
IMC
International
Marine Centre
Mediterranean
Seagrass
Workshop
MEDITERRANEAN SEAGRASS
WORKSHOP
SARDINIA 2015
Abstract book
edited by Ivan Guala and Maria Fais
Oristano, Italy
May 18th - 22nd, 2015

Mediterranean Seagrass Workshop

Sardinia 2015

Organised by

IMC, International Marine Centre

Loc. Sa Mardini, Torregrande, 09170 Oristano (Italy)

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With the collaboration of

Marine Protected Area “Penisola del Sinis – Isola di Mal di Ventre” of Cabras (Italy)

Under the patronage of

Stazione Zoologica Anton Dohrn of Naples (Italy)

Mediterranean Seagrass Association – Seagrass 2000

With the contribution of

Regional Activity Centre for Specially Protected Areas (RAC/SPA, Tunisia)

International Union for Conservation of Nature - Centre for Mediterranean Cooperation (IUCN-Med, Spain)

Italian Society of Marine Biology (SIBM, Italy)

Abstract book edited by Ivan Guala and Maria Fais on behalf of the MSW ’15 Committees

Cover photos: above (AMPSinis - Egidio Trainito) and underwater (Ivan Guala)

Contents

Welcome note

Seagrasses are among the most valuable ecosystems on the earth. Living in the coastal environment, a fragile boundary between land and sea where most of the human population is concentrated, seagrass meadows undergo strong impact. The worldwide perseverance of a motivated scientific community seeks to enlarge the knowledge about this key ecosystems, to develop strategies to assess and to suggest measures to mitigate the impacts. The semi enclosed Mediterranean basin is suffering by changes at a dramatic level. The distribution of seagrass ecosystems is declining, as direct consequence of human-induced or naturally occurring (including climate change) threats. A thorough knowledge of seagrass meadows functioning and evolution is the only possible action we can take for reversing this trend.

The Mediterranean Seagrass Workshop is now at its fourth event, with the objective to bring together seagrass experts from all over the Mediterranean region to present current knowledge of all aspects of seagrass biology and conservation and to discuss the state of Mediterranean seagrasses and the habitats they constitute. The previous workshops were organized in Malta (2006), in Hvar, Croazia (2009), in Essaouira, Morocco (2012) and were all a great success with participants attending from many Mediterranean and extra-Mediterranean countries.

The MSW 2015 is hosted by the IMC – International Marine Centre of Oristano, located on the West coast of Sardinia (Italy). Oristano has a nice and lively medieval city centre. The territory of the Province of Oristano is characterized by an extraordinary natural environment and a rich historical and cultural heritage. Visitors (and scientists) are attracted to its beautiful landscapes and seascapes, with white beaches, coastal lagoons with rich bird fauna and flora, important archaeological sites, historical monuments and traditions. The Gulf of Oristano and the many coastal lagoons are home to extensive seagrass beds; *Posidonia oceanica* alone covers more than 100’000 ha of seabed in the gulf. The Marine Protected Area “Penisola del Sinis – Isola di Mal di Ventre”, in the territory of Cabras, is located just a few hundred meters away from the IMC headquarters.

The workshop sees the participation of over 100 scientists form 23 countries, with a total of 45 oral presentation and 46 posters. The IMC – International Marine Centre of Oristano, hosting institution, in the person of Ivan Guala, the Seagrass 2000, in the person of Giuseppe Di Carlo, the Stazione Zoologica Anton Dohrn of Naples, in the person of Gabriele Procaccini, welcome all the participant whishing a fruitful meeting and a pleasant stay in the nature, the culture and the history of Oristano.

The MSW '15 Organising Committee

Hosts, partners & sponsors

IMC Foundation

The IMC - International Marine Centre (www.imc-it.org), founded in 1988 in Oristano, is a research institute of the Science and Technology Park of Sardinia, committed in research and dissemination of marine science.
The main lines of research involve: (i) study of ecological processes in benthic ecosystems, with particular reference to research, monitoring and management issues of marine protected areas, coastal habitats and species of particular relevance; (ii) applied research and technology transfer in the field of productive initiatives based on the sustainable use of marine resources, in particular in the field of aquaculture and production of microalgae. Moreover, the IMC is active in the fields of scientific and environmental education.

Penisola del Sinis – Isola di Mal di Ventre Marine Protected Area

The "Penisola del Sinis – Isola di Mal di Ventre" Marine Protected Area (www.areamarinasinis.it), located in the western coast of Sardinia (Italy), was established by Environmental Ministry in 1997 and is managed by the Municipality of Cabras. The MPA extends over an area of approximately 250 km^2 and is divided into three zones with different levels of protection according to the management objectives: protection of the biodiversity, promotion of environmental education, implementation of scientific research programmes and promotion of sustainable development. It is also included in SPAMI's list (Annex I of the SPA/BD Protocol of Barcelona Convention) and is recognized as a marine Site of Community Importance (SCI – Natura 2000 Network).

Seagrass 2000

The association Seagrass 2000 (mediterranean.seagrassonline.org) is a non-profit organization, committed to promote seagrass research, management and conservation in the Mediterranean Sea and to create a communication network across Mediterranean countries.
The Association has set a series of priority activities: (i) promote the protection and conservation of Mediterranean seagrass species; (ii) increase awareness of seagrass issues by establishing public and scientific initiatives, including support for the organization of future MSW and other local meetings; (iii) set up and maintain a web page for literature, data and information exchange; and (iv) to enhance conservation, monitoring and educational issues linked to Mediterranean seagrass ecosystems.

The Association functions as a regional but independent body of the WSA and the two together share efforts and initiatives as well as organise joint meetings (ISBW and MSW) to reach a larger audience inside and outside the field.

Stazione Zoologica Anton Dohrn

The Stazione Zoologica Anton Dohrn of Napoli, SZN (www.szn.it), was founded in 1872 by the German zoologist Anton Dohrn. The SZN carries out both basic biological and ecological interdisciplinary research and hosts a historic aquarium. The SZN comprises three large research departments: Biology and Evolution of Marine Organisms, Integrative Marine Ecology and Infrastructures for Marine Biological Research. Three ships and SCUBA diving facilities provide access to Mediterranean ecosystems both in Napoli and at the Island of Ischia.

Italian Society of Marine Biology

The Italian Society of Marine Biology, S.I.B.M. (www.sibm.it) is a non-profit organization founded in 1969; its head office is at the Municipal Aquarium of Leghorn and the Technical Secretariat and the Editorial Office is at the University of Genoa.
The S.I.B.M. aims to carry out activities for the protection and enhancement of marine environment: it promotes studies on sea life, fosters interactions among scientists and spreads theoretical and practical knowledge resulting from research.The main activities of the Society concern the organization of conferences, seminars, round tables and specialized courses; the Editorial Office deals with the publication of the S.I.B.M. newsletter and the journal Biologia Marina Mediterranea.

Regional Activity Centre for Specially Protected Areas

The Regional Activity Centre for Specially Protected Areas, RAC/SPA (www.rac-spa.org) was established by the Contracting Parties to the Barcelona Convention and its Protocols in order to assist Mediterranean countries in implementing the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean. Tunisia has been hosting the Centre since its establishment in 1985.

The MEDKEYHABITATS Project "Mapping of key marine habitats in the Mediterranean and promoting their conservation through the establishment of Specially Protected Areas of Mediterranean Importance (SPAMI)" aims at

establishing cartographic inventory of marine habitats of conservation interest to extend the SPAMI network. The project will assist the countries partners to implement the appropriate measures in relation to the priorities of the Strategic Action Programme for the conservation of Biological Diversity in the Mediterranean Region and the recommendations of the Action Plans for the conservation of marine vegetation, the conservation of the coralligenous and other calcareous bio-concretions and the conservation of dark assemblages (marine caves, canyons, etc…), in the Mediterranean Sea. The MEDKEYHABITATS project is implemented by RAC/SPA funded by MAVA Foundation.

International Union for Conservation of Nature

IUCN, International Union for Conservation of Nature (www.iucn.org/mediterranean), helps the world find pragmatic solutions to our most pressing environment and development challenges.

IUCN is the world's oldest and largest global environmental organization, with more than 1,200 government and NGO members and almost 11,000 volunteer experts in some 160 countries. IUCN's work is supported by over 1,000 staff in 45 offices and hundreds of partners in public, NGO and private sectors around the world.

The mission of IUCN Centre for Mediterranean Cooperation is to influence, encourage and assist Mediterranean societies to conserve and use sustainably the natural resources of the region and work with IUCN members and cooperate with all other agencies that share the objectives of the IUCN.

Ainsley Calladine has provided logistical support for website implementation (http://mediterranean.seagrassonline.org/sardinia/).

The Hotel Mistral 2 in Oristano (http://www.hotel-mistral.it/) has provided use of the conference room and facilities.

The Province of Oristano, Sector Promotion of the Territory, kindly provided the information and the tourist material on the territory of Oristano.

This volume was produced with the contribution of the Fondazione Banco di Sardegna.

Committees

Organising committee

Ivan Guala, IMC – International Marine Centre, Oristano, Italy
Gabriele Procaccini, Stazione Zoologica Anton Dohrn, Naples, Italy
Giuseppe Di Carlo, Mediterranean Seagrass Association – Seagrass 2000

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MSW ’15 overview

MONDAY MAY 18th

Arrival to Oristano, settle in and registration

18.00 MSW Welcome Cocktail

TUESDAY MAY 19th

9.30 – 10.30	Welcome and Opening speech
10.30 – 11.00	Coffee Break
11.00 – 13.00	Session 1
13.00 – 14.30	Lunch Break
14.30 – 15.45	Session 1 (cont.)
15.45 – 16.15	Coffee Break
16.15 – 18.00	Session 1 (cont.)

WEDNESDAY MAY 20th

8.45 – 9.30	Keynote Lecture
9.30 – 10.30	Session 2
10.30 – 11.00	Coffee Break
11.00 – 13.00	Session 2 (cont.)
13.00 – 14.30	Lunch Break
14.30 – 15.45	Session 3
15.45 – 16.15	Coffee Break
16.15 – 17.00	Session 3 (cont.)
17.00 – 18.30	Poster session I and II
20.30	MSW ’15 dinner

THURSDAY MAY 21st

8.45 – 9.30	Keynote Lecture
9.30 – 10.30	Session 3 (cont.)
10.30 – 11.00	Coffee Break
11.00 – 13.00	Session 3 (cont.)
13.00 – 14.30	Lunch Break
14.30 – 16.30	Round Table
16.30 – 16.45	Coffee Break
16.45 – 18.15	Poster session III
18.15 – 19.30	Awards and MSW Wrap up

FRIDAY MAY 22nd

9.00 – 19.00	MSW Field trip

Workshop program in more details

MONDAY 18th

Arrival to Oristano, settle in and registration

18.00 MSW Welcome Cocktail

TUESDAY 19th

9.30 – 10.30 Welcome and Opening speech

10.30 – 11.00 COFFEE BREAK

Session 1. Seagrass biology and ecology

Chair: Abdessalem Shili

11.00 **Beer S.** - "Photosynthesis in the Marine Environment" - excerpts relevant for seagrasses

11.15 **Procaccini G., Dattolo E., Lauritano C., Ruocco M., Marìn-Guirao L.** - *Posidonia oceanica* molecular adaptation to the light environment

11.30 **Dattolo E., Lauritano C., Ruocco M., Procaccini G.** - Circadian fluctuation of gene expression along a bathymetric cline in the marine angiosperm *Posidonia oceanica*

11.45 **Marín-Guirao L., Dattolo E., Ruiz J.M., Procaccini G.** - Differential tolerance and resilience of Mediterranean seagrasses to short-term heat stress

12.00 **Gonzalez E., Sanmartì N., Pérez M., Romero J.** - Negative effects of elevated temperature but not of high ammonium concentrations in the seagrass *Cymodocea nodosa*

12.15 **Celebi B., Zimmerman R.C., Hill V.J.** - Impacts of ocean acidification on photoacclimation of eelgrass *Zostera marina* L.

12.30 – 13.00 Discussion

13.00 – 14.30 LUNCH BREAK

Session 1. Seagrass biology and ecology (continue)

Chair: Lazaro Marín-Guirao

14.30	**Piro A., Iaquinta V., Serra I.A., Bernardo L., Lucini L., Silva J., Olivè Samarra I., Mendes Costa M., Santos R., Mazzucca S.** - Analysis of leaf metabolic pathways in seagrasses living in high and normal CO_2 environments: a proteomics view
14.45	**Ruocco M., Procaccini G., Musacchia F., Sanges R., Olivé Samarra I., Mendes Costa M., Barrote I., Santos R., Silva J.** - *Cymodocea nodosa* response to simulated CO_2-driven ocean acidification: A first insight from global transcriptome profiling
15.00	**Buia M.C., Garrard S.L., Lorenti M., Rotini A., Migliore L., Porzio L., De Stefano M.** - Are all "not-calcifier" marine autotrophs winners in a changing pH world?
15.15	**Bakran-Petricioli T., Liber Z., Šatović Z., Radosavljević I., Kipson S., Schultz S.T.** - Population genetic structure of *Posidonia oceanica* meadows along the eastern Adriatic coast
15.30	**Abadie A., Bonacorsi M., Gobert S., Lejeune P., Pergent G., Pergent-Martini C.** - Patch types in *Posidonia oceanica* meadows around Corsica. How can we use them in seascape ecology?
15.45 – 16.15	**COFFEE BREAK**
16.15	**Azevedo A., Dias J.M., Lillebø A.I.** - Thriving of intertidal seagrass *Zostera noltei*: influence of sediment type and intertidal height
16.30	**Alagna A., Vega Fernandez T., D'Anna G., Fici S., Magliola C., Badalamenti F.** - Adhesive root hairs facilitate *Posidonia oceanica* seedling settlement on rocky substrates
16.45	**Bacci T., Rende S.F., Rocca D., Scardi M.** - Spatial micro-distribution of shoots in *Posidonia oceanica* (L.) Delile meadows
17.00	**Tomasello A., Sciandra M., Muggeo V.M.R., Pirrotta M., Di Maida G., Calvo S.** - References growth charts: a new practical tool for comparing *Posidonia oceanica* growth patterns accounting for age and depth
17.15	**Arland M., Barak S., Winters G.** - Insights into the invasiveness of *Halophila stipulacea*
17.30 – 18.00	Discussion

WEDNESDAY 20th

Session 2. Ecosystem interactions and associated communities

Keynote Lecture

8.45 – 9.30 **Alcoverro T.** - Herbivores as ecosystem engineers in seagrass ecosystems: present and past

Chair: Giulia Ceccherelli

9.30 **Gambi M.C., Keppel E., Guglielmo R., Giangrande A., Garrard S.L. -** Polychaetes associated to *Posidonia oceanica* meadows along a gradient of ocean acidification at a CO_2 vent system (Ischia, Italy)

9.45 **Sanmartí N., Ricart Martìnez A., Romero J., Pérez M.** - The configuration of marine landscape influences herbivory on *Cymodocea nodosa* in a Mediterranean coastal bay

10.00 **Boada J., Selden R., Romero J., Alcoverro T.** - Quantitative modelling of the sea urchin *Paracentrotus lividus* population in the northwestern Mediterranean seagrass meadows of *Posidonia oceanica*

10.15 **Farina S., Oliva S., Guala I., Silva R., Piazzi L., Spanu M., Ceccherelli G.** - Seagrass fragmentation regulates sea urchins predation: can landscape pattern reflect predation process?

10.30 – 11.00 COFFEE BREAK

11.00 **Zubak I., Schultz S.T., Kruschel C., Blindow I.** - What drives fish community structure on *Posidonia oceanica* meadows? A review of available data across the Mediterranean basin

11.15 **Magni P., Como S., Kamijo A., Montani S.** - Effects of *Zostera* spp. beds on the spatial variation in macrozoobenthic assemblages of a boreal lagoon (Furen, Japan)

11.30 **Remy F., Mascart T., Dauby P., Gobert S., Lepoint G.** - Changes of macrofauna stable isotope compositions in a very inconstant seagrass detritic habitat: actual diet modification or baseline shift?

11.45 **Geneid Y.A., El Shaffai A.A**. - Invasion of an invader: a case study from the Suez Channel

12.00 **Ouisse V., Perron C., Fiandrino A., Giraud A., Rochette S.** - Potential distribution of *Zostera noltei* in Mediterranean French lagoons

12.15	**Berov D., Deyanova D., Klayn S., Karamfilov V.** - Distribution, structure and state of seagrass habitats in the SW Black Sea (Burgas Bay, Bulgaria)
12.30 – 13.00	Discussion
13.00 – 14.30	**LUNCH BREAK**

Session 3. Seagrass monitoring, management and conservation

Chair: Rym Zakhama-Sraieb

14.30	**Pace M., Borg J.A., Galdies C.** - Influence of hydrodynamic setting on *Posidonia oceanica* meadow landscape and architecture
14.45	~~**Zucchetta M., Taji M.A., Mangin A., Pastres R.** - A multiscale distribution model for *Posidonia oceanica*: hierarchical Bayesian modelling approach~~
15.00	**Ruiz J.M., Guillén J.E., Otero M.** - Atlas of seagrass habitats in Spain
15.15	**Valette-Sansevin A., Alami S., Bonacorsi M., Damier E., Pergent G., Pergent-Martini C**. - Continuous mapping of the main habitats of the Corsican littoral
15.30	**Shili A., Chaouachi B., El Bahri T., Baccar L., Maïz N.B., Boudouresque C.F.** - The ups and downs of aquatic Magnoliophyta species in the Ichkeul Lagoon (Tunisia): witnesses to climatic and hydrological episodes
15.45 – 16.15	**COFFEE BREAK**
16.15	**Pergent G., Pergent-Martini C., de Florinier M., Bonacorsi M., Clabaut P., Valette-Sansevin A**. - Assessment of carbon sequestrated within the matte of the *Posidonia oceanica* meadow at the NATURA 2000 site “Grand Herbier de la Plaine Orientale”
16.30	**Richir J., Galgani F., Benedicto J., Andral B., Lejeune P., Salivas-Decaux M., Lafabrie C., Lopez y Royo C., Pergent G., Pergent-Martini C., Gobert S.** - Seagrasses or caged mussels to bioassess the contamination rate of Mediterranean coastal waters? That is the question
16.45 – 17.00	Discussion

17.00 – 18.30 Poster presentation (session I and II)

20.30 MSW ’15 Dinner

THURSDAY 21st

Session 3. Seagrass monitoring, management and conservation (continue)

Keynote Lecture

8.45 – 9.30 **Montefalcone M., Vacchi M., Morri C., Ferrari M., Bianchi C.N.** - Seagrass ecosystems status between the sliding baseline syndrome and the need for reference conditions

Chair: Juan Manuel Ruiz

9.30 **Gobert S., Lepoint G., Silva J., Santos R., Lejeune P., du Jardin P., Delvaux B., Cornelis J.-T., Richir J**. - A consensual Diving-PAM protocol to monitor *Posidonia oceanica* photosynthesis

9.45 **Boumaza S., Sengouga A., Misraoui A., Boumaour A., Kahlal M., Larid M., Boukortt R., Semroud R.** - Assessment of the ecological status of Algiers coastal waters using two indices based on the seagrass *Posidonia oceanica*: PREI and BiPo

10.00 **Gerakaris V., Panayotidis P., Vizzini S., Nicolaidou A., Economou-Amilli A.** - Application of *Posidonia oceanica* classification systems to assess the ecological status in the Eastern Mediterranean: the case of Saronikos Gulf (Aegean Sea, Greece)

10.15 **Richir J., Salivas-Decaux M., Lafabrie C., Lopez y Royo C., Lejeune P., Pergent G., Pergent-Martini C., Gobert S.** - Trace element contamination severity of coastal waters: A first bioassessment at the scale of the whole Mediterranean

10.30 – 11.00 COFFEE BREAK

11.00 **Weatherdon L., Martin C.S., Mcowen C., Thomas H.** - Towards a global dataset of seagrass occurrences: current progress, knowledge gaps and challenges

