris*, *M. merluccius* and *M. barbatus* as the fraction of the specimens younger than 1 year (0+ group) on the whole sampled population collected during each survey. The abundance changes of these species were evaluated with respect to the Mediterranean Sea regime shift at the end of the 1980s considering the following environmental variables: SST, raininess, winter NAO index. The fishing effort was also considered as a variable influencing the abundance of the demersal species. The *backward linear multiple regression* was applied in order to investigate the relationship between the density index of each species (response variable) and the environmental variables (predictive variables). The significance of the regression was evaluated by means of ANOVA which allowed to identify between significant predictive variables and not significant ones in the explaining model. Statistical analyses were carried out by means of the SPSS software. The multivariate analysis was applied with the aim to identify significant differences in both the abundance indices as well as in the recruitment index between three different periods: 1) before Eastern Mediterranean Transient, 1988;

2) during EMT, 1989-1999; 3) after EMT, 2000. The matrices for density indices, biomass indices and recruitment indices by year (column) and species (row) were performed. In order to reduce the effect of extreme data, the matrices were fourth root-transformed and Bray-Curtis similarities were estimated between samples. The non-metric Multi Dimensional Scaling ordination was applied in order to identify groups of years related to the different hydrographic conditions connected to the EMT. The ANOSIM test was applied to evaluate the differences among year groups identified. For this analysis the PRIMER software was employed. High changes in SST and NAO index were shown from 1985 to 2005, mostly after 1998 and 1999. A significant decrease of fishing effort was detected throughout the whole study period. In *E. cirrhosa*, *P. longirostris* and *M. barbatus* no significant correlation were observed with respect to all the environmental variables considered. The density indices in *I. coindetii*, *A. foliacea* and *N. norvegicus* were negatively correlated to the fishing effort. The abundance in *M. merluccius* was positively correlated to the NAO index and in *M. poutassou* was positively correlated to both NAO index and raininess. In *N. norvegicus* a significant inverse relationship was detected between the recruitment index and both SST and fishing effort. In *P. longirostris* the recruitment index was negatively correlated to the fishing effort. In *M. merluccius* the recruitment index was positively correlated to the NAO index as shown in the adults. The MDS ordination of the density, biomass and recruitment indices revealed in all the three cases the presence of two distinct year groups: the former corresponding to the years before the EMT and the latter to the years during and after the EMT. The discrimination of these groups was confirmed by ANOSIM test for all the three indices.

Fluxes of particulate matter, carbonates, organic carbon and nitrogen on a shallow continental platform (northern Adriatic Sea)

¹Michele Giani, ²Alfredo Boldrin A.

mgiani@inogs.it

¹Istituto Nazionale di Oceanografia e di Geofisica Sperimentale – OGS, Trieste

²Istituto Scienze Marine ISMAR-CNR, Venezia

Key words: organic carbon; carbonates; nitrogen; settling particulate matter; Adriatic sea; continental shelf.

Time series of composition and fluxes of settling matter in a marine environment, obtained by sediment trap samples, permit to define the main processes driving the dynamic of suspended matter and of the time/space variability of the benthic-pelagic exchanges.

With this aim, the composition and fluxes of settling matter, obtained from different projects (PRISMA 1, MAT, INTERREG) and from published papers, at 5 stations in the western part and 4 stations in the eastern part, both in coastal and offshore areas, of the Northern Adriatic shelf were analysed.

The downward fluxes of particulate matter and associated organic carbon (OC), nitrogen (N) and carbonates were compared to the POC standing stocks and primary productivity of the different areas to obtain estimates of the carbon export. Furthermore, the fluxes of autochthonous settling matter from sediment traps were compared with the mass accumulation rates which showed that the total mass flux and carbonates fluxes were lower than those derived by radionuclide measurements whereas the OC and N fluxes were much higher point of that a relevant organic carbon degradation and nitrogen remineralization takes place at the sediment water interface

Due to the mooring of the traps in shallow waters and close to the sea bottom the gross fluxes were highly dependent on resuspension processes which over impose on the allochthonous particles fluxes and to the freshly produced marine organic matter. The mean yearly particulate fluxes varied from more than 12 to about 3 kg m⁻² y⁻¹, in coastal and offshore areas respectively, and from 200 to 95 gC m⁻² y⁻¹ for particulate organic carbon.

The fluxes were characterized by high seasonal variations as the fluxes can increase 2-3 fold in

autumn or in winter whereas diminished 2-5 folds in spring or in summer. The causes of the seasonality of the fluxes can be related to the riverine discharges, primary production and wind regimes of the basin.

Utilizing the OC/N ratio as index for discriminate the resuspended/riverine sediments and the primary settling matter, the primary marine carbon fluxes ranged, depending on the sites, from 21 to 38 % of the total particulate organic carbon fluxes, with higher percentages in summer.

The export of autochthonous organic carbon toward the sediment was higher in winter and minimum in spring and summer. This could be due to the thermohaline stratification of the water column which allow the accumulation of POC at the pycnoclines and to the higher bacterial demand in the warm seasonal periods.

The export of the coastal traps was higher particularly at the shallowest sites as the scavenging effect of higher concentration of particulate matter can transport particles to the seabed more efficiently.