11.15	~~**Ben Hmida A., Sghaier Y.R., Shili A., Rais C.** - Impact of benthic mini trawl on *Posidonia oceanica* meadow in the north-east of the Kerkennah Islands (Tunisia)~~
11.30	**Infantes E., Karlsson L., Crouzy C., Moksnes P-O.** - *Zostera marina* restoration methods in Sweden using seeds
11.45	**Buosi A., Facca C., Ponis E., Bonometto A., Boscolo R., Parravicini M., Centanni E., Siega A., Volpe V., Sfriso A.** - The Life "SeResto" project. A new strategic approach to meet HD & WFD objectives by SEagrass RESTOration
12.00	**Simeone S., Vacchi M., Monfefalcone M., De Falco G**. - Beach cast *Posidonia oceanica* leaf litter *vs* beach morphology and dynamics
12.15	**Acunto S., Piazzi L., Cinelli F., De Biasi A.M., Pacciardi L., Ceraudo S., Fersini G**. - Transplantation of the Mediterranean seagrass *Posidonia oceanica* through naturalistic engineering techniques: value, weakness and further improvements
12.30 – 13.00	Discussion
13.00 – 14.30	**LUNCH BREAK**
14.30 – 16.30	Round Table: Conservation status of *Posidonia oceanica* meadows, their adaptive management and policy recommendations for future protection
16.30 – 16.45	**COFFEE BREAK**
16.45 – 18.15	Poster presentation (session III)
18.15 – 19.30	Awards & MSW '15 Wrap up

FRIDAY 22nd

Field trip

Morning	Meeting point: in front of the MSW venue (Mistral 2 Hotel)
	Departure to San Giovanni di Sinis (Cabras) in the MPA Penisola del Sinis – Isola di Mal di Ventre
	Visit around San Giovanni area: the archaeological site of Tharros, the tower, San Giovanni's church, shallow seagrass meadows of "Mare Morto" and Mistras lagoon, "Mare Vivo" beach, Capo San Marco.
Lunch break	Lunch on the beach
Afternoon	Meeting point: at the bus stop, side of the San Giovanni's church. Split in two groups:
group 1	Visit to Archaeological Museum of Cabras / IMC laboratories
group 2	Visit to IMC laboratories / Archaeological Museum of Cabras

Back to the hotel is scheduled at approximately 19 pm

List of posters

Session I. Seagrass biology and ecology

1. **Bacci T., Pala D., Fasciglione P., Rende S.F., Nonnis O., Maggi C., Cossu A., Gabellini M. -** Spatio-temporal variability of *Posidonia oceanica* functional features along a depth gradient
2. **Beca P., Stengel D. -** Characterization of *Zostera marina* meadows on the Irish west coast and responses to experimental global warming scenarios – preliminary results
3. **Ben Souissi I., Shili A. -** Distribution, biomass and phenology of *Zostera noltei* meadows in the Northern lagoon of Tunis in the summer of 2014
4. **Bououarour O., El Kamcha R., Boutahar L, Tnoumi A., Bendahhou Z., Benhoussa A., Bazairi H. -** Spatial patterns of the *Zostera noltei* meadows across the Atlantic coast of Morocco: is there a latitudinal gradient?
5. **Elkalay K., Khalil K., Damsiri Z., Frangoulis C., Gobert S., Lepoint G. -** Marine primary production nutrient uptake model interaction and comparison
6. **Elkalay K., Khalil K., Frangoulis C., Gobert S., Lepoint G. -** Modelling of a plankton ecosystem interaction with the *Posidonia oceanica* in the Bay of Calvi
7. **Jahnke M., Pagès J.F., Alcoverro T., Lavery P.S., McMahon K.M., Procaccini G. -** Assessing the importance of genetic and ecological factors for the occurrence of the patchy flowering in *Posidonia oceanica*.
8. **Lauritano C., Bulleri F., Ravaglioli C., Tamburello L., Buia M.C., Procaccini G. -** Antioxidant and stress-related genes in the seagrass *Posidonia oceanica* in the vicinity of natural CO_2 vents at different nutrient conditions
9. **Radonjić I., Varda D., Mačić V. -** Contribution to the knowledge of *Posidonia oceanica* (L.) Delile in the Katič area (Montenegro) identified for designation as a Marine Protected Area
10. **Sghaier Y.R., Zakhama-Sraieb R., Ben Hmida A., Charfi-Cheikhrouha F. -** Spread of *Halophila stipulacea* (Forsskål) Ascherson (Hydrocharitaceae) along the Tunisian coast

Session II. Ecosystems interactions and associated communities

11. **Belando M.D., García Muñoz R., Ramos Segura A., Franco-Navarro I., Bernardeau-Esteller J., García Moreno P., Ruiz J.M. -** Distribution and abundance of *Cymodocea nodosa* meadows and *Pinna nobilis* populations in the Mar Menor coastal lagoon (Murcia, SE of Spain)
12. **Bernardeau-Estellar J., García Muñoz R., Marin-Guírao L., Sandoval-Gil J.M., Ruiz J.M. –** Assessment of long term interaction between the endemic

seagrass *Posidonia oceanica* and the exotic green alga *Caulerpa cylindracea* in the South Eastern coast of Spain (Murcia Region)

13. **Čižmek H., Marković K., Frleta-Valić M., Sertić M., Šarćević T., Zubak I. -** Fish assemblages of the shallow coastal waters in the MPA Mljet, Adriatic Sea
14. **Coppa S., Cucco S., De Falco G., Massaro G., Camedda A., Marra S., Simeone S., Conforti A., Tonielli R., De Lucia G.A. -** *Pinna nobilis* within a *Posidonia oceanica* meadow: evidences of how hydrodynamics define this association in the Gulf of Oristano (W Sardinia, Italy)
15. **Ferriol P., Agawin N.S.R., Sintes E., Moyà G., Arce S. -** Temporal variability of nitrogen fixation rates in the rhizosphere of *Posidonia oceanica*
16. **Gaglianone G., Frezza V., Brandano M. -** Sedimentary facies and foraminiferal assemblages from *Posidonia oceanica* meadows of western Mediterranean Sea
17. **Gambi M.C., Di Meglio E., Donnarumma L. -** Forever young… Colonization pattern of epibionts on *Posidonia oceanica* artificial leaves in relation to ocean acidification
18. **Garrard S., Gambi M.C., Scipione M.B., Patti F.P., Lorenti M., Zupo V., Paterson D.M., Buia M.C. -** Responses of macrofaunal communities of *Posidonia oceanica* to ocean acidification
19. **Güreşen A., Aktan Y., Keskin Ç., Orfanidis S.** - Macroalgal assemblages on *Posidonia oceanica* rhizomes in the North-eastern Aegean Sea (Eastern Mediterranean)
20. **Khalil K., Rabouille C., Raimonet M., Andrieux-Loyer F., Ragueneau O., Elkalay K. -** Spatial and temporal organic matter recycling in Elorn and Aulne estuarine sediments
21. **Padiglia A., Cadeddu B., Demurtas D., Bertolino M., Manconi R., Pronzato R. -** Sponges of *Posidonia oceanica* meadows (Sardinia, W-Mediterranean Sea)
22. **Penna M., Bacci T., Nicoletti L., Rende S.F., Trabucco B., Gennaro P., Marusso V., Cicero A.M. -** Epiphytic bryozoan assemblages on *Posidonia oceanica* leaves in the area affected by Costa Concordia wreck
23. ~~**Selmani J., Ruci S., Kasemi D., Beqiraj S., Kashta L. -** Preliminary data on the *Posidonia oceanica* meadows and associated macrozoobenthic community of Sazani island (Albania)~~

Session III. Seagrass monitoring, management and conservation

24. **Abadie A., Jousseaume M., Lejeune P., Gobert S. -** Mapping *Posidonia oceanica* meadows through time. A story of precision, evaluation and fragmentation

25. **Acunto S., Piazzi L., Cinelli F., De Biasi A.M., Pacciardi L., Ceraudo S., Fersini G., Bonamano S., Piermattei V., Cognetti de Martiis S., Marcelli M. -** Monitoring the effects of the construction of harbor facilities on the priority habitat (1120) *Posidonia bed (*Posidonion oceanicae*)

26. **Bacci T., Rende S.F., La Porta B., Paganelli D. -** The transplanting of *Posidonia oceanica*: Best practices for Italy

27. **Rende S.F., Penna M., Trabucco B., Bacci T., Coppa S., De Lucia G.A., Camedda A., Massaro G., Marra S., Perilli A., Cicero A.M. -** *Pinna nobilis* mapping in *Posidonia oceanica* meadows by video-photographic techniques in the Gulf of Oristano (Sardinia)

28. **Bazairi H. -** Seagrass meadows of the Moroccan Mediterranean coast: state of research and knowledge

29. **Boutahar L., Sghaier Y.R., Ouerghi A., El Kamcha R., Benhoussa A., Ostalé E., Gonzales R., Maestre M., Espinosa F., Bazairi H. -** First data on biomass and abundance of two eelgrass (*Zostera marina*) meadows south to the strait of Gibraltar (Jbel Moussa, Morocco)

30. **Cinti M.F., Frau F., Atzori F., Corrias S. -** Importance of *Posidonia oceanica* meadows for the distribution of the mollusc bivalve *Pinna nobilis* (Linnaeus, 1758) in the Capo Carbonara Marine Protected Area

31. **Frau F., Cinti M.F., Masala V., Acunto S. -** Assessment of the conservation status of *Posidonia oceanica* beds in the marine Site of Community Importance in Villasimius (Italy) within the project Life+ Res Maris

32. **Cossu A., De Luca M., Donno Y. -** Monitoring of marine phanerogams' habitats and assessment of areas exposed to anchoring in the International Marine Park of Bonifacio (Sardinia Area)

33. **Costantino G., Ungaro N., Blonda M., Mariani M., Battista D., Pastorelli A., La Mantia R., Casale V., Perrino V., Barbone E., De Gioia M., Assennato G. -** Recent monitoring data of *Posidonia oceanica* meadows distributed along the Apulian coasts (Eastern-Central Mediterranean Sea) according to the 2000/60 EC Directive

34. **Cvitković I., Despalatović M., Nikolić V., Rožić S., Lušić J., Žuljević A. -** Seagrass *Zostera noltii* as bioindicator of ecological status of Croatian transitional waters

35. **El Kamcha R., Bououarour O., Boutahar L., El Fatouani Z., El Adnani A., Bendahhou Z., Sghaier Y.R., Benhoussa A., Bazairi H. -** Assessment of the environmental health status of the Marchica lagoon (Morocco, Mediterranean) using *Cymodocea nodosa* meadows and its associated macrofauna: preliminary results

36. **Gnisci V., Bonamano S., Micheli C., Cognetti de Martiis S., Piermattei V., Marcelli M. -** Effect of dredging activities on the health status of *Posidonia oceanica* meadows along the north Latium coast (Tyrrhenian Sea)

37. **Guala I., Ivešam L., Krstinić P., Jakl Z., Šijan M., Prvan M., Sertić M., Špika M., Nikolić V., Žuljević A., Cvitković I., Di Carlo G., Rajković Ž. -** Assessment of *Posidonia oceanica* status along the north Croatian coast (Adriatic Sea)

38. **Jakl Z., Šijan M., Prvan M., Sertić M., Čavrak V., Derezanin L., Boi S., Guala I. -** Monitoring of *Posidonia oceanica* meadows in the Telašćica Nature Park (Croatia)

39. **Luzzu F., Tomasello A., Calvo S. -** Detection and mapping of "blue carbon" reservoir storage in *Posidonia oceanica* dead *matte* in front of an extensive industrial area

40. **Parodi V., Molinari A., Bernat P., Moretto P. Cassola M., Coppo S., Bertolotto R.M. -** Evaluation of the ecologica status in Liguria's water bodies applying the PREI index

41. **Panzalis P., Deiana A., Caronni S., Navone A. -** A new methodology for monitoring *Posidonia oceanica* meadows in Tavolara Punta Coda Cavallo MPA using GIS

42. **Scannavino A., Tomasello A., Calvo S. -** Large-scale *Posidonia oceanica* restoration in a Site of National Interest using an innovative bio-plastic transplant system

43. **Semroud R., Boumaza S., Khazimi O., Belbacha S., Boukortt R., Bengrine L., Guelmami A., Guerrah R., Nour I., Boughanem H., Naït-Tayeb A., Tarmoul F. -** Setting up of monitoring systems for *Posidonia oceanica* meadows in the Bou Ismaïl bay (Algeria, southern Mediterranean Sea)

44. **Varda D. -** Some historical records of *Posidonia oceanica matte* in surrounding of Bar, Montenegro

45. **Winters G., Tov R.S., Edelist D., Elmaliach T., Rilov G., Neumark N., Abramovich S. -** A GIS-based tool to protect seagrasses in the Gulf of Aqaba – mapping their distribution, ecosystem services and potential threats

46. **Zakhama-Sraieb R., Sghaier Y.R., Ben Hmida H., Charfi-Cheikhrouha F. -** Seasonal variation of metallic trace elements concentration in *Posidonia oceanica* leaves in El Kantaoui (Eastern coast of Tunisia)

Information for oral and poster presenters

Oral Presentations

Oral presentations will be scheduled in 15-minute time slots. Presentations should not exceed 12 minutes, to allow at least 3 minutes for response to questions from the audience. The time limit will be strictly enforced to keep the workshop to schedule.

Poster Presentations

Posters will be up all week for viewing with designated days and times for poster presentations.

Posters will be presented depending upon the poster session to which your presentation has been assigned. You will be expected to be available to present your poster during the designated session. Authors of posters are asked to adhere to designated set-up and tear-down instructions and times.

Oral presentations

Session 1. Seagrass Biology and Ecology (Tuesday 19th)

"Photosynthesis in the Marine Environment" - excerpts relevant for seagrasses

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Some highlights from the newly released book "Photosynthesis in the Marine Environment" (Beer, Björk and Beardall, June 2014) pertaining to seagrasses will be addressed in this presentation:

- Seagrasses use mainly bicarbonate (HCO_3^-), which is present in seawater at a ~150 times higher concentration than CO_2, as their exogenous inorganic carbon (Ci) source for photosynthesis: HCO_3^- is either dehydrated to CO_2 extracellularly, as aided by proton extrusion and/or carbonic anhydrase, or is transported into the photosynthesising cells via H^+ symport (or OH^- antiport);
- Photosynthetic responses to CO_2 as measured in the laboratory has generated the dogma that seagrasses are Ci-limited in today's oceanic Ci environment. *In situ* measurements using PAM fluorometry, however, indicate that this may not be generally true, and that seagrasses are Ci-saturated already today;
- The light requirement for seagrasses is higher than for algae (they need 5-20% of surface radiation). Opportunistic species (e.g. *Halophila stipulacea*) show plastic responses to changes in light quantity (P_{max} and I_k decreases within weeks of transferring plants from shallow to deep water);
- Seagrass photosynthesis may interact with other marine plant processes. For example, the high productivity of tropical meadows may, by increasing the seawater pH, stimulate calcification rates of algae growing within those meadows;
- The generation of high pH values by seagrasses during the day may confer on dense meadows the role of refugia from ocean acidification.

Posidonia oceanica molecular adaptation to the light environment

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Seagrass meadows are among the most productive ecosystems, with *Posidonia oceanica* being the most important species along the Mediterranean coastline. This species forms extensive mono-specific meadows that are extremely sensitive to medium-high levels of disturbance and are being threatened by fast environmental changes caused by global warming and increasing human activities. The impact can either reflect in higher turbidity along the water column and in increased UV radiation, making the light availability one of the most important factors affecting *P. oceanica* distribution. Plants developed mechanisms of adaptations at multiple levels to track and cope with fluctuations and changes in the light environment. At molecular level, the modulation of gene expression in response to environmental changes allows plants to optimize the utilization of light energy for growth and to prevent damages due to its excess. To detect the relevant molecular adaptation strategies evolved by *P. oceanica* and to assess the plasticity showed in the acclimation under different light regimes, we are employing studies both in natural and controlled conditions. Here, we describe the differences in photo acclimation of plants living along the bathymetric cline observed in field and in a common garden experiment in mesocosms, after the exposition to contrasting light regimes. Using a transcriptional approach (both RT -qPCR and RNA-seq) coupled with a physiological one, we are also testing potential divergences existing among populations and individuals related to light sensitivity. These data should supply new insights for the management of seagrasses ecosystems, for the development of most successful transplantation strategies and ultimately for conservation of biodiversity of these precious ecosystems.

Circadian fluctuation of gene expression along a bathymetric cline in the marine angiosperm *Posidonia oceanica*

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Plants developed several mechanisms to sense light and to cope with its natural diel and seasonal fluctuation. Many species use an endogenous clock to predict signals from the environment and to anticipate circadian light change. Changes in circadian clock genes allow plants to synchronize their physiology with local light and temperature conditions and to adapt to changes in light regimes occurring across environmental gradient (e.g. across latitudes). Understanding the genetic and physiological basis of plants response to the seasonal and daily variation in environmental conditions, could allow to predict the effects on plant physiology of environmental perturbations that could happen in the future, due to anthropogenic pressure and climatic changes. Most of the recently identified genes, associated with endogenous clock in plants, are themselves circadian regulated, with expression peaks phased to occur at a specific time of the day. Here we explore daily variations in the expression of clock genes in the marine angiosperm *Posidonia oceanica* along its bathymetric distribution, where plants are exposed to a natural cline of light and temperature. To do that, we measured genes expression (by RT-qPCR) of photoreceptors and components of the plant clock at two target depths (5 and 25 meter depth) and at six time points during the day. Sampling was performed in a continuous meadow located in the Bay of Calvi, Corsica (thanks to the ESF Cost Action 0906). We discuss the effects of the influence of the distinct light environments on the peak expression occurring at a specific time of the day between the two depths. Further, we discuss the potential adaptive relevance of these results on *P. oceanica* fitness and survival.

Differential tolerance and resilience of Mediterranean seagrasses to short-term heat stress

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The aim of the present study was to determine tolerance to ocean warming of the two main Mediterranean seagrass species *Posidonia oceanica* and *Cymodocea nodosa*. To this end, photophysiological and transcriptomic responses of shallow (5m) and deep (25m) plants were studied during a 5-d exposure to heat (32°C) and after a 5-d recovery to ambient temperature (24°C). Observed responses evidenced interspecific differences in heat tolerance in accordance with the biological attributes and ecological strategies of the species, but also intraspecific differences in relation to the depth origin of plants. The smaller and fast-growing species *C. nodosa*, was able to maintain unaltered leaf carbon budget along heat exposure, thanks to proportionally similar increments in photosynthesis and respiration. Along with this, the lack of alterations at the photochemical and photoprotective levels point to a high tolerance of the species to heat stress. Contrarily, the higher increment in respiration than in photosynthesis showed by the long-lived and slow-growing *P. oceanica* provoked leaf carbon imbalance after 24h of heat exposure, evidencing its higher sensitivity to heat. Interestingly, shallow plants displayed a higher acclimation capacity and after 5d of exposure their photosynthetic and respiratory rates converged to control conditions, whereas deep plants still evidenced symptoms of heat stress. The progressive photochemical efficiency reduction observed in deep plants, reinforced the idea that deeps plants are less able to tolerate heat. In any case, plants from both depths were able to recover their physiological status after a recovery period, indicating that they did not suffer lethal injury under the experimental conditions here tested. An analysis of gene expression (both RT-qPCR and RNA-seq) is ongoing, to dig into the molecular and physiological mechanisms involved in seagrass tolerance to heat stress. In conclusion, the study suggests that warming caused by human-induced climate change will likely have significant negative effects mainly on *P. oceanica* populations. The sensibility of the species to heat will finally depend on the local environmental conditions where plants grow (e.g. different depths or latitudes), a fact that must be taken in to account for the establishment of suitable management and conservation strategies.

Negative effects of elevated temperature but not of high ammonium concentrations in the seagrass *Cymodocea nodosa*

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In recent decades, humans have caused significant changes at both local (e.g. eutrophication) and global (e.g. climate change) scales that are beginning to have serious consequences on coastal ecosystems. Among them, seagrass meadows are dramatically suffering the consequences of environmental deterioration. Specifically, they seem highly sensitive to both temperature and nutrient concentration increases. Although the effects of each factor on seagrass performance are relatively well studied, their potentially synergistic effects have been scarcely explored so far. To fill this gap, we designed a factorial experiment by manipulating temperature (20, 30 and 35 ºC) and ammonium concentration (0, 30 and 300 µM) in microcosms, and we assessed the response of the model species *Cymodocea nodosa* by measuring a series of plant traits, including photosynthetic efficiency, N content, leaf growth, root biomass and demographic balance. We found that temperature clearly affected plant performance, with an optimum at 30 ºC and a clear vitality decrease (low photosynthetic efficiency, low leaf growth, reduced root biomass, negative demographic balance) at 35 ºC, suggesting a tolerance threshold between 30 and 35 ºC. In contrast, high ammonium concentrations did not affect plants, contrary to that occurs in others seagrass species. We conclude that *C. nodosa* is very tolerant to high levels of ammonium, which is in concordance with its distribution in relatively eutrophic coastal lagoons. However, its persistence can be compromised in the future by its thermal tolerance above 35 ºC, as this value is close to the predicted temperatures in the Mediterranean in the case of heat waves under a scenario of climate change.

Impacts of ocean acidification on photoacclimation of eelgrass *Zostera marina* L.

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Increasing atmospheric CO_2 concentration is predicted to have a positive impact on seagrass productivity, which is carbon limited at today's oceanic pH. The positive influence of ocean acidification on photosynthesis and survival of the temperate eelgrass *Zostera marina* has been demonstrated, but the long-term impacts on photoacclimation remain unquantified. This study compared the differences in optical properties and photochemistry of eelgrass grown in controlled outdoor aquarium tanks at different aqueous CO_2 concentrations ranging from 50 to 2000 µmol/kgSW (equivalent to pH 8 to 6) from May 2013 until September 2014. Significant differences in pigment content were observed across the CO_2 treatment gradient after two months of acclimation, overlaid on strong seasonal trends. Plants grown at high CO_2 had both lower total chlorophyll and total carotenoid concentrations per leaf area. However, the carotenoid to chlorophyll ratio increased indicating the activation of photoprotection when CO_2 is excessively available for photosynthesis. Chlorophyll-a specific absorption coefficient was also consistently higher resulting in reduced package effect with increased CO_2. These long-term acclimations of light harvesting efficiency in eelgrass due to ocean acidification mimicked the high light adaptation of plants. Further incubation experiments were conducted in laboratory to account for the dissipation of saturating light energy into different photochemical pathways. O_2 production, CO_2 uptake and fluorescence of the acclimated leaves were measured simultaneously in an oxygen electrode chamber at various pH levels. Light-saturated photosynthetic O_2 production rates increased similarly (~ 6 to 8 fold) when the pH of incubation media decreased from 8 to 6, regardless of the aquarium growth conditioning. However, the magnitude of changes in effective quantum yield, which is a commonly used estimate of photochemistry, did not match with changes in O_2 production. Non-photochemical quenching was highest at high pH indicating the dissipation of light energy as heat when photosynthesis is carbon limited. The instantaneous capability of adjusting O_2 production with respect to pH regardless of the growth conditioning highlights the dynamic regulation of the underlying cellular mechanisms. These control switches of photochemistry in chloroplasts might play a role in the long-term adjustment of pigment pools to maximize the light harvesting efficiency.

Analysis of leaf metabolic pathways in seagrasses living in high and normal CO_2 environments: a proteomics view

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CO_2 concentration in environment is one of the key factor affecting plant primary metabolisms linked to the autotrophy. The Ci uptake in seagrass tissues involves well know enzymes but effects of a high CO_2 environment on physiology are controversial, showing diverse responses and lacking physiological insights and explanations for the observed results. Studies conducted in natural CO_2 vents revealed that seagrasses have adapted to live under permanently high CO_2 levels and are able to exploit CO_2 of volcanic origin. Nevertheless, little information is still available on the effects of more diffuse and stable release of volcanic CO_2 on the chloroplast metabolic pathways. Two sites in the Mediterranean Sea, Vulcano and Panarea islands in the Aeolian archipelago, offer high CO_2 conditions in which populations of *Cymodocea nodosa* and *Posidonia oceanica* are living respectively. The team of researchers emerging from the EU-funded COST action "*Seagrass productivity: From genes to ecosystem management" Action ES0906,* gathered to the islands to perform a study on the seagrass ecophysiology, genomics and proteomics, thus integrating the required know-how and research capacities to successfully accomplish the goals.
C. nodosa leaves were sampled at sunrise and noon in a meadow exposed to CO_2 vents and in a near meadow with normal CO_2 in Vulcano; likewise *P. oceanica* were sampled in Panarea. The sampling followed the scheme optimized for integrate ecophysiological and molecular analyses.
Proteins from leaves were extracted and purified, separated by 1DE SDS-PAGE and protein bands were analyzed by mass spectrometry to find amino acid sequences. Bioinformatic software (Mascot, X!Tandem, GPM) gave identification of proteins against a) public databases (nrNCBI, PPDB, SwissProt, DrZompo), against a customized database built with sequences coming from the *P. oceanica* transcriptomic libraries and against all collected sequences of the enzyme Carbonic Anhydrase. Exposure to high CO_2 concentration gave significant decrease of overall expression of protein in tissues (6 mg/gr dry weight) in respect to those in normal CO_2 (10 mg/gr dry weight). Differential expression of Rubisco and enzymes linked to Ci uptake will be discussed.

The authors thanks the "HighGrass" project (PTDC/MAR-EST/3687/2012) funded by FTC, Portugal.

Cymodocea nodosa response to simulated CO_2-driven ocean acidification: a first insight from global transcriptome profiling

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Global climate changes are imposing multiple pressures to marine organisms. The rising atmospheric CO_2 concentration is causing substantial changes in ocean physics, chemistry and biology. At least three synergic environmental stressors have been recognized as primary driven by CO_2 emissions: ocean warming, oxygen loss and ocean acidification. The effects of CO_2-driven ocean acidification on seagrass metabolism remain largely understudied. A few studies have been conducted near submarine volcanic vents, which mimic the future ocean acidification scenarios, allowing researchers to investigate the performance of marine organisms under long-term exposure to high-CO_2 levels. Apart from these, some mesocosm-based experiments have investigated growth and physiological responses to high CO_2.

For this work, we built an outdoor mesocosm facility at the Centre of Marine Sciences' field station in Algarve, Portugal, to experimentally manipulate CO_2 levels and investigate the effects of high-CO_2/low pH on seagrass metabolism and underlying molecular mechanisms. *Cymodocea nodosa* plants were collected in Cadiz Bay at the end of January 2014 and transported to the mesocosm facility. After a one week acclimation period, *C. nodosa* were either kept under normal (400 ppm) or elevated (1200 ppm) CO_2 concentration for 12 days. Water physico-chemical parameters, irradiance, and chlorophyll-fluorescence-derived photosynthetic parameters were monitored on a daily basis. Here we present, for the first time in this species, results obtained using Illumina RNAseq technology and *de-novo* transcriptome assembly. Using *C. nodosa* RNAs extracted at the beginning and the end of the experiment, we assembled more than 70 thousands unique transcripts and were able to annotate more than 90% of them using the Annocript pipeline. Differential expression analysis revealed about 500 transcripts significantly differentially regulated between plants kept under control and high-CO_2 conditions. Pathways showing largest changes in gene expression included isoprenoid and amino-acid biosynthesis, porphyrin-containing compound metabolism, amine and polyamine biosynthesis, lipid and carbohydrate metabolism. Transcriptome sequencing also significantly increases the molecular resources available for *C. nodosa*, almost completely absent before this study.

Are all "not-calcifier" marine autotrophs winners in a changing pH world?

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Seagrasses evolved from terrestrial plants to live in the sea approximately 90 million years ago when the mean surface water of the oceans was approximately pH 7.7. The natural CO_2 vents at Castello Aragonese (Ischia Island-Gulf of Naples, Italy) constitute a future scenario in which pH values will be back to an ancient condition. In this system, where the pH levels are acidified 40-70% of the time, interesting "site x acidification" interactions exist in the composition and performance of *Posidonia oceanica* system. Shoot density increased by 58 and 82% in acidified zones against control while the height of the canopy decreased. No significant difference was found in photosynthetic performance between control and acidified conditions. Carbon content of the leaves did not differ between stations, suggesting that at the study site *P. oceanica* is not CO_2 limited. The nitrogen content was higher in the acidified sites. Although based on a limited set of environmental samples, the significant correlation found between NH_4^+ concentration in the canopy and nitrogen content of the leaves suggests that NH_4^+ may be the preferred inorganic form for leaf nitrogen uptake. The decrease in phenols is consistent with the time persistence of pH levels, the decrease in the algal coverage and the different grazing pressures. The effect of pH variations on the composition of the diatom assemblages associated to leaves has been analysed for the first time in a natural CO_2 vent system. There is no pH effect on the diversity of the diatom genera recorded on leaves of different age. The decrease in cover by encrusting epiphytes at pH 7.8 favours the dominance of diatoms on the oldest adult leaves as well as on the youngest Intermediate ones. Such a "youthful" status of mature leaves may have a role in enhancing plant production on an areal basis.
Findings in this study seem to contrast with some of the expected responses of seagrasses in an acid environment and suggest that responses of *P. oceanica* to ocean acidification are more complex than known or possibly depending on the spatio-temporal extent that the pH gradient has in a given locale.

Population genetic structure of *Posidonia oceanica* meadows along the eastern Adriatic coast

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The settlement of *Posidonia oceanica* along the eastern coast of the Adriatic is fairly recent taking into account that during the peak of the last glaciation, 18.000 years before present, the sea level was approximately 120 m lower than today. In the Adriatic Sea *P. oceanica* inhabits the narrow zone in the coastal sea from the surface to approx. 40 m of depth. In order to assess the levels of genetic diversity and to investigate inter- and intra-population genetic structure of *P. oceanica* meadows along the eastern Adriatic coast, a total of 268 samples were collected from 15 localities. After DNA extraction, 9 nuclear polymorphic microsatellites loci (Po15, Po4-3, Po5, Po5-39, Po5-49, Poc5, Poc26, Poc42, Poc45) were analysed. The results supported the expectation of high clonality and low genetic diversity levels of this species. This could be explained by predominant clonal reproduction and vegetative dispersal in contrast to sexual reproduction and seed dispersal of this species in the Adriatic. The results are discussed in respect to eastern Adriatic geography, consequent climatic and ecological differences and the dominant sea current flow.

Patch types in *Posidonia oceanica* meadows around Corsica. How can we use them in seascape ecology?

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The meadows formed by the Mediterranean seagrass *Posidonia oceanica* are subjected to various natural (e.g., water movement, light availability, sedimentation) and anthropogenic (e.g., anchoring, trawling, fish farms, explosives) phenomena that erode them and create diverse types of patches. The assemblage of the *P. oceanica* matrix and these patches creates particular seascapes. On the basis of this assessment, we aimed to investigate the importance of the patch type in structuring *P. oceanica* seascapes and to offer new prospects in the large scale studies of seagrass meadows.

Five sites encompassing large *P. oceanica* meadows ranging from 1.86 km² to 4.42 km² along the Corsican coast (France) were considered. Eleven patch types with different sizes, shapes and origins were identified using side scan sonar images (sonograms). Five were recognized as natural and five as anthropogenic. One can be of both origins. The resolution of the sonograms allowed to detect patches of various sizes ranging from 1 m² to 111 829 m². The relation between structural characteristics of patches and the whole seascape aspect was explored using seven landscape metrics relevant for the study of meadows patchiness (patch area, mean radius of gyration, area-weighted radius of gyration, coefficient of variation of the Euclidean nearest-neighbor distance, area-weighted perimeter-area ratio, landscape division index, number of patches). Only a small number of patch types appears to play the strongest role in the characterization of the *P. oceanica* seascapes.

Furthermore, the use of seascape structures seems to be suitable for the development of new tools like indices for the assessment of human impacts on *P. oceanica* meadows. In this perspective we propose a new and simple index, the Patchiness Source Index (PaSI), to estimate the origin of the patchiness (natural or anthropogenic) for a given area. A landscape approach, as well as information on patch dynamic, should be integrated in the new indices that aim to assess the state of conservation of the whole *P. oceanica* ecosystem.

Thriving of intertidal seagrass *Zostera noltei*: influence of sediment type and intertidal height

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During low tide periods, intertidal seagrass meadows may be exposed to harsh conditions, such as oversaturating light irradiances and thermal and desiccation stresses. Nowadays, in Ria de Aveiro (NW Portugal), a mesotidal coastal lagoon, current records indicate that seagrass distribution is restricted to monospecific meadows of *Zostera noltei* in intertidal areas. Since desiccation tolerance plays a major role limiting the vertical distribution of benthic organisms in intertidal, and in order to prevent its decline and contribute to establish the baseline of potential favourable conditions for its recovery, this work aimed to quantify the Relative Water Content (RWC) of this intertidal seagrass, accordingly to sediment type and intertidal heights. The experimental design included the definition of sampling points spaced by about 10 meters, along two transects with different sediment types (sandy and muddy sediments), covering distinct intertidal heights (high, medium and lower intertidal). Five seagrass shoots were collected in each sampling point following ebbing tide and just before flooding tide to assess the RWC, during a tidal cycle (~12 h in the study area), under spring tide conditions in summer. Sediment samples were also collected at each sampling point to evaluate sediment descriptors such as total organic matter and grain size. The results showed that no regular pattern was found between the RWC variation and the different intertidal heights. Nevertheless, the seagrasses that colonise the sandy sediments showed a higher RWC lost, than the muddy ones. This way, while in the sandy sediments, the plants lost about 20 to 31% of its RWC, in the muddy sediments they only lost between 8 to 16%. Thus, this work suggested that the relative importance of sediment grain size was more effective in conditioning the seagrass RWC over a tidal cycle, than the intertidal height itself (i.e. than different exposure times), highlighting the role of sediment compartment characteristics in seagrass recovery plans.

Adhesive root hairs facilitate *Posidonia oceanica* seedling settlement on rocky substrates

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Posidonia oceanica, the dominant Mediterranean seagrass, has been historically described as a species typically growing on mobile substrates whose development requires precursor communities. During more than 10 years of direct observations, we noticed that *P. oceanica* seedlings were often firmly anchored to rocky reefs, even at exposed sites. Thus, we analysed the ultrastructural features of seedling root systems to identify specific traits that may represent adaptations for early seedling anchorage on rocky bottoms.
Subapical sections of adventitious roots were obtained from 2-3 months old specimens collected in the field and were observed at SEM revealing an extensive coverage of adhesive root hairs with a maximum length of 2400 µm. Hairs were provided with an enlarged tips with a maximum width of 78.3 µm, which extended the contact area between the hair tip and the substrate.
To test whether adhesive root hairs may facilitate *P. oceanica* seedlings establishment on rocky substrates, a manipulative experiment was performed. 360 seedlings were reared for 5 months in a land-based culture facility under simulated natural hydrodynamic conditions to identify suitable substrates for early seedling anchorage. Two main substrate features were investigated: firmness (i.e., sand vs. rock) and complexity (i.e., size of interstitial spaces between rocks). Anchorage was strongly influenced by substrate firmness and occurred only on rocks through adhesion by sticky root hairs. Percentage of anchored seedlings on rocks was as high as 89%. The minimum force required to dislodge plantlets attached to rocky substrates reached 23.8 N, which would potentially allow many plantlets to overcome winter storms in the field. The ability of rocky substrates to retain seedlings increased with their complexity. The interstitial spaces between rocks provided appropriate microsites for seedling settlement, as seeds were successfully retained and a suitable substrate for anchorage was available.
Adhesive root hairs allowed fast and strong seedling anchorage to consolidated substrates when the root system was not yet developed. This mechanism could favour plant recruitment on rocky substrates with respect to mobile ones, in contrast with traditional paradigms. Such an adaptation leads to hypothesize a new microsite driven bottleneck in *P. oceanica* seedling survival linked to substrate features.

Spatial micro-distribution of shoots in *Posidonia oceanica* (L.) Delile meadows

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Posidonia oceanica meadows contain huge numbers of shoots and their dynamics are strictly related to spatial distribution patterns of those shoots. In order to investigate the structure of *P. oceanica* meadows at very small spatial scale (i.e. in the 1 cm^2-1 m^2 range), patterns in shoot distribution were analyzed. Spatial distribution of shoots was recorded by cutting all the leaves and by digitizing shoot location from images of 10 square frames (1 m^2), sampled in seemingly uniformly dense meadows at two sites in Southern Italy. Spatial point patterns have been explored testing the sensitivity and robustness through different spatial indices, based on i) nearest neighbour analysis, ii) quadrat counts analysis, iii) fractal dimension. Clark & Evans nearest neighbour distance index has been proved to be the most suitable for aim of the work and it has been selected for the further analysis. Data analysis of the 10 square frames (1 m^2) highlighted regular spatial point patterns ($R>1$; $p<0.0001$) in most cases (8 frames), while aggregated ($R<1$; $p<0.01$) and random ($R=1$) spatial point patterns were rare. In addition, mean value of nearest neighbour distance of shoots in each square frame analyzed has been shown to be always close to 2 cm (min: 1.73 cm; max: 2.21 cm). The potential implications of this type of data set were highlighted. Both nearest neighbour distance of shoots and spatial point pattern typology (aggregated, random or regular) could provide useful and integrative information for the study of *P. oceanica* macrostructure (e.g. implementation of shoot growth models, development of new descriptors). The raw data, provided by the authors as supplementary material, are currently the first and the only information available about shoot spatial micro-distribution. In this regard, although our data set cannot represent the whole spectrum of variability in *P. oceanica* meadows, it certainly shed some light on the small scale patterns of *P. oceanica* meadows and it prompts us many questions, some of which are still unanswered.

References growth charts: a new practical tool for comparing *Posidonia oceanica* growth patterns accounting for age and depth

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Over the past three decades an increasing amount of dating records dealing with *Posidonia oceanica* growth performance was incorporated into a variety of studies, from which a dualistic nature of the factors influencing seagrass growth arose. A large amount of literature focused on the role of exogenous factors in explaining rhizome growth variations, while only few studies invoked the importance of endogenous factors in driving growth. A particular attention was paid on the confounding role of shoot age, as endogenous factor, when the effect of exogenous variables on growth performance is analyzed. Shoot age confounding implies serious interpretation problems, since it is difficult to distinguish between the effects on *P. oceanica* growth due to spatio-temporal exogenous variations or simply to the unbalanced age structure of samples. A practical tool to overcome the problems linked to age confounding is to build references growth charts just used as yardstick for comparison purposes. References growth charts represent the distribution of a given biometric measurement changing with age, and typically are used in Auxology for establishing whether a generic individual at a given age lies within the 'normal' range. Their use can be extended to other disciplines, although very large data set are needed. In this study, *P. oceanica* references growth charts have been built using statistical methods, including GLMM, Segmented Regression and Nonparametric Quantile Regression, working on $4 \cdot 10^4$ lepidochronological measures collected along Sicilian coasts from 1 to 32 m depth. We detected two different trends of growth along depth, separated by a change point estimated at 15 m depth. Above and below this depth two distinct references growth charts have been built. Different curves of growth performance *vs.* age have been estimated at the 10th, 25th, 50th, 75th, 90th percentile, showing nonlinear patterns with the highest values of rhizome elongation and primary production at shoot age of about 4 years, followed by a monotonic decrease with aging. These results highlight the need to control for shoot age and recommend references growth charts as new tools to assess growth performance of *P. oceanica* samples coming from different depths and areas, accounting for their demographic structure.

Insights into the invasiveness of *Halophila stipulacea*

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Halophila stipulacea is an invasive tropical seagrass spreading from the Indian Ocean to the Mediterranean and recently to the Caribbean Sea. Salinity and temperature are major factors influencing the distribution of seagrasses. The aim of the study was to test the tolerance levels of *H. stipulacea* to different temperatures and salinities which would indirectly give us information of how far this species can spread.