The downward flux of OC amounted to 1.6-60 % of the total POC standing stock per day, the highest values were reached in winter and autumn whereas the lowest in spring-summer.

The comparison of the primary autochthonous matter settling flux with mass accumulation rates showed that the fluxes were 0.1-0.6 fold lower for total suspended particulate matter and carbonates but were up to 3.7 fold higher for organic carbon and 4.5 fold higher for nitrogen. This suggests that a relevant part of OC and N settling to the bottom is consumed or remineralized at the sediment-water interface before being buried.

Estimates of the nutrients fluxes along the Gargano-Split section (Middle Adriatic Sea)

F. Grilli¹, M. Marini¹, A. Campanelli¹, E. Paschini¹, A. Russo², A. Coluccelli²

f.grilli@ismar.cnr.it

¹ Institute of Marine Sciences, CNR-ISMAR, 60125 Ancona, Italy

² Department of Marine Sciences, Polytechnic University of Marche, 60131 Ancona, Italy

Key Words: Adriatic Sea, Nutrients, Fluxes, Current.

The Gargano-Split transect, which approximately marks the borderline between the middle and southern Adriatic, is exposed to the influences both from the northern and southern Adriatic and its dynamics is controlled also by the topographic effect induced by the Palagruža Sill.

The aim of the study is to calculate estimates of the fluxes of water and dissolved inorganic nutrients from the northern shelf area, where large nutrient inputs come from rivers, towards the deep sea due to both the surface and deep circulation. The knowledge of nutrient flux through this section would be a crucial information to understand the fate of the continental nutrient input.

During the Dynamic of the Adriatic in Real Time (DART), the U.S. Naval Research Laboratory (NRL) together with the NATO Undersea

Research Centre (NURC) deployed 12 bottom-mounted Acoustic Doppler Current Profilers (ADCPs) from November 2005 to September 2006 along the Gargano-Split section. During the same period, four different oceanographic cruises were carried out. Hydrographic stations were sampled with the CTD/Rosette to measure physical (temperature, salinity and density) and chemical (oxygen, orthosilicate, orthophosphate and dissolved inorganic nitrogen- DIN) parameters. Measurements of current velocities allowed estimation of water fluxes, and the net nutrient transports were estimated from the latter combined with nutrient concentrations.

Some results concerning oceanographic properties, water current time series, water and nutrient fluxes through the water column were successfully achieved.

Atmospheric CO₂ concentrations and $\delta^{13}\text{C}$ over the western and eastern Mediterranean basins during summer 2007

Leonardo Langone¹, Antonio Longinelli², Carlo Ori¹, Enricomaria Selmo²

leonardo.langone@ismar.cnr.it

¹CNR-ISMAR, Sede di Bologna, Via Gobetti 101, 40129 Bologna, Italy

²Dept. Earth Sciences, University of Parma, V. Usberti 157A, 43100 Parma, Italy

Key words: Atmospheric CO₂ concentration, $\delta^{13}\text{C}$ of atmospheric CO₂, Mediterranean, western and eastern basins, summer 2007.

In the framework of the VECTOR Project, four oceanographic cruises were carried out during summer 2007 covering large sections of both the western and eastern Mediterranean basins by using the R/V *Urania* and *Universitatis*, respectively. The atmospheric CO₂ concentration was measured with a Siemens Ultramat 5E analyser on both the outward and the return journeys and 46 discrete air samples were collected by means of evacuated Pyrex flasks. The $\delta^{13}\text{C}$ value of the CO₂ from the flask air samples was measured in the laboratory following well established procedures.

The purpose of this study is to obtain a statistically significant picture of the situation in the Mediterranean during summer and to compare these data with similar measurements carried out during late autumn in the eastern Mediterranean over the last decade and in open ocean (2007).

The CO₂ concentrations in the western basin are characterized by frequent and marked variations ranging from about 381 to about 394 ppmv: values of up to 398 and 415 ppmv were recorded occasionally, particularly close to the Gibraltar Strait. The measured $\delta^{13}\text{C}$ values are very homogeneous, with a mean value of -9.70 ± 0.22 ‰ in contrast with the large $\delta^{13}\text{C}$ fluctuations that were expected in this basin.

The eastern basin shows, on average, considerably lower CO₂ concentrations than those recorded in the western basin but more variable in space and time. The overall range is between about 375 and

398 ppmv, but most of the values are between 375 and 388 ppmv. The $\delta^{13}\text{C}$ values of the discrete air samples are again very homogeneous with a mean value of -9.37 ± 0.16 ‰, less negative than the mean value calculated for the western basin. The distribution of the measured values is expected to be related either to the emissions from different continental areas (and to the dynamics of the air masses) or to the emissions from the heavy ship traffic.

The CO₂ concentrations are slightly lower than those measured during late autumn 2007 in the eastern Mediterranean (386 to 394 ppmv with a marked peak at 412 ppmv) and considerably higher than those measured in open ocean (382 to 385 ppmv in the Indian and Southern Oceans). The $\delta^{13}\text{C}$ values (-9.0 to -10.1 ‰) are more negative than those measured in the eastern Mediterranean in late fall 2005 (-8.70 to -9.01 ‰) and in the Indian and Southern Ocean in late fall 2007 (-8.26 to -8.39 ‰). The data obtained from summer 2007 show some inconsistency between the two variables with a lack of a direct relationship between them. Variable environmental conditions may conceal the expected effect of the terrestrial biospheric sink of CO₂ during summer.