Plants collected from the northern Gulf of Aqaba, Red Sea (Eilat, Israel), were exposed to different temperatures (27^{o} C [control; maximum water temperature at collection site], 30^{o} C and 33^{o} C) or salinities (40 [control; salinity at the collection site], 15, 25, 55, 60 and 65 PSU). Each treatment lasted 2-3 weeks, and was followed by a 4-week recovery phase. Plants were followed over time for changes in growth parameters and photophysiology in parallel to changes in gene expression.
In the temperature stress experiments, there was a steady increase in maximal electron transfer rates (ETRmax) at 30^{o} C. An increase in chlorophyll content was seen in treatment tanks at 30^{o} C and 33^{o} C. Leaf area decreased at 33 ^{o}C. ETRmax and leaf area seemed to be good indicators of temperature stress. Plants could acclimate at 30^{o} C which is 3^{o} C higher than Eilat's maximal water temperatures (27^{o} C), but seemed to suffer at 33^{o} C.
In the salinity stress experiment, there was a steady decrease in leaf number at 15 and 65 PSU, an increase at 40 PSU and no significant change at 25 and 60 PSU. At 60 PSU, a drastic decrease in quantum yield and leaf area was observed. Quantum yield, leaf count and leaf area were found to be good indicators of salt stress in *H. stipulacea*. Overall, plants coped less with salinities of 15 and 65 PSU. At 25 PSU, plants were similar to the control plants. At 60 PSU, plants could acclimate to the salinity with indications of stress.
Studies are ongoing at the gene expression and metabolic levels to investigate molecular mechanisms of *H. stipulacea* stress tolerance. The results showed *H. stipulacea* could grow at various temperatures and salinities and this indicates that its invasiveness could continue to be an issue in the coming future.

Session 2. Ecosystem interactions and associated communities (Wednesday 20th)

Keynote Lecture

Herbivores as ecosystem engineers in seagrass ecosystems: present and past

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While herbivores can have strong impacts on terrestrial ecosystems, much less is known of their role in marine systems. Here I present a review of the literature to determine (1) which herbivores have a (semi-)aquatic lifestyle and are important consumers of seagrasses, (2) their impact on seagrass abundance and species composition and (3) their ecosystem functions. All marine herbivores have a strong impact on submerged plant abundance and species composition. They may maintain grazing lawns. Because they sometimes target belowground parts, their activity can result in local collapse of plant beds. Semi-aquatic species, including green turtles, serve as important aquatic-terrestrial linkages, by transporting nutrients across ecosystem boundaries. Migratory species with large home ranges are potentially important dispersal vectors of plant propagules and nutrients. Clearly, aquatic herbivores have strong impacts on seagrasses and can be critical ecosystem engineers of aquatic systems, with the ability to modify direct and indirect functional pathways in ecosystems. While global populations of marine herbivores are declining, some show remarkable local recoveries with dramatic consequences for the systems they inhabit. A better understanding of these functional roles will help set priorities for the effective management of marine herbivores along with the seagrass habitats they rely on.

Polychaetes associated to *Posidonia oceanica* meadows along a gradient of ocean acidification at a CO_2 vent system (Ischia, Italy)

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Polychaetes represent one of the most diversified and abundant taxa associated with seagrass meadows. These organisms show various feeding habits at different levels of the complex seagrass food web, representing suitable bioindicators of meadow structure and environmental status and disturbances. Ocean acidification (OA) is today considered one of the most pervasive stressors for marine biota at the level of species, communities and ecosystems. Naturally acidified systems, such as CO_2 vents, represent suitable natural laboratories to study the effects of OA on benthic organisms. An analysis of polychaetes associated with *Posidonia oceanica* meadows located around shallow CO_2 vents off the island of Ischia, is presented here.

Polychaetes were collected in November 2011 with an air-lift sampler (40x40 cm; 4 replicates per station) along a gradient of OA at the Castello's vent system at six stations (3 on the south and 3 on the north side), ranging from extreme low pH conditions (mean pH 7.5 occurring only on the south side) to control, normal pH conditions (8.12); a further control station was considered, 600 m from the Castello in similar environmental conditions and ambient pH (S. Anna meadow). A total of 99 taxa and about 4200 individual polychaetes were collected. Taxa richness showed higher values in the acidified stations, especially on the south side; similarly abundances were from two- to four-fold higher under low and extreme low pH conditions, in respect to control ones, due to relatively few dominant taxa. These are represented by *Amphiglena mediterranea*, *Syllis gerlachi*, *S. prolifera, Exogone dispar*, *Sphaerosyllis pirifera*, *Polyophthalmus pictus* and *Kefersteinia cirrata*. Multivariate analysis showed a separation between control and low pH assemblages and a separation between low pH and the extreme low pH site on the south side. Control stations showed higher variability among replicates, while acidified stations, especially those under extreme low pH conditions, showed a more homogeneous assemblage structure. These results demonstrate that many species of polychaetes are robust to OA, however, the high seagrass shoot density, occurring at acidified stations, may buffer the negative effect of this stressor on the biota, and explain both the high diversity and abundance observed there.

The configuration of marine landscape influences herbivory on *Cymodocea nodosa* in a Mediterranean coastal bay

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The composition and configuration of underwater coastal landscapes, or seascapes, strongly affect their communities by shaping both, its structure (species abundance, distribution and diversity) and the ecological processes they support (species functional traits and species interactions). Among these processes, herbivory is considered one of the most influential. Herbivory affects primary production, plant performance and fitness, nutrient cycling and community diversity, among others. Herbivory is considered a key function in seagrass systems. However, how landscape composition and configuration patterns affect herbivory is poorly explored. To help filling this gap, we tested the effect of landscape configuration on herbivory pressure in *Cymodocea nodosa* meadows. We assessed herbivory in four different configurations: the center of continuous meadows, and the meadow edges adjacent to rocky reef, sandy unvegetated areas, and *Posidonia oceanica* meadows. We measured rates of herbivory indirectly, assessing the frequency of bite marks in leaves. We also determined plant traits (shoot growth, leaf length and nutrient content) under the same conditions. The frequency of bite marks were the highest in the leaves from meadow edges adjacent to *P. oceanica* meadows and in those adjacent to rocky reefs. Nitrogen content in leaves was higher near *P. oceanica* meadows but not near rocky reefs. However these differences were not reflected in shoot growth that did not vary significantly among configurations. Our results suggest that foraging behavior of fishes may be related to the spatial interplay among habitats, probably linked to feeding preferences. The higher nitrogen content found suggest the presence of some mechanism driving these differences such as plant-herbivory interactions and/or the edge effect associated with higher nutrient inputs to the system influenced by the presence of a high productive habitat, the *P. oceanica* meadow, adjacent to the habitat studied. This study highlights the importance of the landscape configuration, and more particularly adjacent habitats, in affecting the patterns of herbivory as well as the nutrient content of leaves in *C. nodosa* meadows.

Quantitative modelling of the sea urchin *Paracentrotus lividus* population in northwestern Mediterranean seagrass meadows of *Posidonia oceanica*

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A quantitative model for the sea urchin *Paracentrotus lividus* associated with shallow macrophyte ecosystems of the NW Mediterranean (macroalgal dominated rocky bottoms and *Posidonia oceanica* seagrass meadows) was developed using size-structured matrices. This sea urchin is responsible for important ecosystem shifts, especially on rocky substrata where overgrazing by the echinoderm can produce large barrens. Mathematical modelling approaches are useful tools to investigate these ecosystem shifts and help predict the major forces leading to sea urchin population growth in nature. The aim of the present work was to explore the effect of top down processes (fisheries) and environmental factors (nutrient content and temperature) on the distribution of this species, and the indirect effects in the creation of seabed barrens. The model was built using ecological processes data (i.e. predation rates and settlement in different temperature and nutrient conditions) measured in the field from previous studies of the authors in both habitats. In addition, structural characteristics of aspects that provide refuge to sea urchins were also taken into account (i.e. number of crevices in the rocks, unburied rhizome layer in seagrass meadows and canopy height of algae and *P. oceanica* leaves). Individual growth rates (Gompertz curve) were used to evaluate the transition matrix between the 3 size classes previously established; juveniles (from 1 to 3cm test diameter; TD), young adults (3 to 5cm TD) and adults (>5cm TD). Elasticity analyses were performed to analyse the relative importance of each ecological process in determining the distribution of the population. The outputs of the model show the distribution (densities of each stage) according to different fishing pressures, nutrient and temperature conditions within each habitat. The grazing effect was then calculated according to herbivory rates measured in the field. The results obtained were used to analyse the conditions under which macrophyte systems are prone to succumb to herbivory pressure and shift to less productive states.

Seagrass fragmentation regulates sea urchins predation: can landscape pattern reflect predation process?

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In Mediterranean benthic ecosystems of shallow water, local-scale predation maintains a main control on both sea urchin population and the ecological structure of macrophyte community. The use of the habitat by local predator guild in dependence on the regional context shapes prey distributions across the environment. On rocky habitat, the sea urchin *Paracentrotus lividus* is widely known as prey of apex fish predators that indirectly shape the structure of benthic assemblages whereas, in structured *Posidonia oceanica, P. lividus* can find shelter from predators. In this study, we assessed survival rates of *P. lividus* in a Marine Protected Area (Sardinia) at the aim to evaluate the role of composition and configuration of landscape on its predation risk. Sites of different landscapes were selected in function of their heterogeneity estimated according to the different proportions and spatial interspersion of four classes of habitats defined on the basis of *P. oceanica* meadows arrangement: (1) continuous, (2) fragmented and (3) patchy meadows and (4) absence of seagrass (i.e. rocky bottom with macroalgae communities). In order to capture the domain of the ecological process, a sampling grain 5x5 meters was used as minimal spatial resolution at which information is assessed. Specifically, continuous sampling units in a grid of 7x7 cells yield landscape quadrats of 35×35 m and allowed a finer description of the spatial pattern. For each cell we also estimated structural variables of seagrass habitats such as unburied mat, shoot density, canopy height, cover percent, roughness and the natural abundances of prey and predators. After placing the tagged sea urchins, we daily observed the survival rates for twenty days. Predation risk was significantly higher in continuous and fragmented seagrass habitats and predator marks were typically produced by gastropod's attacks. Landscape indices were used to correlate the amount of available habitat for gastropods movements with sea urchin's predation risk. Interestingly, estimated predation rate was negatively correlated with natural sea urchins density across grid cells. Results suggest that, although fishes are considered among the most important pressures on sea urchin population, especially in effective MPAs, bottom predators' control can be relevant in structurally complex environment such as seagrasses.

What drives fish community structure on *Posidonia oceanica* meadows? A review of available data across the Mediterranean basin

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The importance of seagrass meadows as a habitat for fish assemblages has been documented in numerous studies worldwide. *Posidonia oceanica* meadows in the Mediterranean provide valuable habitat for fish species, including food sources and refuge from predators for juveniles and adults. We assembled all published research on fish assemblages associated with *P. oceanica* meadows, and performed a meta-analysis that tests hypotheses regarding the drivers of community structure across all of these studies. We found a total of 14 published research articles containing fish species abundance data at *P. oceanica* meadows between 1982 and 2010, with an average of just under two sampled fish communities per study. The results show the presence of 112 taxa (fish richness ranging from 27 to 53 per paper, 41 on average), in *P. oceanica* meadows within a depth range from 1.0 to 40.0 meters. Studies varied in sampling method (skid trawl, visual census, beam trawl), time of day (day/night), and protection level (MPA/non-MPA). The geographical location of the sampling sites ranged from 38.15 to 44.38 N and from 0.50 W to 18.48 E. Of the physical predictor variables, the survey method had the most significant effect on the community abundance matrix, but latitude, as expected, was also a significant influence in PERMANOVA analyses. In addition, we found that total predator abundance, total resident predator abundance, and total transient predator abundance each individually had a significant effect on the remaining fish community. We conclude that the fish communities in *P. oceanica* meadows are partly organized according to the abundance of predatory species. Although we found high variability in the fish communities associated with *P. oceanica* meadows, the published data on the abundance of fish inhabiting *P. oceanica* meadows is scarce. More data using uniform sampling methods are needed throughout the Mediterranean basin for a basic understanding of the drivers of fish communities on *P. oceanica* meadows.

Effects of *Zostera* spp. beds on the spatial variation in macrozoobenthic assemblages of a boreal lagoon (Furen, Japan)

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The effects of *Zostera* spp. beds on the spatial distribution of infauna were measured in the boreal lagoon of Furen located on the northeastern coast of Hokkaido Island (Japan). Two habitat types, i.e. *Zostera* spp. beds and unvegetated sediments interspaced within *Zostera* spp. beds, were compared at different locations along a nearshore-offshore gradient. It was proposed that if the ecological processes influencing the infauna distribution are not affected by the presence of *Zostera* spp., then there should be no differences between the two habitat types in (i) the spatial pattern of distribution of the mean infauna abundances across locations, and (ii) the spatial pattern of variance in abundances calculated within different locations of the lagoon. To test these hypotheses, on August 2012, three replicate samples were collected 3-5 m apart in each of three sites 50-100 m apart, in each of the two habitat types, in each of three locations 500-1000 m apart.
The results revealed considerable differences in the distribution of infauna abundances across locations between the two habitat types. There were significant Location x Habitat effects in the mean abundance of the most dominant taxa, such as *Macoma calcarea*, *Mya arenaria oonogai*, *Assimineidae* sp., *Prionospio japonica*, *Anisogammaridae* sp., *Corophiidae* sp. and *Sohaeromatidae* sp. Also the spatial variance at the smallest scale (i.e. among replicates) for these organisms varied between habitat types, being higher in *Zostera* spp. beds than in unvegetated sediments. Collectively, the results demonstrated that *Zostera* spp. affects the spatial heterogeneity in intensity of processes influencing patterns of infauna distribution in the Furen lagoon over different spatial scales, from a few to hundreds meters. This is the first study which assesses the effects of *Zostera* spp. beds on the spatial variation of macrozoobenthic assemblages in a boreal lagoon of Japan.

Changes of macrofauna stable isotope compositions in a very inconstant seagrass detritic habitat: actual diet modification or baseline shift?

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Decayed leaves of the Neptune grass *Posidonia oceanica*, detached and then exported during storms, constitute an important compartment in terms of organic matter transfer from the seagrass bed to the other habitats, particularly coastal habitats. These exported litter accumulations (*ELA*) support a diverse (more than 130 species) and abundant (up to 4900 id.m^{-2}) vagile macrofauna (invertebrates > 500µm) assemblage which may play a key role in the degradation, enrichment and carbon transfer from *P. oceanica* dead material to coastal food chains. Indeed, preliminary results of vagile invertebrates gut content observations show that even if only a few of these species ingest a large proportion of *P. oceanica* dead leaves fragments, most of the others ingest a small but non-negligible part, suggesting a potential role of the whole community in the mechanical fragmentation of the dead leaves.

ELA are very dynamic habitats with highly variable food availability, quality, and composition. Such an inconstant habitat may result in drastic modifications of the invertebrate community but also of its trophic structure and ecology. To test this hypothesis of influence of pulsed availability, quality and composition of food sources on the vagile macrofauna diet, we took seasonal samples in Calvi Bay (Corsica, 8°45'E; 42°35'N), at two sites between August 2011 and May 2012. Stable isotopes analysis (C&N) were conducted at an individual level on dominant macrofauna species and mixing and isotopic niche model packages in R were used. Bayesian inference "SIBER" package highlighted significant seasonal and spatial differences of diet at the community, specific and even intraspecific level. Data confirm the potential transfer of seagrass material to animal tissues but in various proportions depending of the species and the season. But one question remained: are these variations reflection a true diet change, or only a spatiotemporal baseline variation of the food sources isotopic composition? "SIAR" Bayesian mixing model showed that it depends on the species and that the two responses co-occur. We emphasized the need to work at the specific level but also with an adequate temporal resolution for sampling to encompass diet and baseline variability.

Invasion of an invader: a case study from the Suez Channel

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After the year 1869, a major change in the Mediterranean marine ecosystem occurred. A pathway called Suez Canal was created allowing the passage of alien invasive species from the Red Sea to the Mediterranean, which is currently harboring over 900 introduced marine species. About 54% of these established non-native species reached through the Suez Canal. Whilst most of the studies dealing with marine invasive species focused on the Mediterranean, very few were done in the Suez Canal itself. The goal of this study is to review the distribution and current status of two invasive marine plants in the Suez Canal, specifically the Bitter Lakes area. This area was selected because of its special environmental conditions and its importance as a major fishing ground in the entire canal. Visual observations of the marine vegetation in the study sites were carried out starting year 2001. *Halophila stipulacea*, a tropical seagrass distributed along the coasts of the western Indian Ocean and the Red Sea, has migrated and is widely found around the Mediterranean. It was recorded in the Suez Canal by the Cambridge Expedition in 1924 and is known to occur in the shallow sandy-muddy bottom areas along its western coast. Since 2000, different studies along the Bitter Lakes have shown total disappearance of seagrass meadows caused by another invader that have replaced the seagrass plants and reached a percentage cover of nearly 100% in some of the studied sites. A new intruder was the green seaweed *Caulerpa prolifera*, a Mediterranean algal species that was recorded in the Gulf of Suez in 1984, among few species migrated from the Mediterranean to the Red Sea. It has rapidly colonized different locations in the Suez Canal replacing *H. stipulacea* meadows. However, in 2004, a dramatic change took place in the study area where *C. prolifera* began diminishing allowing the previously found *H. stipulacea* to inhabit the seafloor. While salinity reduction from hypersaline conditions – due to growing of coastal communities along the Bitter Lakes with more fresh water discharge – may cause the expansion of *C. prolifera* in the study area, the reasons why it declined and disappeared are still unclear.

Potential distribution of *Zostera noltei* in Mediterranean French lagoons

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Seagrasses are particularly affected by anthropogenic pressure. They have been currently used as an ecological indicator of human disturbances, especially in the context of the Water Framework Directive (WFD, 2000/60/EC). However, presence or absence of seagrass is also the result of natural environmental conditions which may lead to a misinterpretation of this species distribution as an ecological indicator. The present study aimed (1) to identify the environmental variables, both anthropogenic and natural, which control the distribution of *Zostera noltei* in French Mediterranean lagoons and (2) to predict the effect of reducing anthropogenic pressure on their potential distribution. This project was based on a correlative model approach (Generalised Additive Model) which test the association of environmental variables (selected among 29 variables in this study) with absence or presence of *Z. noltei* on 547 benthic stations in 16 lagoons of Languedoc-Roussillon (France) from 2001 to 2013. The best model selected as the one with the best quality of prediction, included both natural (bottom shear stress, depth and light) and anthropogenic (nitrogen and phosphorus concentrations in water) variables. Best model predictions were in accordance with observations in 88% of cases. This high score was possible thanks to the diversity of environmental variables, allowing to find the most important ones influencing the presence of *Z. noltei*. Hence, *Z. noltei* distribution was modelled as firstly constrained by the shear bottom stress resulting from wind actions. The anthropogenic stress (nutrients and chlorophyll *a* concentrations in water) also remained important. The effect of natural (bottom shear stress) and anthropogenic (nutrient concentration) variables on the *Z. noltei* distribution would be indirectly affected by the presence of other competitor species which cannot support high shear stress and low nutrient content in water. Using the best model for scenario of predictions show that a significant reduction of anthropogenic pressure (scenario corresponding to a "good" state in the context of WFD), may allow an increase of *Z. noltei* distribution in these lagoons. However, this positive effect seemed to be limited to deep or slightly wind-exposed lagoons.