Seasonal cycles of pH and carbonate system parameters in the southern Adriatic Sea during one year of VECTOR project

Anna Luchetta¹, Carolina Cantoni¹, Stefano Cozzi¹, Giulio Catalano¹, Giuseppe Civitarese², Fabio Raicich¹

anna.luchetta@ts.ismar.cnr.it

¹ CNR ISMAR – Istituto di Scienze Marine, U.O.S. Trieste, viale R. Gessi 2, 34123, Trieste, Italy

² OGS Istituto Nazionale di Oceanografia e Geofisica Sperimentale, Trieste, Italy

Key words: Seawater pH; time series; carbonate system parameters, carbon dioxide, saturation states, Southern Adriatic.

Within the VECTOR project (activity 8.1.2) the pH and other physical chemical parameters were acquired as seasonal time series from September 2007 to June 2008, at the AM1 station (in the centre of the Southern Adriatic Pit). The pH was measured by the spectrophotometric method (precision ± 0.003) and the results expressed on “total scale” at 25°C ($\text{pH}_T@25^\circ\text{C}$). In a few seasons also the total alkalinity (A_T) was measured by potentiometric titration at 25°C (precision $\pm 3 \mu\text{mol/kg}$) and the results were checked against sea water certified as reference material (by dr. A.G. Dickson). The other derived parameters of the carbonate system (pCO_2 , DIC, Ω_{Ar} , Ω_{Ca}) were computed from pH, TA, salinity, temperature, SiO_2 , PO_4 according to Lewis and Wallace 98.

The pH seasonal variability was the highest in the upper layer (0-100 m), as clearly recognizable in fig 1a, b being the pH value mainly driven by biology during the productive seasons (from spring to late summer) or by mixing with deeper waters and exchange processes with atmosphere in winter. In the deeper layers (intermediate and bottom) the seasonal variability was lower but not negligible, probably driven by remineralization processes of dissolved and particulate organic matter locally produced, as suggested by Apparent Oxygen Utilization (AOU) and nitrate seasonal variabilities (fig. 1c, d, e, f).

Generally, the highest differences of physical and biogeochemical properties can be observed in both the upper (0-100m) and the intermediate (100-800 m) layers in September and June whereas during wintry season (January and February) variabilities were much lower. Through early to late summer season, the nutrients pH and dissolved inorganic

carbon (TCO_2) all suggest that both layers are strongly affected by biology (quite active primary production in the upper layer although in general the region has to be considered oligotrophic, and remineralisation processes in the intermediate layer). As confirmed by the good correlation with AOU and fluorescence. The vertical variabilities of such parameters are large, representing the 28 %, 0.4 %, -115 % of the total amount. Narrower changes can be observed passing from the intermediate to the bottom layer (800 – bottom) in January, February and June. *A good correlation between changes of nutrients, pH, carbonate system and AOU is still observed, indicating the significant contribution of remineralisation processes to the final values.*

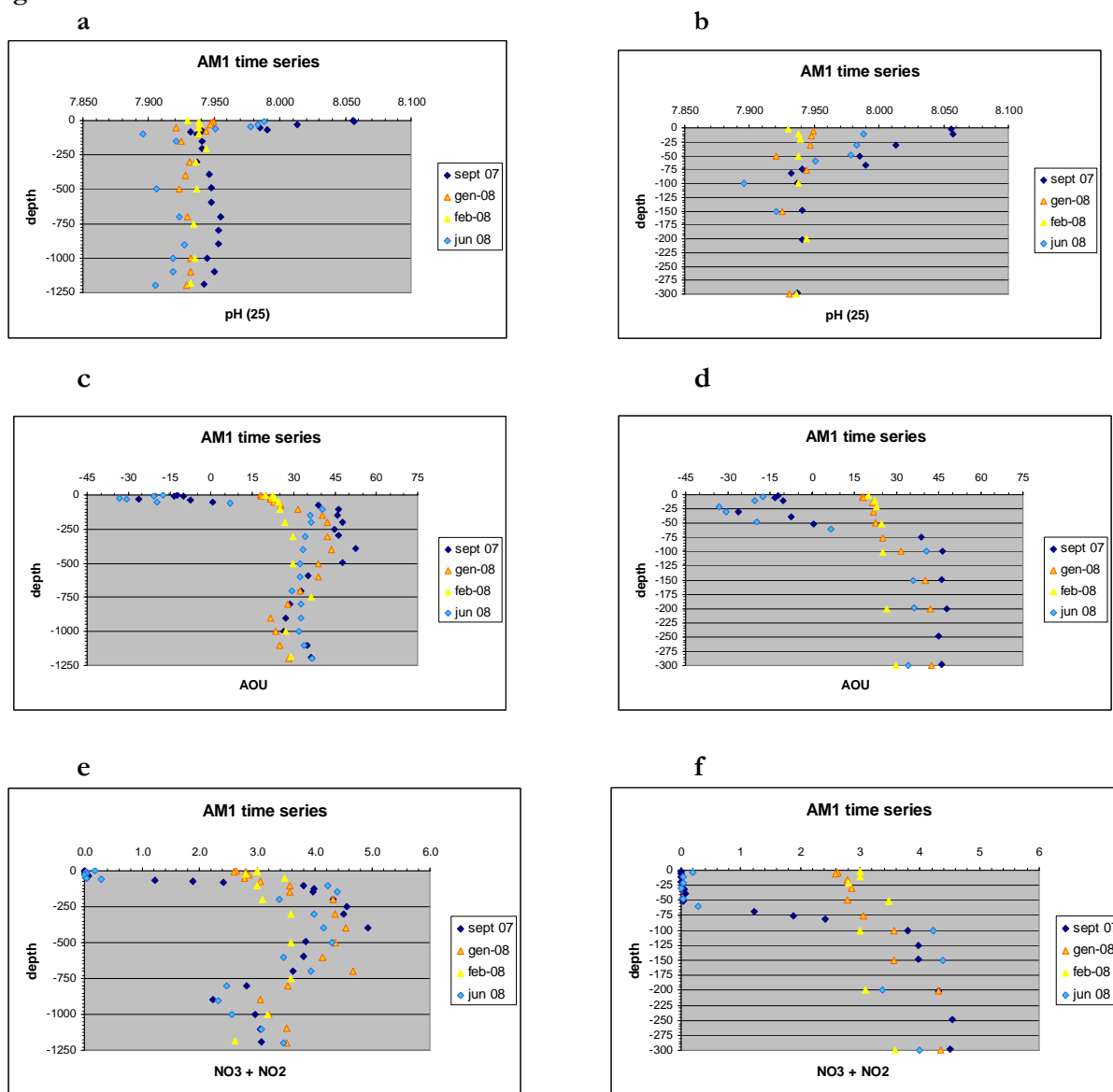
The physical and biogeochemical differences between the intermediate and the bottom layer further suggest that water masses of different origin filled these two layers. The persistence of inter layers variability through the year might suggest the absence of any abrupt change in the circulation scheme.

The three forms of carbon dioxide in seawater ($\text{TCO}_2 \text{ aq}$, HCO_3^- , CO_3^{2-}) and the saturation states of calcite and aragonite were computed, from the experimental measures of pH and total alkalinity (reported in table 1) along the water column, in February June and October 2008. Values at surface show to be higher than the surface values of other oceanic regions, this is due to the higher alkalinity of the Mediterranean Sea, thus confirming peculiar characteristics of the carbonate system and the good saturation states of the Med Sea and southern Adriatic sea in particular.

Table 1: Carbonate system properties (TCO_2 , HCO_3 , CO_3 , Ω_{Ca} , Ω_{Ar}) in the three layers of the southern Adriatic Pit.

Upper	T pot	Sal	pH _T (25)	TA	TCO ₂	HCO ₃	CO ₃	Ω_{Ca}	Ω_{Ar}
Feb 08	13.732	38.757	7.937	2635.7	2339.8	2113.9	215.2	5.0	3.3
	0.053	0.002	0.004	4.3	4.1	4.5	1.6	0.0	0.0
June 08	16.808	38.619	7.959	2611.6	2310.1	2072.3	222.1	5.2	3.4
	3.099	0.116	0.038	4.1	26.0	38.8	14.5	0.3	0.2
Oct 08	17.241	38.753	7.958	2623.7	2320.81	2081.6	223.4	5.2	3.4
	2.743	0.049	0.055	7.9	30.3001	49.9	22.4	0.5	0.3

Fig 1



Copepod grazing and reproduction in the Gulf of Naples

Maria Grazia Mazzocchi, Diana Sarno, Adriana Zingone, Ylenia Carotenuto, Iole Di Capua

grazia.mazzocchi@szn.it

Stazione Zoologica Anton Dohrn, Napoli

Key words: Copepods, grazing, egg production, phytoplankton, coastal waters.

Grazing, i.e., the intake of particle food items by zooplankton, is one of the major processes contributing to the functioning of marine plankton communities, since zooplankton as major primary consumers play pivotal roles in structuring the pelagic food webs in the oceans. Copepods are the numerically dominant component of marine zooplankton and key elements in pelagic food webs due to their grazing impact on phytoplankton and protozoans. A new understanding of the relationships between copepods and their food environment has led to replace the traditional view of copepods as simple, passive filter feeders by a more complex picture of multiple, variable feeding mechanisms performed by these small crustaceans. A large body of evidence suggests now that copepod diets are very diverse and affected by a wide array of behavioural and environmental characteristics.