Distribution, structure and state of seagrass habitats in the SW Black Sea (Burgas Bay, Bulgaria)

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Seagrass habitats play an important role in maintaining the biodiversity and functions of coastal marine ecosystems of the Black Sea. Eutrophication pressures in the 1970s and 1980s had a severe impact on phytobenthic communities, including deterioration, decrease in geographical and depth distribution and disappearance from certain areas. The state of Zostera *spp.* habitats in the SW Black Sea has not been studied since the 1970s. The purpose of this study is to evaluate the current distribution, structure and overall condition of seagrasses in Burgas Bay, Bulgaria.
Historical sites with seagrass meadows were surveyed by SCUBA diving between 2009 and 2014, using destructive sampling and georeferenced digital photogrammetry. Nutrient concentrations in water were measured seasonally at selected sites to study the effects of eutrophication on seagrasses. Seagrass biomass, shoot density, leaf length and leaf area index were measured. Species diversity and biomass of zoobenthic organisms were also determined. Community structure was analyzed with multivariate statistical methods based on photo and destructive samples.The geographical extent of the meadows was mapped in GIS on recent satellite images, then verified by georeferenced photo samples.
Results indicate that most of the seagrass meadows reported in the area in the late 1970s are present today. A decrease in the depth limit of the habitat was established in areas under local eutrophication pressures. A clear depth-related change in community structure was observed, where Z*ostera noltei* dominated the 1-3 m depth range, followed by a mixed Z*. noltei – Zannichellia palustris - Zostera marina* community (3-4 m) , and dominance of *Z. marina* between 4 and 7 m. Zoobenthic communities within seagrass meadows were dominated by the gastropods *Bittium reticulatum* and *Rissoa* sp., the bivalve *Loripes lucinalis*, and oligochaetes. Abundance and species richness, as well as faunal dominance were significantly higher in seagrass meadows than in adjacent unvegetated sediments.
Biometric parameters of *Z. noltei* showed significant correlations with measured eutrophication pressures (nutrient concentrations, LUSI index, sediment organic matter content). The ecological quality status of selected meadows was evaluated by using a multimeric indicator based on *Z. noltei* phenology data, which also showed clear correlation with anthropogenic pressures.

Session 3. Seagrass monitoring, management and conservation (Wednesday 20th)

Influence of hydrodynamic setting on *Posidonia oceanica* meadow landscape and architecture

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Seagrass meadow characteristics, including distribution, shape, size, and within-meadow architectural features may be influenced by various physical factors, including hydrodynamic forces. However, such influence has hardly been assessed for meadows of the ecologically important and endemic Mediterranean seagrass *Posidonia oceanica*. Estimates of wind-generated wave energy and the energy attenuated by depth were computed by a hydrodynamic model, WEMo (Wave Exposure Model), for five sites on the north-eastern coast of the Maltese Islands which each supported patchy, reticulate and continuous bed types of *Posidonia oceanica*. The distribution of *P. oceanica* meadows at these sites were mapped to a depth of circa 15 m using a combination of aerial photography and SCUBA diving surveys. Data on meadow architectural attributes were collected for each of the three *P. oceanica* bed types at each of the five study sites. Metrics for *P. oceanica* landscape features were calculated via FRAGSTATS v4 for replicate 2500 m^2 subsamples that were extracted from the seagrass habitat maps. The results indicate that landscape and architectural features of relatively deep *P. oceanica* meadows are significantly influenced by the hydrodynamic setting. *P. oceanica* meadows tend to be patchier with lower overall cover, more complex patch shapes and reduced architectural complexity along a wave exposure gradient from low to high energy. The findings from the present study highlight the importance of understanding the influence of hydrodynamic factors on the natural dynamism of seagrass meadow landscape and architecture for the conservation and management of *P. oceanica* habitat.

A multiscale distribution model for *Posidonia oceanica*: hierarchical Bayesian modelling approach

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Posidonia oceanica is a seagrass species endemic to the Mediterranean Sea, which is considered as an indicator of environment quality in coastal areas. This species forms large meadows, which are sensitive to several anthropogenic pressures, as a result the decrease in their extension is considered a priority issue for the Mediterranean Sea. The aim of this study was to develop a multiscale Species Distribution Model for *P. oceanica*, to be applied to the Mediterranean North African coast, in order to obtain an estimation of the potential distribution of this species in the region. As the study area is a data-poor zone with regard to seagrass distribution (i.e. only for some areas detailed distribution maps are available), the Species Distribution Model was calibrated using high resolution data from 5 Mediterranean sites, located in Italy and Spain and validated using available data concerning the North African coast. The probability of presence of the species in a given area was modelled using a hierarchical Bayesian approach as a function of the bathymetry and some water characteristics (i.e. water transparency; dissolved organic matter; sea surface temperature; salinity) mainly obtained from satellite-derived Earth Observations. Water transparency plays a major role, but also other variables, such as sea surface temperature, are important at larger spatial scales in explaining meadows distribution. The availability of high resolution time-series of input data allowed us to apply the validated model to the whole North African coast. The main results highlight how the downscaling procedure can help in improving predictions of distribution even for broad scale applications when high resolution environmental inputs are available.

Atlas of seagrass habitats in Spain

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Knowledge of the distribution and extent of seagrass habitats is currently the basis of management and conservation policies of the coastal zones in most European countries. This basic information is being requested through European directives for the establishment of monitoring programmes and the implementation of specific actions to preserve the marine environment. In addition, this information is crucial for the quantification of the ecological importance usually attributed to seagrass habitats due to, for instance, their involvement in biogeochemical cycles, marine biodiversity and quality of coastal waters or global carbon budgets. The seagrass atlas of Spain represents a huge collective effort performed by 79 authors across 30 Spanish institutions largely involved in the scientific research, management and conservation of seagrass habitats during the last three decades. They have contributed to the availability of the most precise and realistic seagrass maps for each region of the Spanish coast which have been integrated in a GIS to obtain the distribution and area of each seagrass species. Most of this information has independently originated at a regional level by regional governments, universities and public research organisations, which explain the elevated heterogeneity in criteria, scales, methods and objectives of the available information. On this basis, seagrass habitats in Spain occupy a total surface of 1,541,63 km^2, 89% of which is concentrated in the Mediterranean regions; the rest is present in sheltered estuarine areas of the Atlantic peninsular regions and in the open coastal waters of the Canary Islands, which represents 50% of the Atlantic meadows. Of this surface, 71.5% corresponds to *Posidonia oceanica*, 19.5% to *Cymodocea nodosa*, 3.1% to *Zostera noltei* (=*Nanozostera noltii*), 0.3% to *Zostera marina* and 1.2% to *Halophila decipiens*. Species distribution maps are presented (including *Ruppia* spp.), together with maps of the main impacts and pressures that has affected or threatened their conservation status, as well as the management tools established for their protection and conservation. Despite this considerable effort, and the fact that Spain has mapped wide shelf areas, the information available is still incomplete and with weak precision in many regions, which will require an investment of major effort in the near future to complete the whole picture and respond to demands of EU directives.

Continuous mapping of the main habitats of the Corsican littoral

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The availability of maps of the main habitats and types of bottom constitutes a priority for managers of the marine environment. For several years, a number of studies have been undertaken in order to meet this requirement, but they generally only cover limited areas and the methods used, as well as their accuracy, vary widely from one site to another.
An original approach has been initiated for this purpose along the coast of Corsica (1 000 km of coastline); it has involved (i) surveying all the available data (293 identified maps), (ii) selecting and extracting the most relevant data (date and method of acquisition, accuracy), (iii) updating the data on surface habitats (e.g. upper limits of the *Posidonia oceanica* meadows) by means of remote sensing of recent images, (iv) homogenizing all the available data (typology of benthic biocenoses in the Mediterranean), (v) assembling the full set of data within an easily incrementable Geographical Information System (GIS), and (v) proposing a scale of reliability making it possible to associate a degree of confidence to each point on the map.
This approach has resulted in the production of a map covering the whole of the Corsican coastline down to 50 to 150 m depth (depending on the sector considered), including, where there is an overlap, only the data with the highest degree of reliability. The surface area mapped is estimated at more than 299 700 ha, which makes it one of the largest recent maps ever produced for the Mediterranean. The *P. oceanica* meadow covers a surface area of about 57 500 ha, or 45.3% of the seabed between 0 and 50 m depth. In relation to the earlier data collected in the 1990s (potential surface area of seagrass beds), the extension of *P. oceanica* has remained relatively stable, and the differences observed may be explained mainly by the accuracy of this new map which possesses a greater degree of reliability.

The ups and downs of aquatic Magnoliophyta species in the Ichkeul Lagoon (Tunisia): witnesses to climatic and hydrological episodes

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The 80-km² Ichkeul Lagoon (northern Tunisia, Mediterranean Sea) exhibits a rare functioning process. In autumn and winter, it is fed by freshwater *wadis* (rivers), which create an overflow towards the Mediterranean Sea. Conversely, seawater enters the lagoon (*via* Bizerte Lagoon) in summer, after the end of the rainy season. According to the seasonal and interannual alternation of low and high salinity, *Potamogeton pectinatus* (Potamogetonaceae) and *Ruppia cirrhosa* (Ruppiaceae), respectively, thrive in the lagoon. Phytophagous wintering waterfowl populations (up to 200 000 individuals) exploit the lagoon, making it one of the most important wintering places in northern Africa, recognized as a high value Word Heritage site.

Here, we mapped the lagoon vegetation in the period extending from 1993 through 2010. However, earlier maps are available dating back to the 1960s. Up to 1993, vast meadows of *P. pectinatus* were present in most of the lagoon (western and south-eastern parts), while *R. cirrhosa* was confined to the north-eastern part, near the mouth of the channel that links Ichkeul Lagoon to Bizerte Lagoon. From 1994 onwards, *P. pectinatus* meadows abruptly collapsed. From 1996 to 1999, *R. cirrhosa* 'moved' to the western sites formerly occupied by *P. pectinatus*. From 2000, *R. cirrhosa* also collapsed, which left the lagoon almost devoid of aquatic Magnoliophyta. In 2003, after an exceptionally rainy year, both species reappeared, with *P. pectinatus* reaching its greatest extension in 2006, in the central part of the lagoon.

Our results evidence long-term dramatic changes in the presence or absence, extension and localisation of aquatic Magnoliophyta in a large Mediterranean lagoon. These changes are of paramount importance for the phytophagous waterfowl populations, which mainly feed on *P. pectinatus*. These changes are related to the climate episodes (e.g. wet vs. dry years, North Atlantic Oscillation), human use of water from tributary rivers, summer evaporation, and the resulting salinity and water level year-round cycles. Our long-term dataset constitutes a priceless tool to foresee future changes, in the context of the current climate change.

Assessment of carbon sequestrated within the *matte* of the *Posidonia oceanica* meadow at the NATURA 2000 site "Grand Herbier de la Plaine Orientale"

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The coastal vegetation, and in particular the seagrasses, plays a major role in the fixation of carbon. *Posidonia oceanica*, a species endemic to the Mediterranean, is of particular interest because of the constitution of a particular structure, the *matte*, which enables the sequestration of carbon over long periods of time.
An initial assessment of the stocks of carbon sequestrated within the *matte* has been undertaken in two sectors of the NATURA 2000 site "*Grand Herbier de la Plaine Orientale"*, Biguglia in the north and Aléria in the south.
The surface area of the meadow has been measured by means of the combined use of aerial remote sensing (shallow zone) and side-scan sonar (deep zone). The thickness of the *matte* has been assessed by means of seismic reflection using a 2.5 KHz sediment probe and a sparker. The calibration of the seismic data was performed by scuba diving at the level of *intermatte* cliffs, clearly visible on the seismic profiles.
The seagrass meadow at the NATURA 2000 site extends from 3 to 41 m depth and covers an estimated total area of 22 667 ha, or 52.4% of the bottom between 0 and 50 m depth. The speed of propagation within the *matte* (celerity), estimated by comparison of the field data (*intermatte*) and the seismic profiles, ranges from 1 600 to 1 700 $m.s^{-1}$. The thickness of the *matte*, estimated on the basis of the mean celerity, is on average 2.7 m for the Biguglia zone where it may locally exceed 8 m; it is on average 3.2 m for the Aléria zone where it may exceed 13 m, in particular off the mouth of the coastal river Tavignano. The presence of *matte* beneath the sediment should also be noted in patches of sand within the meadow and also beyond the lower limit. The quantity of carbon sequestered at this NATURA 2000 site may exceed 60 million tons. However, it would be necessary to carry out coring within the *matte*, in several representative sectors, in order to assess more accurately the amounts of carbon sequestered at this site.

Seagrasses or caged mussels to bioassess the contamination rate of Mediterranean coastal waters? That is the question

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Biological indicators have the capacity to integrate the temporal changes of contaminants, concentrations or fluxes over various time-scales, and are thus considered as interesting tools for water quality biomonitoring. Since the mid-70ies, French programs have developed water monitoring approaches based on the use of bivalve molluscs; and recently the natural background and the extent of water contamination were bioassessed at the scale of the whole western Mediterranean. But even if bivalve molluscs are viewed as reliable bioindicators, their use is not always made easy as a result of their absence in numerous coastal regions that force their transplantation (cages) during several months before their sampling and analysis. This weakness led several scientists to evaluate the bioindicator abilities of other marine organisms. Seagrasses, whose ability to bioaccumulate contaminants proportionally to environmental contamination levels has been clearly demonstrated, have thus been proposed as an appropriate alternative tool for coastal water quality assessment. Very little studies have however so far considered the combined utilization of these two groups of bioindicator organisms, *i.e.* caged bivalve molluscs and seagrasses. In the framework of the STARECAPMED project, we therefore compared and discussed the bioaccumulation of trace elements in the Neptune grass *Posidonia oceanica* and in caged Mediterranean mussels *Mytilus galloprovincialis*. The sampling was performed at the scale of the western Mediterranean. The two species told two contamination stories which, although sometimes different, showed to be complementary. *P. oceanica* and *M. galloprovincialis* bioaccumulated dissolved trace elements from the water column and thus provided information regarding trace element contamination severity integrated over several days to a few months. Seagrasses, strongly rooted in the sediments, reflected the long-term exposure to trace elements since sediments offer

a degree of time integration over several years to decades. Caged mussels, as filter feeder artificially maintained in the water column, bioaccumulated trace elements from their particulate phase, and therefore gave valuable information regarding continental-terrigenous inputs to coastal waters. In conclusion, seagrasses and mussels should neither supplant, nor substitute, but rather complement each other in order to provide the full time- and space-integrated coastal contamination story of the Mediterranean.

Session 3. Seagrass monitoring, management and conservation – continue (Thursday 21st)

Keynote Lecture

Seagrass ecosystems status between the sliding baseline syndrome and the need for reference conditions

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Marine coastal ecosystems are facing compositional and functional changes due to the increasing human footprint worldwide, and the assessment of their long-term changes becomes particularly challenging in this new "Anthropocene Epoch". Measures of change can be done by comparing the present ecosystem status to a defined baseline representing the reference condition. The "syndrome" of the sliding (or shifting) baselines, which describes the incremental lowering of ecological standards, has become a major concern when long-term changes have to be assessed because an already degraded environment status could be accepted as reference. The challenge of delineating ecosystems change in the context of sliding baselines is particularly relevant along highly anthropized coasts, as the case of the Liguria (NW Mediterranean Sea), where pristine coastal areas could not be expected anymore. The Marine Strategy Framework Directive (MSFD, 2008/56/EEC) suggests three approaches to define reference conditions: i) comparison with the status in Marine Protected Areas (MPAs); ii) use of historical information; iii) modelling. Here we report recent applications of these three approaches in Liguria to assess the status of seagrass meadow ecosystem. Ligurian MPAs are too recent and often insufficiently enforced, so that *Posidonia oceanica* meadows developing in MPAs are far from the expected good ecological status. Available historical information on seagrass distribution was sometime unreliable. Models are promising but face intellectual difficulties (e.g., choice of descriptors). Validating historical data with predictive models showed effective in delineating the trajectory of change experienced by the Ligurian seagrass meadows. Many meadows have been lost and most are showing structural degradation, which favoured the substitution by alien green algae of the genus *Caulerpa* and triggered a phase shift in the seagrass ecosystems, with the consequent loss of biodiversity, functioning and economic value of the ecosystem services provided by healthy meadows.

A consensual Diving-PAM protocol to monitor *Posidonia oceanica* photosynthesis

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The seagrass *Posidonia oceanica* is widely recognized as an effective bioindicator of the health status of Mediterranean coastal waters. Chlorophyll fluorescence measurements, in particular through the Pulse Amplitude Modulated (PAM) fluorometry method, are performed to study aquatic plant ecology and vitality and to assess their responses to diverse stressful factors. However, the current understanding of *P. oceanica* photosynthetic responses to environmental stresses does only allow scientists to use the PAM-method as a complementary tool to other more-robust monitoring techniques. Consequently, a more in-depth knowledge of the natural causes of variability of *P. oceanica* photosynthetic responses are a prerequisite to any surveys relying on that time and cost-effective method. In the framework of the STARECAPMED project, this work aimed to determine the influence of several environmental (depth, daytime, season) and plant-specific characteristics (leaf age, leaf part analyzed, epiphytic coverage) on the photosynthetic responses (Y, ETR, RLC) of *P. oceanica*. Water temperature, irradiance and several biochemical parameters of the seagrass (chl.*a,* chl.*b*, C, N, P, micronutrients such as Fe, Cu) were measured as well. The field survey was performed in a pristine meadow in the Calvi Bay, Corsica. Environmental and plant-physiological characteristics deeply influenced *P. oceanica* photosynthetic responses. As an example, ETR decreased with depth, contrary to Y that mostly increased. ETR was lower in the basal part of leaf blade, and the epiphytic coverage of leaf tips slightly increased their ETR compared to leaf tips cleaned of epiphytes. Depth and leaf part-related variations in RLC were also observed. Because of this natural variability, it appears essential to develop a consensual protocol of chlorophyll fluorescence measurements to publish reliable and comparable results between studies. We therefore notably suggest to perform measurements close to midday, when photosynthetic responses are the highest; at 10-15 m depth in order

to avoid, among others, low depth light irradiance variability; on the middle part of the 3rd-4th external leaf, well developed, highly photosynthetic, and little epiphyted. Finally, because *P. oceanica* fluorescence was correlated with N, P and chl.*b* leaf contents, the PAM-method could afterwards be used as bioindicator technique, according to the consensual protocol proposed.

Assessment of the ecological status of Algiers coastal waters using two indices based on the seagrass *Posidonia oceanica*: PREI and BiPo

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The development and application of biological indicators in order to assess the ecological status of Mediterranean coastal water has experienced a boom since the adoption of the Water Framework Directive (WFD 2000/60/EC). The objective of this study was to identify which of two indices based on the seagrass *Posidonia oceanica*, BiPo (Biotic index using *Posidonia oceanica*) and PREI (*Posidonia oceanica* Rapid Easy Index), is more suitable for assessing the ecological status of coastal waters in Algeria.
Both indices were applied to 13 sites located along the Algiers coast (Algeria, southern Mediterranean Sea). The BiPo is based on four metrics of *P. oceanica* (shoot density, leaf length, depth and lower limit type), and the PREI is based on five metrics (shoot density, leaf area, ratio between epiphytic and leaf biomasses, depth and lower limit type).
The ecological status of each site was determined according to the two indices, so the ability of each index to reflect pressure gradients (land use, urban effluents, artificial structures…) was also assessed. The PREI seems to best reflect the expected ecological status, while it is not the case for the BiPo index which loses its correlation with human pressures. As a conclusion, we suggest the use of the PREI for assessing the ecological status of Algiers coastal waters.

Application of *Posidonia oceanica* classification systems to assess the ecological status in the Eastern Mediterranean: the case of Saronikos Gulf (Aegean Sea, Greece)

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Many indices (or classification systems) based on the marine angiosperm *Posidonia oceanica* (a Biological Quality Element according to the EU Water Framework Directive) have been developed and applied in the Western Mediterranean, and only part of them have been applied and tested in the whole Mediterranean basin. In order to fill the gap, we performed an application of the different classification systems in a given geographic area of Eastern Mediterranean Sea where the WFD is implemented. Four (4) indices based on *P. oceanica* (POMI, BiPo, VALENCIA CS and PREI) were applied to 8 sites of Saronikos Gulf (Aegean Sea, Greece). In order to evaluate the results of ecological quality status determined by each index, the anthropogenic pressures were taken into consideration. Three of the indices, PREI, BiPo and VALENCIA CS, presented not only high comparability between them but also a good relationship with anthropogenic pressures. The remaining index (POMI) showed significant differences classifying the ecological quality status of the studied sites differently in 33% of the cases and presenting a weak correlation with human impacts. The differences found for the POMI index are probably due to the different type of metrics (i.e. most of them relating to the level of plant physiology) used and their different response time to environmental stress. Our study demonstrates that classification systems could provide sufficiently reliable and comparable results despite their differences in the definition of reference conditions, the number and type of metrics and the strategy of aggregation of the metrics.