In the frame of VECTOR-L4-A1.4, we investigated the grazing activity and secondary production of copepods that are representative of zooplankton communities at st. MC, site of a long-term time-series (LTER-MC) in the inner Gulf of Naples (Tyrrhenian Sea). Our goal was to estimate grazing rates, natural diets, and egg production and viability of target species that are abundant consumers in Mediterranean coastal zooplankton in different seasonal conditions. Experiments were conducted in the laboratory in correspondence with the weekly serial sampling at st. MC in periods of different environmental and trophic conditions (February, July and December 2007 and February 2008). Target species were the calanoid copepods *Acartia clausi*, *Paracalanus parvus*, *Centropages typicus*, *Temora stylifera*, and *Clausocalanus* spp., which account for most of the copepod abundance in different periods of the annual cycle at st. MC. Moreover, these species have different

behavioural habits of food acquisition, despite common characters in size and general morphology, suggesting different impacts on phyto- and microzooplankton assemblages. Grazing rates (clearance and ingestion) and quality of natural diets were estimated with the food removal method by incubating selected zooplankters in bottles with natural particle assemblages from st. MC and measuring the decrease in food concentration (as size-fractionated chlorophyll *a* and plankton species concentration) compared to that in control bottles without grazers. Copepod egg production (as eggs produced per female per day) and viability (percentage of hatched eggs) were measured according to standard protocols. Our results showed that i) grazing rates differed among species, ii) according to the species, grazing rates and diets changed or not on a seasonal basis, iii) the acquisition of the smallest size-fraction of autotrophic compartment was negligible. For example, in July, *P. parvus* and *T. stylifera* grazed significantly colonial diatoms of medium and large size (*Leptocylindrus danicus*, *Cerataulina pelagica*, *Pesudo-nitzschia* spp.), together with dinoflagellates (15-30 μm) and ciliates, while they neglected small size flagellates (< 5 μm) and diatoms (<10 μm), which were very abundant at that time. The average egg production decreased from *T. stylifera* and *C. typicus* (about 50 eggs $\text{f}^{-1} \text{d}^{-1}$) to *A. clausi* (~ 20 eggs $\text{f}^{-1} \text{d}^{-1}$) and *P. parvus* (11 eggs $\text{f}^{-1} \text{d}^{-1}$ in February, 7.5 eggs $\text{f}^{-1} \text{d}^{-1}$ in July). Egg viability was high (> 90%) for all species and periods, with the exception of February 2007 when the lower percentages recorded (*A. clausi* 57%, *P. parvus* 77%) were probably related to low nutrition values of natural diets.

Benthic Foraminifera from Atlantic Ocean and Mediterranean Sea: who, how many and what differences?

Irene Pancotti¹, Anna Sabbatini¹, Caterina Morigi², Andrew J. Gooday³,
Roberto Danovaro¹, Alessandra Negri¹

i.pancotti@univpm.it

1- Polytechnic University of Marche, Italy

2-Stratigraphy Department, Geological Survey of Denmark and Greenland, Denmark

3-National Oceanography Centre, United Kingdom

Key words: Mediterranean Sea, benthic foraminifera, monothalamous taxa, biomass.

Studies on deep modern benthic foraminifera in the Mediterranean Sea are not abundant and generally focused on the fossilizing polythalamous component of the assemblage. We present preliminary results of living (Rose Bengal stained) benthic foraminiferal faunas in bathyal and abyssal sediment samples. Density, species composition and biomass of this protists are determined at 19 sites across a transect from the Atlantic (Seine Abyssal Plain) to the eastern Mediterranean Sea from 1850 to 4345 m water depth.

In this framework we investigated the 63-150 μm and >150 μm fractions of two replicate samples in the first 5 cm of sediment including also the analysis of monothalamous taxa (both hard and soft-shelled).

Our results evidence that the Atlantic samples show a generally high abundance with respect to the Mediterranean samples whereas in the Mediterranean basin is evidenced an overall relatively low density and an eastward decreasing abundance trend. In the foraminiferal assemblage the soft-shelled monothalamous taxa represent the most important element that in the deepest site (Ierapetra, eastern Mediterranean) becomes the

only component of the benthic fauna. This is mainly represented by *Nodellum membranaceum*, “*Nodellum*-like” forms and *Resigella moniliforme*, which have been reported from Atlantic, Pacific and Southern Ocean, but are not common in the Mediterranean Sea. All monothalamous taxa described in this work are reported for the first time in this environment.

Polythalamous agglutinated and calcareous taxa are in general more abundant in the coarser fraction and in addition their abundance increase in the Atlantic Ocean and in the Tyrrhenian Sea respectively. Moreover the Atlantic foraminiferal samples are extremely rich in fragments of tubular forms belonging to genera *Rhabdammina* and *Rbizammina* and Komokiaceans specimens.

Finally, the biomass values (in the fraction >63 μm) based on the volumetric method (Altenbach, 1985) range from 68.41 mgC m⁻² at the sites of the Alboran region to 0.48 mgC m⁻² at the Ierapetra station, south of Crete. Our data represent a starting point for future comparison between foraminifera and metazoan meiofauna biomass.

Plankton variability in the Gulfs of Naples and Salerno during four seasonal cruises

Santarpi L., I. Di Capua, G. Franzè, F. Margiotta, M.G. Mazzocchi, M. Modigh,
I. Percopo, M. Saggiomo, A. Zingone and V. Saggiomo

santarpi@szn.it

Stazione Zoologica Anton Dohrn, Napoli, Italy

Key words: Primary Production, HPLC, phytoplankton, microzooplankton, meso-zooplankton, Tyrrhenian Sea.

Planktonic communities were studied in the two adjacent Gulfs of Naples and Salerno during four seasonal cruises (from July 2007 to June 2008), in order to assess their variability along trophic gradients. The sampling stations were located along coastal-offshore transects (6 stations in the Gulf of Naples and 5 in the Gulf of Salerno). Physical parameters were acquired by means of CTD. Measurements of organic and inorganic nutrients, total and size-fractionated Chl *a*, pigments spectra (HPLC), primary production, and abundance and composition of phytoplankton and micro-zooplankton were carried out at selected depths along the entire photic zone. Meso-zooplankton assemblages were analysed in the 0-50 m layer.

Marked differences were detected in the trophic status of the two Gulfs during the sampling periods. The Gulf of Naples was characterized by mesotrophic conditions in inshore areas while oligotrophic conditions were observed in the offshore areas. In the inner part of the Gulf of Naples, phytoplankton blooms were observed in late spring and summer, probably driven by terrestrial inputs. During the blooms, notably high values of primary production and biomass were recorded (PP up to 40 mgC m³ h⁻¹ and Chl *a* > 6 mg m⁻³). Phytoplankton assemblages were mostly represented by small non-colonial diatoms (e.g. *Bacteriastrum parallelum* and *Chaetoceros tenuissimus*) in summer and colonial diatoms (*Thalassiosira* spp., *Chaetoceros* spp.) in spring. The off-shore stations were characterized by low autotrophic biomass values and primary production rates in all seasons. Small phytoflagellates (e.g. prymnesiophytes) and cyanobacteria were the main phytoplankton

groups. The micro-zooplankton assemblages of the Gulf of Naples were dominated by protozoans (ciliates), which showed the highest biomass and abundance values in the inner stations (up to 6000 cell L⁻¹; 53 µgC L⁻¹). The percentage contribution of the nauplii to the micro-zooplankton biomass increased in the inner stations during the late spring and summer (up to 50%). The meso-zooplankton assemblages of the Gulf of Naples were highly diversified and dominated by typical coastal calanoid copepods (*Acartia*, *Paracalanus*, *Centropages*) and meroplanktonic groups; a high variability was observed in their composition at the seasonal scale.

By contrast, the Gulf of Salerno showed oligotrophic characteristics in both inner and offshore areas. Phytoplankton assemblages were dominated by small phytoflagellates and cyanobacteria in all seasons. The micro and meso-zooplankton assemblages of this Gulf were rather uniform at the spatial and temporal scales. The micro-zooplankton assemblage was dominated by ciliates and the meso-zooplankton by oloplanktonic groups, characterized by juveniles of calanoids and cyclopoid copepods (*Oithona*, *Oncaea*).

While the external stations of the two Gulfs showed very similar features in all seasons, the coastal planktonic communities markedly differed among the two Gulfs in terms of abundance, biomass and community structure. This diversity between the two Gulfs seemed essentially driven by differences in terrestrial inputs and coastal circulation.

VECTOR Project: Final results from the Northern Marche coastal area

Tramontana M.¹, Bisiccia C.¹, Colantoni P.¹, Nesci O.¹, Savelli D.¹, Troiani F.¹, Fontolan G.², Tarragoni C.³, Baldelli G.¹, Borda G.P.¹, Bucci C.¹, Donatelli U.¹, Sabatini L.¹, Schiaroli A.¹, Tiberi V.¹

mario.tramontana@uniurb.it

¹ Università degli Studi di Urbino “Carlo Bo”

² Università degli Studi di Trieste

³ Università di Roma “La Sapienza”

Key words: VECTOR, Coastal area, Northern Marche, Late Quaternary evolution, hazard and vulnerability.

Within the VECTOR Project the evolution of the Northern Marche coastal area including the Foglia and Metauro river mouths has been reconstructed eventually focusing on hazard and vulnerability connected with expected sea-level rise. Specifically, for the Foglia and Metauro river-basins a 40 m-resolution DTM has been created, and original 1:50000 geomorphic, geolithologic and land-use maps have been processed by a GIS system, being the latter based on Corine data and the others derived both on pre-existing data and on original field surveying and aerophoto interpretation. For the coastal area 1:10000 geomorphic, geolithologic and land-use maps have also been produced, and a bathymetric survey has been carried out by single-beam echosounder thus allowing, together with a re-elaboration of pre-existing data, to derive a DEM of the offshore. Furthermore, a detailed geological map of the submerged area in the Pesaro offshore has been realized. A characterisation of near-bottom sediments and benthic faunal assemblages has also been achieved based on existing data. Finally, to frame the study-area evolution in a larger context, lithostratigraphic data from sediment cores have been re-elaborated extending southward to the Esino river mouth.

The main results can be summarized as follows.

- Since the coastal flats/terminal floodplains switch-points are effective tools in marking the position of outlets in highstand stages, the terminal valley-reaches between Foglia and Esino have been analysed to detect evidence for pre-Holocene river mouths. The middle Pleistocene terraces of the Cesano and Misa valleys reveal an overall maintenance of the respective river-mouth position during highstand stages. Conversely the arrangement of the Metauro and Foglia terraces hint at significant late Pleistocene coastal retreat.
- Plano-altimetric distribution of fluvial terraces, stressing valley-downcutting rates,

can be indicative of different rates in tectonic uplift. Terraces occur in the study area both inside valleys and in coastal areas, resulting from multiple controls, e.g. tectono-climatic, eustatic and isostatic, anthropogenic, and complex-response related. Terraces along the coastal area allowed detecting downcutting rates since middle Pleistocene lesser in the Cesano-Esino sector (0.15 ± 5 mm/yr) and higher in the Metauro-Foglia area (0.40 ± 0.5 mm/yr).