Trace element contamination severity of coastal waters: A first bioassessment at the scale of the whole Mediterranean

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Human activities generate large volumes of waste that supply marine coastal environments in pathogens, organic matter, nutrients and toxicants. Among the wide range of toxicants are trace elements. Since the latter are toxic for aquatic organisms from threshold levels and as they are therefore likely to cause multiple damage to the population, the community and the ecosystem levels, their environmental occurrence has to be accurately monitored in order to guarantee appropriate environmental management of coastal zones and to preserve marine coastal ecosystems and the goods and services they provide. In the framework of the STARECAPMED project, the present study aimed to monitor, for the first time, the coastal contamination of the entire Mediterranean by As, Ag, Cd, Cu, Hg, Ni and Pb, using *Posidonia oceanica* as bioindicator species. But sustainable coastal management also requires the development of appropriate contamination classification systems intended, among other purposes, for environmental managers and policy makers. The combined utilization of several complementary monitoring tools, *i.e.* water quality scale, pollution index (TEPI and TESVI) and spatial analysis (PCA, CA, correlation analysis and GIS mapping) successfully led to the development of an operational classification system of this kind. In particular, the mapping of the trace element contamination according to a new proposed 5-level water quality scale using the quantile method precisely outlined the contamination severity along Mediterranean coasts and facilitated interregional comparisons. The reliability of the use of *P. oceanica* as bioindicator species was further again demonstrated through several global, regional and local detailed case studies. In conclusion, holistic approaches such as developed in the present study should be privileged to accurately monitor the contamination rate of coastal waters and to transfer relevant information on this composite problem to environmental managers and policy makers.

Towards a global dataset of seagrass occurrences: current progress, knowledge gaps and challenges

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For a number of years, the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) has collaborated with Dr. Frederic Short (SeagrassNet, University of New Hampshire) and other seagrass experts worldwide to compile a global georeferenced dataset of seagrass occurrences. More than 184,000 point and polygon records have been collated to date. The GIS dataset and associated metadata can be downloaded from UNEP-WCMC's Ocean Data Viewer, thereby providing ready-for-use information on the location of this critical habitat to policy-makers, conservationists, and scientists. This knowledge is necessary to inform better decisions regarding marine conservation (e.g., marine spatial planning) and to ensure the sustainable use of our ocean's resources (e.g., ecosystem service valuation). This and other similar datasets on the distribution of key marine habitats - e.g., saltmarshes, mangroves, and corals (also curated and distributed by UNEP-WCMC) - have been used in numerous global and regional studies that examine the status of sensitive marine biodiversity and related impacts. Occurrence datasets such as these are also used to inform predictive models aimed at filling spatial gaps in knowledge. Moreover, such a global dataset can support analyses that explore the contribution of seagrass and other 'blue carbon' ecosystems (e.g., saltmarsh, mangrove) to carbon sequestration, thereby aiding climate change mitigation.
As part of an interactive session, we will:

1. Present current progress towards collating a global dataset of seagrass occurrences, highlighting the achievements of such collaborative endeavours and the relevance of this dataset to global science, conservation, and policy initiatives; and
2. Facilitate a discussion with Mediterranean seagrass experts to develop recommendations for addressing the knowledge gaps and challenges (e.g. licensing issues) that have been identified.

In particular, this session will focus on improving our collective knowledge of the spatial distribution of seagrass ecosystems in data-poor regions of the Mediterranean by drawing from local and regional expertise. Given the importance of these ecosystems to sustaining marine biodiversity, regulating carbon, and supporting global fisheries, such contributions towards developing a comprehensive and accurate dataset can help to ensure that scientists, conservationists, policy-makers and other decision-makers have the appropriate information to make better-informed analyses and decisions.

Impact of benthic mini trawl on *Posidonia oceanica* meadow in the north-east of the Kerkennah Islands (Tunisia)

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Declines in the cover of *Posidonia oceanica* meadows have been recorded in many areas along the Tunisian coast and have been attributed to several natural and anthropogenic impacts. Illegal trawling has been identified as one of the most important direct causes of large scale degradation of *P. oceanica* meadows in the Gabes Golfe (Tunisia), mainly in shallow meadows. This work is a contribution to the evaluation of the impact of mini trawl, called "kiss", on the *P. oceanica* meadow in the north-east of the Kerkennah Islands (Tunisia). During a fishing campaign, 40 boats were observed on an area of 1256 ha. The biomass destroyed during the repeated passes of trawl gear over the seabed was estimated by about 55 tons. The characteristics of the meadow (recovery, density shoots, biometrics and leaf biomass) are described in an area impacted by trawling and in a reference site in order to assess the impact of this fishing practice and essentially the recovery of the meadow impacted by trawling.

Zostera marina restoration methods in Sweden using seeds

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Seagrass meadows and the ecological and economical services that they provide are declining worldwide as a result of human perturbations. In this context, restoration projects support protection efforts and conservation programs to manage this priority habitat. Restoration of seagrass meadows is a very complex process and methods and procedures have to be chosen in relation to environmental characteristics of coastal sites and species involved. Along the Swedish west coast more than 50% of the *Zostera marina* (eelgrass) meadows have vanished since the 1980's. As environmental conditions are improving, interest to restore lost habitats are growing, but methods are lacking for restoration of temperate eelgrass beds in Scandinavia where the short growing season create special challenges for restoration. For example, in contrast to most areas, eelgrass seeds in Sweden do not germinate the first year, but lay dormant during the winter and germinate the following spring, which may create large natural losses of seeds during the winter period.

In the present study we compared different approaches to eelgrass restoration in Sweden by broadcasting dormant seeds in fall and following spring. Two planting methods were compared: a) broadcasting seeds over the sediment, b) covering seeds with a thin layer of sand in different environmental conditions. Seed predation was assessed using enclosure and exclosure experiments. The costs of the restoration activities were also estimated from seed collection, seed storage and seed planting. Preliminary results indicate that large natural losses of seeds occur during the winter, but with large variation between different environments and a seedling success varying from <1% to 10%. Seedling success was 3 times higher when seeds were covered by sand. The crab *Carcinus maenas* predated 60-70% of seeds in the enclosures. The seedling success and summer shoot density was compared between the broadcasting approaches and weighted against costs to determine the best methods for restoration of eelgrass in Sweden.

The Life "SeResto" project. A new strategic approach to meet HD & WFD objectives by SEagrass RESTOration

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Pristine conditions in transitional water ecosystems are characterized by the dominance of aquatic angiosperms. Aquatic plants consolidate bottoms, prevent erosion, support benthic and fish communities as nursery and food areas, and favour the bird presence. Hence, they may contribute to the achievement of a good ecological status as required by the WFD (2000/60/EC). Their reduction or disappearance is a symptom of environmental deterioration. Over the past few decades, the aquatic angiosperms have shown a significant decrease on a worldwide scale and in some areas of Venice Lagoon (Adriatic Sea), particularly in the central and Northern basins, as a consequence of anthropogenic activities.
At present, most of the anthropogenic pressures which caused their decline or disappearance in Venice Lagoon have significantly decreased creating the ecological conditions for a new colonization. In this context, the project SeResto (LIFE12 NAT/IT/000331), funded by the European Commission, aims at restoring the angiosperm meadows in the Northern basin of Venice Lagoon where the natural seed spreading is hampered by the presence of island, tidal marsh barriers and long residence times.
The project has two main strengths: i) the widespread transplantations of small angiosperm sods and manual dispersion of rhizomes and seeds and based on a low costs and low impact on donor sites approach, ii) the participation of fishermen and hunters daily living the lagoon for recreational purposes. Thirty-five sites have been selected and in each one 9 sod-bearing plants (diameter: 30 cm), supplied by fish farms where angiosperm meadows are almost natural, have been transplanted. In addition, the plant spreading is enhanced by the dissemination of hundreds of rhizomes, 1500 at minimum in each area during the project period (52 months).
In 8 sites, out of the 35, biological and chemico-physical conditions are being monitored monthly during the first and last year and quarterly in the intermediate period. Ecological indices, based on the study of macrophytes, macrobenthic fauna and fish fauna (Biological Quality Elements), as required by the WFD 2000/60/EC, will allow to assess changes in the Ecological Status of the study sites. Preliminary results are encouraging in great part of the selected areas although some difficulties have been recorded in areas with high water turbidity and the presence of

thionitrophilous macroalgae, especially Ulvaceae, favoured by the unexpected weather conditions of summer 2014. Information on the restoration effectiveness and the relationship between the angiosperm presence/growth and the environmental conditions can be employed for interventions in other lagoon areas and can be exported in other similar transitional environments.

Beach cast *Posidonia oceanica* leaf litter *Vs* beach morphology and dynamics

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Seagrass beach-cast litter deposits are a common feature of several coastal areas around the world. Such organic litter may form large deposits on the beach, playing a significative role in the geomorphic evolution of the coast. This role is already evident under normal weather conditions, in particular on low energy beaches. Here, we discuss the interactions between *Posidonia oceanica* beach cast leaf litter ('seagrass berms' or 'banquette') and beach morphodynamics.

The formation of seagrass berms depends on the availability of litter in the upper shoreface. In sheltered areas, the presence of litter on submerged beaches is related to the occurrence of *P. oceanica* meadows close to the shore. Conversely, on exposed beaches, the seagrass litter can be transported as floating material during storms and successively deposited far from the meadow, when the storm decreases in energy.

The beach cast leaf litter is part of the exchanged material on submerged beach, non-submerged beach and dunes. A major role of the seagrass berms ('banquettes') is beach protection from erosion, which is a paradigm that is often reported in literature. However, few studies investigated this process in a quantitative way. The residence time of leaf litter deposits on beaches can be relevant for beach protection. When the residence time of seagrass berms on beach is higher than the time interval between consecutive storms, part of the storm energy can be dissipated through breakdown of the seagrass berms deposit. The beach cast litter deposits are often removed from the beachface using different techniques, mainly with heavy machinery. In this case, removal operations could influence the morphology of beaches in terms of flattening and obliteration of sedimentary features (e.g., sediment berms, cusps, embayment, beachface step). Hence, this operation can indirectly affect the swash processes causing, for instance, modifications of the run-up regime. Furthermore, the removal of seagrass berms from Mediterranean beaches can affect the sediment budget. However, the protection afforded by seagrass berms in relation to beach erosion remain not completely explained in terms of the energy used by waves and storms for the breakdown of seagrass berms ('banquette').

Transplantation of the Mediterranean seagrass *Posidonia oceanica* through naturalistic engineering techniques: value, weakness and further improvements

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Transplantation of seagrasses is considered a useful method to favour the recovery of degraded meadows. Hence, many projects have been carried out worldwide and a manifold of techniques have been applied. However, the choice of transplantation procedures remains a main problem to be assessed. In order to optimize efforts and to minimize risks of plants loss, the applied methodologies should take into account typology of hosting substratum, hydrodynamic conditions, depth and seagrass species.

Due to their fundamental ecological role in the Mediterranean coastal system, many restoration projects aiming to preserve *Posidonia oceanica* meadows took place in the last decades. Several transplantation techniques have produced different results. In fact the same transplanting methodology may originate diverse results under different environmental conditions.

Recently, naturalistic engineering techniques developed on land, have been used for transplantations of *P. oceanica*. Pilot projects concerning small surfaces were carried out between 2006 and 2010. More recently, a large-scale program (0.1 km^2) was realized in 2012 at Civitavecchia (Roma, Thyrrenian Sea). The applied technique consists basically of mattresses filled with sand coupled with a net covering able to hold steady in situ the plant rhizomes. These structures have been variously modified in time to be adapted to the different type of substratum and various hydrodynamic conditions of the transplanting sites.

Following the results of these transplantation experiences, we analyzed pros and cons of the techniques in order to improve the methodology. Firstly, these techniques may be considered suitable to large-scale projects allowing to minimize transplantation times. Secondly, the rhizomes may be successfully fixed to the structures; the majority of the transplanted shoots was not damaged showing a very good vegetative vitality with the production of new rhizomes, leaves and roots few months after transplanting. Finally, this procedure is flexible, as the basic technique can be modified and tailored to the various environmental conditions of the different receiving site. However, the results obtained in different areas are highly heterogeneous suggesting that a careful selection of the hosting site is a focal point. To this aim, a pilot study before the beginning of large-scale project seems mandatory, providing a fundamental support to guarantee successful results.

Poster presentations

Poster session I
(Wednesday 20th)

[1] Spatio-temporal variability of *Posidonia oceanica* functional features along a depth gradient

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Spatio-temporal variability of *Posidonia oceanica* functional features have been evaluated along a depth gradient. Although phenological and lepidochronological descriptors have long been studied, not many studies focused on their natural variability existing at the meadow scale. In this regard we present a large data set of phenological and lepidochronological values (e.g. number of intermediate leaves, width and length of adult leaves, leaf surface area, rhizome production, leaf formation rate), consisting of 800 shoots analyzed, gained in four years of monitoring (August 2008, 2009, 2010, 2011) in NW Sardinia coast (Italy), in a meadow in good ecological status and not subject to significant anthropogenic pressure. The environmental investigations were carried out under a technical project, named SAPEI, provided the electrical connection between Sardinian coast and Latium coast through the Tyrrhenian Sea. In this regard, these functional features have been evaluated in 20 sampling stations placed evenly in a meadow of about 700 ha, which extends from 6 down to a depth of 30 meters. Results of this work can represent a useful reference about the mean values of functional descriptors of the plant along a depth gradient relatively to a common meadow like the one that we have investigated. Moreover, particular attention was located to the variability around the mean value, given both by the potential natural temporal fluctuations and by the variability existing at small spatial scale inherent in the sampling activities.

[2] Characterization of *Zostera marina* meadows on the Irish west coast and responses to experimental global warming scenarios – preliminary results

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Climate change is an important emerging threat to marine ecosystems, with future scenarios projecting global warming, ocean acidification, and a potential rise in sea level for the 21th century. Seagrasses are most widely distributed in the northern hemisphere, playing a key role in coastal zones in terms of high productivity and supporting biodiversity. *Zostera* spp. have declined dramatically worldwide, mainly due to human pressures, including eutrophication and habitat loss. Marine angiosperms are recognized as important indicators of environmental disturbance in the Water Framework Directive but their habitats and populations are poorly characterised in Ireland. The present project focuses on the capabilities of ecologically important *Zostera* spp. and an invasive seaweed - *Sargassum muticum*, Phaeophyceae, - to adapt to climate change in Ireland. Biomass and *in situ* productivity, and monitoring of key environmental variables for the distribution of *Zostera* spp. and *S. muticum* in selected areas on the Irish coast, were investigated. The potential impacts of simulated future scenarios of climate change, and model habitat suitability for these target species were studied under controlled lab conditions.We hypothesized that *S. muticum* and *Zostera* spp. occupy the same ecological niche, and that their interactions, as well as their responses to future climatic conditions, could greatly reduce the distribution and productivity of the *Zostera* beds on the Irish coast. To investigate the physiological adaptations of *Z. marina* to light and temperature in mesocosm experiments, we compared the photosynthetic pigment concentration and lipid content. In addition, PAM chlorophyll (Chl a) fluorescence was used to study (photo) acclimation to physiological stress; morphological variation and growth rates were also measured.

[3] Distribution, biomass and phenology of *Zostera noltei* meadows in the Northern lagoon of Tunis in the summer of 2014

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Seagrass meadows of *Zostera noltei* are widely distributed over the coasts of Tunisia and represent relatively dominant populations in the Northern lagoon of Tunis. This brackish environment was the subject of a plan of restoration and development implemented in the mid 1980's to deal with problems of eutrophication.
This work is a contribution to the characterization of seagrass meadows of *Z. noltei* in the Northern lagoon of Tunis, with (i) mapping meadows along 36 equally spaced and well distributed transects, (ii) measuring the biomass with its two components, above and below-ground, in representative stations of different types of seagrass meadows, and (iii) the observation of phenological characteristics of the plant.
The results show that *Z. noltei* meadows grow over 40% of the total area of the lagoon. They spread gradually to the Southern part of the lagoon where they are able to survive and to thrive. The total biomass in the North lagoon of Tunis was about 2512 tons of DW in June of 2014. Most of this biomass comes from dense beds with cover of 50 to 90%. The phenological characteristic analysis shows that the mean density is about 1830 shoots/m², the average length and average width of the leaves are 26.6 cm (SD = 6.9) and 1.8 mm (SD = 0.2), respectively. Depending on the type of cover, the total length of rhizomes varies between 2.3 and 40.6 m/m² and the average number of leaves/shoot is between 3.1 and 4.5 (SD = 0.4). Flowering, which begins in April, continues until the end of August. The flowering rate varies between stations, ranging from 0 to 16% in June of 2014. The study should be extended to other seasons to better understand the characteristics and dynamics of *Z. noltei* meadows, which have a very important role in the restoration and the ecological balance of the Northern lagoon of Tunis.

[4] Spatial patterns of the *Zostera noltei* meadows across the Atlantic coast of Morocco: is there a latitudinal gradient?

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Seagrass meadows exist in most shallow, sheltered, soft-bottomed marine coastlines and estuaries throughout the world and rank among the most productive systems in the ocean. *Zostera noltei* Hornemann is a small seagrass largely widespread in intertidal areas of Western Europe and North-West Africa, the Mediterranean Sea and in the Black Sea.
In Morocco, intertidal *Zostera noltoi* meadows were identified at six coastal ecosystems across c.a. 2500 km of its Atlantic coast (Tahaddart estuary, Moulay Bousselham, Sidi Moussa, Oualidia, Khnifiss lagoons and Dakhla Bay). The present work aimed at assessing the spatial and latitudinal variation of *Z. noltei* meadows by measuring the density of shoots, leaf biomass, root-rhizome biomass, number of leaf /shoot and the average length and width of leafs. Samples were conducted between December 2014 and January 2015, using a hand PVC corer (12.5 of diameter). When possible, a downstream and upstream comparison is performed in each site.
Density of shoots fluctuated between 1972 and 9833 shoots m^{-2}. Leaves biomass varied between 32 and 259 gDW/m^2 and root-rhizome biomass oscillated between 21 and 314 gDW/m^2. Number of leaves per shoot fluctuated between 2.47 and 3.4 leaf per shoot, the leaf length between 4.9 and 30.8 cm and the leaf width 0.6 and 2 mm. These results showed, on the one hand, a clear spatial variation across a downstream-upstream gradient in each site and, on the other hand, a latitudinal pattern in the biomass and morphometry of the *Z. noltei* meadows across the Atlantic coast of Morocco. Significant differences were evidenced for all variables (ANOVA, $p<0.05$). The root-rhizome biomass and density of shoots are higher southward while the number of leaves per shoot, leaf biomass and the average length and width of the leaves are greater northward.
These results are compared with literature data from the distribution range of *Z. noltei*. Further analysis regarding the genetics, the associated benthic invertebrates and the sediment contamination are being performed and will increase the knowledge on such ecosystems and help in understanding their interaction with environment conditions.

[5] Marine primary production nutrient uptake model interaction and comparison

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The objective of this work is to simulate the nitrogen flow incorporation (gN m^{-2}) for four primary producer of the bay of Calvi (Corsica, France) (phytoplankton, macro-algae, *Posidonia oceanica* leaves and their epiphytic). The presented work focus on the determination of the main environmental factors which determine the incorporation of inorganic nitrogen by the various primary producers. The effect of the light intensity, the temperature and the internal and external nitrogen concentration on these incorporations was studied. The model was able to respect the relative importance of the incorporations of the various producers. The incorporations of NO_3 and NH_4 by the phytoplankton are more important than those of the benthic producers. The macro-algae incorporations present an intermediate values between, the phytoplankton one and the *P. oceanica* leaves and their epiphytic. The incorporations of NH_4 by the phytoplankton are higher than the incorporations of NO_3. Considering the importance of nutrients as limiting factor for primary production growth, a formal recalibration of the model regarding parameters related to biochemical processes is recommended. Modelled nutrient concentrations can be improved by recalibration several parameters related to biochemical processes.

[6] Modelling of a plankton ecosystem interaction with the *Posidonia oceanica* in the Bay of Calvi

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This study concerns the numerical simulation interaction of a coastal pelagic ecosystem with the seagrass benthic one. The model is applied to the plankton ecosystem of the Bay of Calvi (Corsica). The biological model considers the variables phytoplankton, zooplankton, nitrate, ammoniac, particulate organic matter and the *Posidonia oceanica*. The system is influenced by nutrient, temperature and irradiance. This model simulates the typical plankton and seagrass variation in the considered area. The model shows that seagrass productivity is mainly controlled by nutrient and light. A basic validation of the simulations is presented and indicate that results are in good agreement with in situ data. The model reproduces many temporal trends of the biological variables, both qualitatively and quantitatively and so gives insight into the main mechanisms responsible for the ecological complexity in the Bay of Calvi.

[7] Assessing the importance of genetic and ecological factors for the occurrence of patchy flowering in *Posidonia oceanica*

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The occurrence of sexual reproduction and flowering synchronization of angiosperms has been widely studied and may be induced by external or internal cues. Although factors such as predator satiation and pollination efficiency may explain why synchronization can increase individual fitness, the actual mechanisms of synchronization are obscure for the majority of plant species. In this study we aimed to assess the importance of ecological and genetic factors in shaping flowering heterogeneity of *Posidonia oceanica* at the small spatial scale (metres), where shoots and patches were subjected to similar levels of the major potential external drivers such as temperature and light availability. We assessed four external ecological factors (vegetative tissue production, leaf nitrogen and carbon content and herbivory) and three genetic factors (heterozygosity, relatedness and clonality). We sampled six patches with contrasting flower abundances at three different localities and analysed whether spatial heterogeneity in the abundance of flowers was due to (1) clone identity and clone synchronization, (2) variation in nutrient availability per individual, potentially caused by spatial heterogeneity in herbivory rates (or nutrient re-location *via* clonal integration) or (3) kin selection and sibling synchronization. Moreover, we also investigated if levels of genetic diversity, specifically observed heterozygosity as a proxy for individual fitness, differ between flowering patches and patches with low flower abundance.
We show that genetic factors play a major role: Both internal relatedness and heterozygosity have a significant positive interaction with the abundance of flowers. Moreover, vegetative tissue production and the number of clones per patch were negatively correlated with the number of flowers, although at a low level of significance. Sharing of clones within localities was almost exclusively among patches with high flower abundance and patches with low flower abundance, respectively. Our results support the kin selection hypothesis and indirectly the resource-budget hypothesis, as well as an interaction between genetic factors and environmental factors as cause for the observed heterogeneous flowering patterns. Overall, the results shed new light onto the mechanisms explaining flowering synchronization in *P. oceanica*.

[8] Antioxidant and stress-related genes in the seagrass *Posidonia oceanica* in the vicinity of natural CO_2 vents at different nutrient conditions

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Studies on stress genes are fundamental to understand how marine organisms maintain or re-estabilish a normal metabolism in face of physical or chemical disturbances. Aquatic organisms are in fact constantly exposed to environmental stimuli and natural and/or dissolved anthropogenic variables/compounds, including both physical (e.g. cold, heat, salinity and pH) and chemical (e.g. heavy metals, hydrocarbons and other pollutants) stressors. Human activities have intensified in coastal area, increasing the number of stressors that act simultaneously over natural systems (e.g. ocean acidification and eutrophication).
In this study, Reverse Transcription-Quantitative Polymerase Chain Reaction (RT-qPCR) was used to characterize metabolic processes at the cellular level in response to natural CO_2-enrichment and artificial nutrient-enrichment in proximity of a volcanic vent located in the Ischia island (Gulf of Naples, Tyrrhenian Sea). We evaluated the differential expression of selected stress genes in the seagrass Posidonia oceanica collected in a control site and in the vicinity of the CO_2 vents. In each location, plants experienced three different nutrient concentrations: natural (without adding any nutrient), low- and high- enrichments.
Results show that nutrient addition mainly induced an over-expression of genes codifying for antioxidant proteins, in sites not influenced by CO_2-enrichment. In particular, we observed an increase in the activity of glutathione synthase, responsible of the synthesis of the antioxidant protein glutathione. In addition, we also observed the up-regulation of glutathione peroxidase, catalase, ascorbate reductase and cythocrome P450. When analysing the effects of nutrients in the acidified site, trends in expression changes were similar, but expression levels were notably lower. Interestingly, the over-expression of the above mentioned genes was always higher at low nutrient exposure, while other antioxidant enzymes (i.e. glutathione S-transferase and glutathione reductase) were more activated in high nutrient conditions. The difference in response between acidified and control site and in different nutrient conditions seems to derive from the combined affect of multiple stressors, in a way that still remains obscure. Effects of different stressors should be disentangled in order to identify stress-specific genes as early indicators of stressful conditions at sea and during laboratory experiments.

[9] Contribution to the knowledge of *Posidonia oceanica* (L.) Delile in the Katič area (Montenegro) identified for desigation as a Marine Protected Area

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Posidonia oceanica meadows are protected by the Habitats Directive (1992/42/EC) and the Barcelona Convention (SPA/BD Protocol). Recently, they have been selected as a Biological Quality Element representative of aquatic Mediterranean angiosperms for monitoring the ecological status of coastal waters under the Water Framework Directive (2000/60/EC). Mediterranean countries are required to protect *P. oceanica* meadows because of their importance for coastal ecosystems, and the designation of Marine Protected Areas (MPAs) is one of the commonest tool to achieve this objective. Preliminary monitoring was carried out in the Katič area which had been identified for designation as a MPA, in order to assess the state of *P. oceanica* meadows and to highlight the occurrence of potential pressures and threats. The mainly aim was to collect data and improve the knowledge on what will eventually be the first MPA in Montenegro.

Sampling was carried out in 2012 along six transects and three depth ranges. At each sampling site, the presence of living plants was recorded and the GPS position recorded. Structural variables of the meadows (shoot density, percentage cover, substratum type) were assessed *in situ*; shoot samples were collected at the mid-point transects (15 m depth) to assess morphological variables (number of leaves, their length and width, coefficient A%, leaf area index) and measure levels of metals in the leaves (Cu, Cd, Pb, Zn, Fe, Na, K, Mg, Ca, Cr).

Our observations revealed the presence of *P. oceanica* beds in areas where they were not previously reported, thus highlighting the need of more accurate distribution maps. Results were compared with data in the literature for other *P. oceanica* meadows in other parts of the Mediterranean and the state of the meadows in Katič and the possible causes of regression are discussed, as well as the need and the significance of protection measures.

This study provides a contribution to the knowledge of the state of *P. oceanica* meadows in Katič and represents a baseline for further research and regular monitoring necessary for assessing the state of the seagrass at this locality.

[10] Spread of *Halophila stipulacea* (Forsskål) Ascherson (Hydrocharitaceae) along the Tunisian coast

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The aim of the present work was to document the appearance and spread of the tropical seagrass *Halophila stipulacea* along the Tunisian coast, based on new data from a target surveys and through compilation of previous information. The first record in Tunisian marine water was in Sfax (South-East of Tunisia) in 2003. Over the last decade, the number of new sightings increased almost exponentially, especially in the Gulf of Gabès (Chebba, Ras El Louza-Melloulech, Kerkennah Islands, Mahres and Kneiss Islands). At present, twelve years after its mention, the total surface area colonised by this seagrass along the Tunisian coast is estimated to be at least 200 km^2. The benthic habitats occupied by *H. stipulacea* are dead *Posidonia oceanica* rhizomes, infralittoral soft bottoms, *P. oceanica* and *Cymodocea nodosa* beds. Rapid spreading of this species observed in Tunisia seems to be governed by human activities (e.g. fishing, anchoring, shipping transport) and can be considered as potential threat for native benthic communities.

Poster session II
(Wednesday 20th)

[11] Distribution and abundance of *Cymodocea nodosa* meadows and *Pinna nobilis* populations in the Mar Menor coastal lagoon (Murcia, SE of Spain)

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The Mar Menor (135 km^2) is one of the most important hypersaline coastal lagoons in the Western Mediterranean Sea, its bottoms were originally colonized by monospecific meadows of the seagrass *Cymodocea nodosa*. However, since the 1970's, drastic hydrographic changes caused by various human activities has seen the expansion of a number of species common in the adjacent Mediterranean waters, of which development had been limited up to now due to high salinities and temperatures. Among these species, the seaweed *Caulerpa prolifera* and the endangered fan mussel *Pinna nobilis* are those experiencing a broader spread in the lagoon and with a great potential to interact through both bottom-up and top-down processes have, as a result of which they have become key species of the lagoon ecosystem. In fact, previous maps of benthic vegetation suggest a huge decline of seagrass populations as *C. prolifera* has expanded. Moreover, both the algae and the filter feeder could play a key role in the control of planktonic communities, which development in the lagoon waters could have been accelerated in the last decades due to the great enhancement of eutrophication and pollution processes. Therefore, quantification of benthic vegetation communities, in particular *C. nodosa* meadows, and *P. nobilis* populations are crucial for the understanding of the Mar Menor ecosystem, but overall for the management of human activities and the implementation of conservation actions given its current protection status and the urgent need to obey European Directives (Habitats, Water Framework and Marine Strategy). In this context, precise maps of the distribution and abundance of benthic vegetation and *P. nobilis* in the Mar Menor was obtained during the spring-summer of 2014 by means of direct measurements (macrophytes cover, density and biomass and *P. nobilis* density) performed on 57 sampling points and qualitative observations (presence/absence) performed on 189 additional points as well as on 155.5 km of lineal transects using a trawled videocamera. Data obtained suggests that seagrass abundance in the lagoon is much higher than that reported in some previous studies and does not support the hypothesis of a long-term decline. *P. nobilis* has spread over a surface area 56.8% of the lagoon seafloor with a mean density of 2.17 ind.·100 m^{-2} and maximum values (up to 22.5 ind.·100 m^{-}2) located in the northern part of the lagoon under the maximum influence of the Mediterranean waters.

[12] Assessment of long term interaction between the endemic seagrass *Posidonia oceanica* and the exotic green alga *Caulerpa cylindracea* in the South Eastern coast of Spain (Murcia Region)

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The green alga *Caulerpa cylindracea* has rapidly spread throughout the Western Mediterranean during the last 20 years. Compared with other native benthic communities, *Posidonia oceanica* meadows seems to be highly resistant to the colonization by the alga. Nonetheless, it is suggested that in the long-term *C. cylindracea* could affect the seagrass altering its vitality, structure and functions, however little is known about the interactive effects between these two structuring species. To this end, the abundance of both macrophytes was quantified and monitored in invaded and non-invaded localities of the South Eastern coast of Spain (Murcia Region) over an 8-year period (2007-2014). Results indicate that no differences were highlighted between invaded and no invaded meadows and all the monitored meadows showed stable or progressive trends in shoot density, meadow cover and net population growth. Regardless of the depth, in all of the invaded localities *C. cylindracea* biomass present inside the seagrass leaf canopy was about 10 to 50–fold lower than that measured just outside the leaf canopy. In summary, our results do not support the existence of a long-term competitive interaction between the invasive alga and the native seagrass, at least in the studied meadows and at the meadow level. *C. cylindracea* forms huge biomass gradients associated to the seagrass meadow edges that are stable with time, which suggests the existence of highly limiting conditions for algal growth and survival under the *P. oceanica* leaf canopy. Future research on such limiting factors could help us to understand the invasive capacity of the alga and the factors involved in the resistance of native habitats to bioinvasions.

[13] Fish assemblages of the shallow coastal waters in the MPA Mljet, Adriatic Sea

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Mljet National Park (Eastern Adriatic Sea) covers the entire north-west part of Mljet Island and it's the oldest national park in Croatia (one of the oldest in the Mediterranean basin). The fish assemblage of the MPA Mljet was censused in September 2014 as a part of fish monitoring programme. Data were collected in situ by using non-destructive diver visual census methodology over four different habitat types (infralitoral algae, *Posidonia oceanica*, unconsolidated sediment, coralligenous formations). A total of 141 transects (20x5m) were surveyed, 60 of which were in the *P. oceanica* meadow (43%), at three depth ranges (7-12 m, 17-22 m and 27-32 m). The fish assemblage comprised 43 species of which 33 were recorded in *P. oceanica* seagrass meadows (77%). A total of 22918 individuals were counted, including gregarious species (i.e. *Chromis chromis*, *Spicara smaris*). The preliminary results show that the percentage of *P. oceanica* coverage had statistically significant effect on the variability in the community structure with sampling depth explaining significant part of the residual variability. These results might suggest that differences in fish community structure are primarily related to habitat structure but more research and more data needs to be collected in order to perform the full analyses and make relevant conclusions. This study provides a baseline for future fish monitoring programme and for potential management actions in this MPA.

[14] *Pinna nobilis* within a *Posidonia oceanica* meadow: evidences of how hydrodynamics define this association in the Gulf of Oristano (W Sardinia, Italy)

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The fan mussel *Pinna nobilis* is the largest bivalve of the Mediterranean Sea, declared protected since 1992. It is a sessile suspension feeder endemic of this basin which lives mainly on soft sediments colonized by seagrass meadows. This study considers a population living within a *Posidonia oceanica* bed in the Gulf of Oristano (W Sardinia, Italy), a site included within a Marine Protected Area and in two Sites of Community Importance. Based on field surveys conducted in 2007, 2009 and 2014 differences in density, size, and shell burial level of *P. nobilis* were investigated in relation to meadow's distribution and characteristics. Moreover, the spatial differences in density and orientation of *P. nobilis* were related to hydrological features. *P. nobilis* showed a mean density of 4.06±1.13 ind./100 m^2 and a significant increase in population size was observed between 2009 and 2014. A high-resolution multibeam survey revealed that the *P. oceanica* bed was characterized by a striped structure. Toward the inner sheltered sector of Gulf, the meadow became hill-shaped. A comparison between meadow structure and *P. nobilis* distribution showed that specimens are mainly located at the edge of the channels within the striped meadow, whereas the edge effect resulted less noticeable within the hill-shaped meadow. The compactness of the seabed influences the shell stability: the burial level decreased with the increasing of fine sediments. Bottom current direction and speed are the main factors influencing shell orientation, whereas wave action is negligible. Where bottom current speed exceeded 0.07 m/s specimens resulted in line with the prevalent current direction with the ventral side exposed to incoming flow. These features suggest that feeding strategy is an important factor in determining shell orientation, possibly in addition to drag. Food availability could be the driving force in determining the patchiness distribution of *P. nobilis* population with higher values in those sites close to the mouth of the lagoons, in sedimentation area or in the meadow channels where the water flow is conveyed. These findings contribute to increase the knowledge on the *P. nobilis*-*P. oceanica* association and provide useful information for improving conservation measures.

[15] Temporal variability of nitrogen fixation rates in the rhizosphere of *Posidonia oceanica*

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Biological nitrogen fixation has been proposed as an important process to provide the large nitrogen demand of seagrass ecosystems. From previous studies, nitrogen fixation rates in tropical and temperate seagrasses varied with species, seasons and locality. To date, the nitrogen fixation rates in the rhizosphere of *Posidonia oceanica* have not been quantified. Here, we present the temporal variability of the nitrogen fixation rates in the rhizosphere of *P. oceanica* using Acetylene Reduction Assay in perfusion experiments. This research is the first to investigate the role of *P. oceanica* rhizosphere as a site of intense nitrogen fixation that can significantly contribute as a source of new N in the ecosystem.

[16] Sedimentary facies and foraminiferal assemblages from *Posidonia oceanica* meadows of western Mediterranean Sea

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Sedimentary facies and foraminiferal assemblages of sediments sampled into seven *Posidonia oceanica* meadows from Western Mediterranean Sea were investigated. Six sampling sites are localised in Italy (Maratea, Ponza Island, Santa Marinella, Giglio Island, Osalla and Alghero), and one in France (Argentella, Crovani Bay, Corsica).

The role of *P. oceanica* meadows in the sedimentary processes was investigated in different contexts: sampled meadows are set up both on soft and hard substrates, often forming *"mattes"*, in geographical areas subject to different wind and sea conditions (waves and longshore currents) and characterised by various coastal landforms and terrigenous inputs derived from costal erosional processes and/or fluvial contributions.

A sedimentological, compositional, micropaleontological and geochemical characterisation of 111 bottom sediment samples, collected by SCUBA diving between 0 and 35 mwd, was carried out and finally tested with a Q-mode cluster analysis.

Five sedimentary facies have been recognised, from terrigenous to mixed siliciclastic-carbonate and carbonate. Facies (and subfacies) are distinguishable by sorting, gravel content, abundance and maturity of clastic sediments, and weighted average of carbonate content. In all facies, foraminifers and red algae dominate the bioclastic fraction, whereas other bioclastic components are very subordinate and show a variable distribution.

In all the investigated sites, benthic foraminiferal assemblages are generally dominated by typical epiphytic species, such as *Asterigerinata mamilla*, *Lobatula lobatula*, *Peneroplis pertusus*, *Planorbulina mediterranensis*, *Rosalina* spp. and miliolids. Nevertheless, these assemblages show some differences in the different sites according to the presence or absence of terrigenous contributions and, consequently, to the water turbidity. This parameter influences symbiont-bearing foraminifer as *P. pertusus*. Moreover, the samples from Argentella (Crovany Bay) are characterised by a peculiar assemblage, in which *Miniacina miniacea* dominates with very high frequencies.

[17] Forever young... Colonization pattern of epibionts on *Posidonia oceanica* artificial leaves in relation to ocean acidification

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Ocean acidification (OA) is today considered one of the most pervasive stressors for marine biota at the level of species, communities and ecosystems. Naturally acidified systems, such as the CO_2 vents, represent suitable laboratories to study the effects of OA on benthic organisms. An analysis of the colonization pattern of epibionts settled on artificial leaves (mimics) of *Posidonia oceanica* in relation to ocean acidification at the shallow CO_2 vents off the island of Ischia, is here presented. Mimics of *Posidonia oceanica* artificial leaves (dark green flexible PVC stripes 1 cm wide x 36 cm long) were placed from September 2009 to September 2010 along a gradient of OA of the Ischia vent's system at six stations (3 on the south and 3 on the north side of the study area), located at extreme low pH (mean pH 7.5), low pH (7.8), and control, normal pH conditions (8.12). Six artificial leaves per station were collected every three months and analysed for taxa identification and estimates of coverage (algae and sessile clonal invertebrates) and number of individuals (not clonal taxa).

Patterns of colonization in control stations showed a progressive increase in time in coverage values of many organisms, mainly calcifying forms as coralline algae, which represent the dominant taxon, spirorbids and bryozoans. Colonization of artificial leaves located in low pH stations followed a similar temporal pattern as control conditions, but with lower coverage and higher patchiness of calcareous forms at 12 months of colonization. Epibionts in extreme low pH conditions were dominated by filamentous green/brown algae, with the occurrence of a few coralline algae, spirorbids and bryozoans, especially in the early months of colonization (3 and 6 months). Colonization at 9 and 12 months showed the disappearance of even these rare calcareous organisms and occurrence only of filamentous turf and fleshy algae, with a very simplified epibiont assemblage, remaining at an early, young colonization stage. These results indicate a strong selection of calcareous forms and the lack of successional stages in extreme low pH conditions, while the few calcifiers settled at short exposure time (3-6 months) do not seem to survive at longer exposure to critical values of OA.