- A new 39 m-deep (i.e. -38 m BSL) core in the Fano harbour has been achieved and new ¹⁴C datings obtained. The bedrock (Pliocene marine clays) is overlain by the Metauro alluvium dating to > 45000 yr BP at the base and to 43895 ± 265 cal. yr BP at -27 m, in turn unconformably overlain by up to about 15 m-thick marine deposits, whose top (ca. -5 m) dates to 1160-1250 cal AD.
- Fan construction, constrained by two ¹⁴C datings (10700+95 and 10880+95 yr BP), occurred at river outlets in low sea-level conditions. Holocene sea-level rise caused the erosion of intermediate and distal fan sectors, generating 1-8 m-high wave-cut cliffs stepping the modern coastal plain. Diversity in cliff-heights at different river mouths relate to the original sedimentary fan-relief, in turn connected with different lithology of the river basins, viz. different bed-load supply.
- The southward deflection of the modern Cesano outlet accounts for lateral switching of the channel promoted by the presence of a fan. A paleochannel reveals similar behaviours in the Metauro, although the position of the modern mouth here accounts for piracy performed by one of the several small streams

initiated on the wave-cut scarp. Since retreat of the wave-cut scarps at the fan-apexes means local base-level fall and stream adjustment, minor streams (e.g. Arzilla) originated tight series of ingrown meanders by coupling downcutting with the tendency to increase channel sinuosity.

- The hazard and vulnerability (e.g. emerged land loss) of crucial sectors of the studied coastal area have been evaluated taking into account both wave action and the possible effect of expected sea-level rise derived for the years 2050 and 2100 by projections IPCC 2007 and Rahmstorf 2007.

Space-time variability of suspended matter and particulate organic carbon (POC) in the Southern Adriatic and Mediterranean Sea

¹Turchetto M., ²Langone L., ¹Boldrin A., ¹A. De Lazzari, ²Miserocchi S.

margherita.turchetto@ismar.cnr.it

¹Istituto Scienze Marine ISMAR-CNR, Sede di Venezia, Castello 1364/A, Venezia, 30122

²Istituto Scienze Marine ISMAR-CNR, Sede di Bologna, Via P. Gobetti, 101, Bologna, 40129

Key words: Particulate organic carbon, Mediterranean sea, southern Adriatic.

In the framework of the VECTOR Project, the bio-geo-chemical characterisation of suspended matter was analysed in the western (WMED) and eastern (EMED) Mediterranean and in the Southern Adriatic (SA). In SA the interannual variability was studied in time series data starting from 1997.

Two cruises (TRANSMED leg II and III) were carried out along a W-E transect in the Mediterranean Sea (Fig. 1) from May 28 to June 24, 2007, to collect water samples in 10 stations (including one station in the Atlantic). In the SA, to highlight the seasonal variability, 6 cruises were carried out along the Bari-Dubrovnik transect, in November 2006, February, April, September 2007, February and June 2008 (Fig. 1). The parameters analysed were: total suspended matter (TSM), particulate organic carbon (POC), particulate total nitrogen (PTN) and organic carbon stable isotopes ($\delta^{13}\text{C}_{\text{POC}}$).

Our data confirm the general oligotrophy of the Mediterranean Sea, as the higher concentrations were observed in the Atlantic and in marginal areas as the Ligurian basin and SA. TSM values ranged 0.01-1.40 mg l⁻¹ (avg., 0.20±0.18 mg l⁻¹). POC concentration was variable from 23.10 to 201.42 µg C l⁻¹ (avg., 26.40±1.86 µg C l⁻¹) and PTN was on average 4.73±3.77 µg N l⁻¹ (range 0.63 - 32.26 µg N l⁻¹), with a W-E decreasing trend in concentration, more evident in the epi-pelagic layer (0-100 m).

In the SA, the concentrations of POC and PTN in the 0-100 m layer were about 3 times higher than in the deeper layer; the maximum values were observed in the spring season (April-June) with a concentration peak in the sub-surface layer, shifting deeper from late winter to autumn.

The different geographic provinces of the Mediterranean can be differentiated in terms of C/N and $\delta^{13}\text{C}_{\text{POC}}$.

C/N molar ratio was on average 6.54±1.68, close to the values characteristic of phytoplankton.

In WMED, C/N ratio increases deepening as a result of the faster degradation of N in the organic matter along the water column. In EMED the values in the deeper layer were generally lower respect to the upper ones and this can be correlated to the presence of a higher microbiological activity in the deeper part of the water column. $\delta^{13}\text{C}_{\text{POC}}$ values were lower in the deep layer respect to the epi-pelagic environment (on average -25.24±1.21 ‰ and -24.19±1.21 ‰, respectively).

The analysis of POC time series in SA (Fig. 2) shows a progressive increase in concentration from 1997 to 2005, both in the upper and in the deeper layers, followed by a decrease, at the values observed before 2002, in the years 2006-2008. In particular, the POC concentration on average in 2004-05 was double with respect to that measured in 1997-99 and in 2006-08.

The observed strong seasonal and interannual variability in particulate organic matter is mainly driven by the autotrophic production processes occurring in the upper euphotic layers. This process is affected by light and nutrient availability, the latter in turn is subject to the physical water mixing that is mainly produced by the winter deep convection process, which brings inorganic nutrients in the upper euphotic zone from deeper layers. Possible factors controlling this variability will be discussed.

Microbial indicators of environmental changes in a coastal lagoon

Zaccone R., Azzaro M., Azzaro F., Caruso G., Monticelli L. S., Maimone G., Leonardi M., La Ferla R., Raffa F.

rosabruna.laferla@iamc.cnr.it

Istituto per l'Ambiente Marino Costiero (IAMC) – CNR, Messina, Italy

Key words: Prokaryotic abundance, enzymatic activities, organic matter, production, respiration.

Coastal aquatic ecosystems are among the most geochemically and biologically active areas of the biosphere playing an important role in the global cycles. The carbon flux in aquatic environments is ruled by microorganisms that provide both organisation and oxidation of the organic matter by means production and respiration processes, respectively. The aim of the research is to assess whether microbial parameters may be used as bioindicators of organic matter turnover and biogeochemical cycles.

The prokaryotic community both in term of abundances (total prokaryotic abundances, vibrios) and activities (enzymatic hydrolysis of proteins, by leucine aminopeptidase -LAP, polysaccharides by β -glucosidase -GLU and organic phosphates by alkaline phosphatase -AP; heterotrophic prokaryotic production -HPP; respiration -R) has been investigated together with physical and chemical parameters (temperature, salinity, nutrients) and particulate carbon and nitrogen (POC, PON) incidence, for a 2 years period (2006-08) in the coastal area of Cape Peloro (Messina). This area is constituted by two brackish basins (Faro and Ganzirri), comprised between the Tyrrhenian and Ionian Seas.

In Ganzirri lake, the values recorded for temperature and salinity ranged from 13.3 to 29.6 °C and from 29.32 to 38.40 respectively. In Faro lake they ranged between 14.23 and 28.79 °C and between 33.56 and 37.83 respectively.

In the Ganzirri lake, the prokaryotic abundances maximal concentration occurred in summer 2008 when it reached $7.58 \times 10^7 \text{ mL}^{-1}$, while the minimal value was observed in autumn 2006 ($0.35 \times 10^7 \text{ cells mL}^{-1}$). In addition, another peak of $5.71 \times 10^7 \text{ mL}^{-1}$ was observed in summer 2007.

In the Faro lake, lower values than in the Ganzirri lake were always registered (range $0.26 - 2.91 \text{ cell} \times 10^7 \text{ mL}^{-1}$, in autumn 2006 and 2007, respectively).

The abundance of vibrios followed a seasonal trend and was significantly correlated with temperature in both lakes ($R^2=0.51$ and $R^2= 0.79$, $P<0.01$, in Ganzirri and Faro respectively), indicating a direct stimulation of warm season on

bacterial growth. In the Ganzirri lake it showed the lowest values in winter and spring 2007 (3 CFU mL^{-1}); the maximum was observed in summer 2007 (910 CFU mL^{-1}). In general lower values in Faro than Ganzirri lake were observed (range $4 - 330 \text{ CFU mL}^{-1}$).

The POC and PON distributions showed similar seasonal trends in both ponds, with the lowest values in winter-spring and the highest ones in summer-autumn period. Generally higher values were found in Ganzirri (maximum POC: $1245,5 \mu\text{g l}^{-1}$) than in Faro lake (minimum POC: $179,49 \mu\text{g l}^{-1}$). The C/N ratio, always lower than 5, suggested the predominance of heterotrophic biomasses in this ecosystem.

The obtained results for microbiological parameters showed that the Cape Peloro area was characterised by high seasonal variability, which was higher than the spatial one.

Variability among the stations was observed for enzymatic activity rates; with higher values in Ganzirri than in Faro, in particular for AP.

In Ganzirri lake, the HPP varied from $1.26 \mu\text{g C l}^{-1} \text{ h}^{-1}$ (winter 2006) to $15.13 \mu\text{g C l}^{-1} \text{ h}^{-1}$ (summer 2007), resulting higher than those usually reported for coastal lagoons. In the Faro lake the HPP values were lower than those recorded in Ganzirri lake.

Respiration activity ranged from 0.73 to $8.65 \mu\text{l O}_2 \text{ h}^{-1} \text{ h}^{-1}$ in Ganzirri lake and from 0.53 to $6.18 \mu\text{l O}_2 \text{ h}^{-1} \text{ h}^{-1}$ in Faro lake, with lower values in winter and spring than in summer –autumn periods.

Positive correlations have been observed between temperature and HPP, AP, β -GLU, and POC in the Ganzirri lake.

This study underlines that microbial processes may be useful indices of environmental changes and may provide functional ecological information for protecting of coastal areas.

We suppose that global warming may affect microbial metabolism, so these new data together with previous research in this area, could allow to formulate hypotheses for a future climate change scenario.

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