[18] Responses of macrofaunal communities of *Posidonia oceanica* to ocean acidification

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Ocean acidification has been shown to have highly variable responses from individual macrofaunal invertebrate species, while effects at community level are largely unknown. In predicting the consequences on whole assemblages, both direct and indirect effects of acidification must be taken into consideration. This study demonstrates how invertebrate assemblages associated with the highly productive seagrass *Posidonia oceanica* respond to natural acidification that occurs at CO_2 vents off the coast of Ischia (Italy, Tyrrhenian Sea). We examined seasonal differences in macrofaunal community structure between two distinct pH zones: control (pH 8.1) and acidified (pH 7.8) and show that many groups of invertebrate taxa were robust to acidification effects. Within the interval of pH values, differences in community structure appeared to be driven by the indirect consequences of acidification, such as changes to canopy structure and food availability, rather than physiological intolerance to low pH. The number of invertebrates collected in acidified stations was almost double that of control stations during the study and many heavily calcified species appeared to thrive. These results highlight how positive indirect factors may buffer the ecological impacts of acidification, and give evidences that this highly productive habitat may provide refuge to its associated communities from future ocean acidification.

[19] Macroalgal assemblages on *Posidonia oceanica* rhizomes in the North-eastern Aegean Sea (Eastern Mediterranean)

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We investigated the macroalgal assemblages on the rhizomes of the Mediterranean seagrass *Posidonia oceanica* in Gökçeada Island (Eastern Mediterranean) in order to evaluate the spatio-temporal dynamics of the species composition and abundance.

Sampling was performed by Scuba diving twice (August 2014 and November 2014) in two meadows representing two different environmental conditions: Kaleköy Port (moderately stressed) and Çiftlik Bay (pristine to slightly stressed). In each meadow two sites were selected 100 m apart from each other both at 5 and 15 m depths. Samples (9 shoot per site) were examined under a stereomicroscope to estimate the percentage cover of macroalgae settled on the first 10 cm of the rhizomes and identified macroalgae were grouped into six morpho-functional groups (siphonous, sheet-like, filamentous, coarsely branched, jointed calcareous, crustose).

A total of 26 macroalgal species were found belong to Chlorophyceae (3), Phaeophyceae (3) and Rhodophyceae (20). The species number (per 9 shoot) ranged from 17±0 in Kaleköy Port meadow to 19±0 in Çiftlik Bay meadow and the total percentage cover ranged from 5±1 in Çiftlik Bay to 174±27 in Kaleköy Port.

Filamentous species were the prevailing group during the study due to the presence of *Lophosiphonia cristata*. Crustose (*Peyssonnelia squamaria*) and siphonous species (*Flabellia petiolata*) were also abundant, whereas percentage cover of jointed calcareous and coarsely branched species was low at both regions. Species diversity was lower in Kaleköy port, probably as a result of the intensive growth of filamentous forms.

The presence of the two invasive species *Acrothamnion preissii* and *Caulerpa cylindracea* on *Posidonia oceanica* rhizomes was also observed.

[20] Spatial and temporal organic matter recycling in Elorn and Aulne estuarine sediments

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Organic matter biogeochemical processes at the sediment-water interface were studied in two small temperate estuaries Elorn and Aulne (Brittanie, France). Experimental data and steady-state model simulations were used to investigate the coupling between carbon, oxygen and nitrogen cycles in the estuarine sediments. A numerical model of early diagenetic processes (FEMME-OMEXDIA) was used in this study including oxic and anoxic mineralization. It was developed to reproduce the sediment-depth profiles of carbon, oxygen, nitrogen and other chemical species. Organic carbon was modelled as two degradable fractions with different first-order degradation rates and nitrogen:carbon ratios. The values of several parameters (bioturbation coefficients, porosities, sedimentation rate, temperature, the bottom water concentrations of O_2, NO_3, NH_3, PO_4) were constrained using field measurements and literature values. The distributions of different profiles predicted by steady-state calculations were compared to observe data sets from the two estuaries, at different seasons February, May, July and October 2009. After adjustment of the critical parameters, the degradability rate constants for two fractions of carbon, the organic matter flux and the fraction of fast-decaying organic carbon deposited at the sediment–water interface, the model showed a good agreement between predicted and measured profiles for each data set at different seasons and localisations. The estimated parameters indicate that the degradation rates of labile material are more important in Elorn than Aulne estuary. For both Elorn and Aulne estuaries, the degradation rates of labile material are larger in winter than in spring. Another objective of this modeling effort was to include the seagrass dynamics and to better understand the dynamic relationship between seagrass beds and their sedimentary environment using a diagenetic model.

[21] Sponges of *Posidonia oceanica* meadows (Sardinia, W-Mediterranean Sea)

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Sponges are one of the main components of Mediterranean benthic ecosystems. Aim of this work was to perform a preliminary survey of conspicuous sponges in the Marine Protected Areas of Capo Caccia – Isola Piana and Asinara (North-Western Sardinia) harbouring wide *Posidonia oceanica* meadows. Specimens were photographed *in vivo,* collected along linear transects in shallow water by snorkeling and SCUBA diving, preserved (dry and/or ethanol) and identified at species level. Preliminary results show notable values of taxonomic richness when compared to previous papers confirming that *P. oceanica* meadows represent a suitable habitat for sponges. Some sponge species preferentially colonize rhizomes, others are found mainly in inter-mattes areas; only a few species are able to settle on leaves. Rhizomes offer a steady, permanent and shaded substratum, while leaves represent an unsteady substrate been smooth, short-lived, more exposed, and constantly moving. Sponges perform different key functional roles in the meadows: a) they host diversified invertebrate associations providing also refuge for sciaphilous invertebrates and nursery for juveniles at body surface and within canals of the aquiferous system; b) they are able to recycle particulate and dissolved organic matter acting as biofilters (active filter feeders); c) they contribute to improve circulation by pumping activity in the water column producing microcurrents particulary effective in lentic conditions. On the other side, to live in the meadows is very advantageous for sponges, gaining protection against storm surges. However data suggest the need of continuous monitoring to assess the impact of invasive algae such as those belonging to the genus *Caulerpa* and contribute to shed light on the problem of diversity loss by alien species.

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[22] Epiphytic bryozoan assemblages on *Posidonia oceanica* leaves in the area affected by Costa Concordia wreck

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Epiphytes cover on *Posidonia oceanica* leaves in the area affected by Costa Concordia wreck (Giglio Island, Tuscany, Italy) have been assessed as indicator of environmental quality within the integrated monitoring plan set up after the accident. Bryozoans have wide habitat distribution and are one of the most common sessile organisms in the epiphytic community of *P. oceanica,* have large species diversity and so are potential indicators of environmental factors and changes. The samples were taken from shortly after the sinking of the ship until just before the removal of the wreck in July (2012, 2013 and 2014). Three sampling sites were selected according to an asymmetric hierarchical experimental design. Three sampling areas of approximately 5 × 5 m and tens of meters apart from each other were randomly selected in each site. Five orthotropic shoots were collected haphazardly for each area. The sites were differently related to the influence of the wreck; one impact and two control sites. Percentage cover of bryozoan species was evaluated on the whole internal face of the four outer leaves per shoot. The analysis of the epiphyte community allowed us to identify most species normally present on these substrates. Besides a high natural spatio-temporal variability, feeble differences in the bryozoan assemblages were detected between the site near the wreck and the control sites, probably as a consequence of several synergic effects, firstly to the physical presence of the wreck and of the wreck removal yard.

[23] Preliminary data on the *Posidonia* meadows and associated macrozoobenthic community of Sazani island (Albania)

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The seagrass *Posidonia oceanica* meadows are scarcely studied in the Albanian coast. Data presented in this work have been collected during an assessment of benthic communities of Sazani Island, Albania, in May 2013. The *P. oceanica* meadow has a limited distribution around this island, covering a relatively small area on its eastern coast. Although this meadow seems to be under degradation, it is still a good shelter for high species number and high abundance of benthic macroinvertebrates. The highest species richness and abundance has been recorded for sponges, hydrozoans, gastropods, bivalves, polychaetes, echinoderms, bryozoans and ascidians. The sciaphilic and photophilic communities were clearly evident, associated respectively to the *P. oceanica* rhizomes and leaves. Referring to the species richness and abundance, a rapid assessment of ecological and environmental state of benthic macroinvertebrate community has been done. Other parameters used for the assessment of the state of *P. oceanica* meadow have also been recorded, and possible reasons for the degradation of the meadow have been highlighted. These assessments of the benthic macroinvertebrate community and the state of seagrass meadow are also important within the framework of monitoring, conservation and management of the only Marine Protected Area of Albania, where Sazani Island is a core area.

Poster session III
(Thursday 21st)

[24] Mapping *Posidonia oceanica* meadows through time. A story of precision, evaluation and fragmentation

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Over the last decades, the interest in mapping *Posidonia oceanica* beds has increased along with the improvement of the equipment's precision of data acquisition. In Calvi Bay (Corsica, France) the meadows cover an area of about 5 km² and are found at a depth ranging from 3 m to 37 m. The availability of three distinct datasets for 1997, 2002 and 2010 allowed to assess changes in the patchiness of the meadows in the bay and to investigate evolution of maps precision through a surface analysis via GIS software. Thus, three maps were elaborated combining aerial photographs and side scan sonar images. The meadows percentage of cover through time was assessed using four bathymetric sections: 0-10 m, 11-20 m, 21-30 m and 31-40 m.

Differences in the patchiness of *P. oceanica* meadows between 1997 and 2010 appear to be moderate (less than 3 %) in the sections 0-10 m and 11-20 m and then greatly increase with depth: 24 % at 21-30 m and 39 % at 31-40 m. This amazing regression seems hardly natural and unlikely given the slight quantity of human activities that can cause damages on the *P. oceanica* meadows of the Calvi Bay. These results are likely to be mainly due to the improvement of precision and resolution of the aerial photographs (5 m in 1997, 0.8 m in 2002 and 0.5 m in 2010) and sonar images (5 m in 1997, 3 m in 2002 and 0.5 m in 2010). An issue of habitat determination (human vs instrumental) linked with the method adopted for mapping can also cause differences in the percentage of cover.

Given the different accuracy among the three maps, the real regression and fragmentation of *P. oceanica* meadows could be hardly assessed. However, in several areas where the human activities are important, a clear regression or even a disappearance of the meadows has been observed. It is obvious that the last maps are more accurate than the previous ones and, thus, the former can be used for management purpose as well as for study on the patchiness; however, they still keep uncertainty no matter which method is used to create them.

[25] Monitoring the effects of the construction of harbor facilities on the priority habitat (1120) *Posidonia beds (*Posidonion oceanicae*)

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Posidonia oceanica is a Mediterranean endemic species that forms dense and extensive meadows, providing important ecological functions and services and supporting a rich and diversified community, including species of economic interest. Over the last few decades many *P. oceanica* meadows have disappeared or have been altered as a result of increased coastal urbanisation and industrialisation. Current main threats to the habitat are related to: water and organic enrichment (eutrophication); disruption of the sedimentation/erosion balance along the coast; human induced coastline modifications; degradation by boat trawling and anchoring; increased salinity near water desalination facilities; elevated water temperature near electric power plants and proliferation of invasive algal species.

Conservation management is mainly focused on protective measures, therefore, over the last 25 years the EU has built a vast network of protected areas known as Natura 2000. The legal basis for Natura 2000 originates from the Birds and the Habitats Directive. In fact, *P. oceanica* meadows are identified as a priority habitat type for conservation under the Habitats Directive (92/43/CEE) and are also included within the boundaries of marine Sites of Community Importance (SCI).
However, isolated protected areas cannot thrive. Hence, an appropriate conservation approach requires agriculture, energy and transport policies to be sustainable. Under this context the Port Authority of Civitavecchia promoted a monitoring program in which two SCI located nearby the Civitavecchia Port were selected. Additionally, the construction of the new harbor facilities imposes mitigation measures and monitoring activities to guarantee the continued presence of the priority habitat “Posidonia beds (*Posidonion oceanicae*)”. In the present work, we describe the seagrass monitoring plan and the most relevant results obtained, as well as presenting maps showing the distribution of meadows of the seagrass and an overview of the habitat’s status along the coast of Civitavecchia, including a distribution analysis of primary production data.

[26] The transplanting of *Posidonia oceanica*: best practices for Italy

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In the last decades *Posidonia oceanica* meadows have been undergoing a strong regression phenomena mainly due to a rapid and high overexploitation of coastal zones (e.g. urban encroachment, waste dumping), that significantly altered their natural characteristics and heavily affected marine ecosystems in the whole Mediterranean Basin. As *P. oceanica* meadows are protected as priority habitat according to Habitat Directive 1992/43/CEE and Barcelona Convention (16.02.1976) and play an important role within some European Directives (WFD: 2000/60/EC and MSFD: 2008/56/EC) each type of human pressure that potentially produces impacts or changes on *Posidonia* meadows must be deeply assessed to avoid any negative effect on this sensitive habitat.
In this contest, transplant of *P. oceanica* plants may be necessary to reduce meadow regression or to facilitate meadow recovery, reducing the sacrifice of those portions of meadows destroyed by infrastructural works. The Italian National Institute for Environmental Protection and Research (ISPRA) published the technical volume “Preservation and management of coastal-marine ecosystems. The transplanting of *Posidonia oceanica*" (in Italian language) with the aim to provide a useful tool for operators and Public Administrators involved in this topic at different levels. The manual contains all available information on transplant of *P. oceanica* derived from a critical analysis of the existing technical and scientific literature and reports, the legal aspects of this issue as well as the main biological characteristics of *P. oceanica* meadows. Moreover specific details about different transplant techniques and their results over time in some case studies in Italy, have been presented in specific datasheets enclosed to the manual.

[27] *Pinna nobilis* mapping in *Posidonia oceanica* meadows by video-photographic techniques in the Gulf of Oristano (Sardinia)

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Pinna nobilis spatial distribution have been analysed through a video – photographic approach in a *Posidonia oceanica* meadow in the Gulf of Oristano (Sardinia, Italy). In situ visual censuses and 2D/3D georeferenced vertical photographic survey were conducted by SCUBA diving in different sampling transects. The experimental procedure was carried out in the summer of 2014. Data have been processed using the photogrammetric techniques, in particular, in this work we presented the procedure and processing techniques to realize the orthographic planar micro cartography mosaics from photo sequences. Results of this study, although preliminary, showed the time-cost effectiveness of this approach to map the distribution of benthic species.

[28] Seagrass meadows of the Moroccan Mediterranean coast: state of research and knowledge

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Seagrass meadows are highly productive and key ecosystems that undergo widespread loss due to 'climate-related' and human-mediated stressors as well as natural causes. Therefore, basic information about the distribution, abundance, and characteristics of seagrass meadows and their environment is critical for managers to assess and monitor the resource.
Such knowledge is lacking for Morocco and there is a clear need to acquire baseline data for monitoring and protecting these important habitats. The present review summarizes the state of the research and the knowledge on seagrass meadows of the Mediterranean coast of Morocco. Data were assessed using a compilation of historical data compared to recent confirmed observation and field surveys conducted within the framework of several projects (MedMPAnet, Medkeyhabitats, etc.).
Of the five species of strictly marine Magnoliophyta found in the Mediterranean Sea, four are also currently identified along the Mediterranean coast of Morocco (*Posidonia oceanica*, *Cymodocea nodosa*, *Zostera marina* and *Zostera noltii*); the Lessepsian immigrant *Halophila stipulacea* has not been recorded yet.
Apart from *C. nodosa*, that showed large distribution, the other species remain spatially localized and their distribution has been declining since they have disappeared from many localities. This is the case of *Zostera marina* that has probably disappeared from many localities (e.g. Cap des Trois Fourches, Marchica lagoon). However, some previous citations, such as the presence *of Posidonia oceanica* in the Marchica lagoon, seem to be a systematic confusion. Moreover, quantitative data on the characteristics of seagrass meadows are very scarce and many areas of knowledge gaps were identified along the Mediterranean coast of Morocco. An in-depth study of seagrass meadows occurring in Morocco is strongly required and would substantially increase the knowledge on such habitats and help in their conservation.

[29] First data on biomass and abundance of two eelgrass (*Zostera marina*) meadows south to the strait of Gibraltar (Jbel Moussa, Morocco)

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Eelgrass (*Zostera marina*) ecosystems are key components of the marine environment. In the Mediterranean, the species is present in coastal lagoons and the innermost part of very sheltered bays. The worldwide declines in its distribution and abundance requires, however, sound monitoring and management. Abundance and distribution are two of the most commonly measured parameters to design eelgrass restoration programs and to establish measures to protect it (e.g., establishing boundaries of a marine protected area).

In Morocco, there are knowledge gaps related to eelgrass ecosystems. The species has disappeared from many localities where it was historically cited. Recently, in the framework of the MedKeyHabitats project aiming at characterizing the key habitats in the marine part of the site 'Jbel Moussa' (southern the Strait of Gibraltar), two Eelgrass meadows were identified at the Benyounech and Al-Marsa bays. Their deep limits were at about -15 m depth. The present study intented to provide, for the first time in Morocco, baseline quantitative data for monitoring and protecting these important habitats. Samples were performed by scuba diving in September 2014 at -7 depth (Benyounech bay) and at -10 and -15m (Al-Marsa bay). The eelgrass beds were characterized by considering shoot density, biometry and biomass of leaves, rhizomes and roots.

First results revealed significant differences in biomass and morphometric parameters, between the two meadows, except for the number of leaves per shoot. The *Z. marina* meadow located at Benyounech bay seems to be well developped, showing the highest values of shoot density (745 ± 113 shoots.m^{-2}), total biomass (7.72 ± 1.38 g DW.m^{-2}) and aboveground biomass (3.08 ± 1.12 g DW.m^{-2}). However, at Al-Marsa Bay, a clear bathymetric pattern was observed, with the highest values of average length (175.8 ± 18.83 mm) and width of leaves (3.77 ± 0.21 mm) at -10 m depth. The results obtained at Jbel Moussa were compared to other regions in the Mediterranean to assess the quality and the health of the eelgrass meadows of Jbel Moussa.

[30] Importance of *Posidonia oceanica* meadows for the distribution of the mollusc bivalve *Pinna nobilis* (Linnaeus, 1758) in the Capo Carbonara Marine Protected Area

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Posidonia oceanica meadows are the preferential habitat for many plant and animal protected species including the mollusc bivalve *Pinna nobilis*. In this study, we evaluated the importance of the substrate structure for the distribution of the species in the Capo Carbonara Marine Protected Area (Sardinia south east), recognized as a Specially Protected Area of Mediterranean Importance (SPAMI) and Site of Community Importance (SCI ITB040020) of the Natura 2000 network.
For this purpose four study areas, exposed to the North West and South East of the Capo Carbonara promontory, and characterized by *P. oceanica* meadows on both sandy and rocky substrates, with a total area of about 20ha, have been investigated. Visual sightings were conducted *in situ* during the months of September and October 2013 and 2014 along linear transects at depths between 1 and 10 meters to collect information on the presence, morphometric characteristics and depth of specimens of *P. nobilis*. A total of 139 individuals were recorded, 126 of them were alive (90.6%) and 13 were dead (9.4%); 51 individuals (36.7%) were found on rocky substrates, with a mortality rate of 6.2%, an average height of 34.4±9.9 cm, and at an average depth of 4.7±1.7 m. On sandy substrates, the number of individuals was 88 (63.3%), with a mortality rate of 11.4% and average height of 39.65±14.3 cm, at the average depth of 5.8±2.1 m.
This study confirmed the importance of *P. oceanica* for the distribution of *P. nobilis*, which showed a preference for *P. oceanica* meadows set on sandy substrate.
Therefore, for the management purposes of the Capo Carbonara Marine Protected Area, it would be interesting to understand which are the main causes of the greater mortality registered on sandy substrate and if these causes are related to environmental (i.e. sedimentation, predation) and/or anthropogenic (i.e. anchoring, collecting) factors.

[31] Assessment of the conservation status of *Posidonia oceanica* beds in the marine Site of Community Importance in Villasimius (Italy) within the project Life+ Res Maris

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The marine Site of Community Importance (SCI ITB040020) of the network Natura 2000 is included almost entirely within the perimeter of the Marine Protected Area Capo Carbonara (South East Sardinia, Italy) which is characterized by a high biodiversity, with 720 species and 30 marine habitats reported. Hence, it is recognised as a Specially Protected Area of Mediterranean Importance (SPAMI). During the summer the area is affected by anthropogenic impacts due to recreational activities (e.g. fishing, pleasure boating, swimming, diving) that represents potential threats to some species and protected habitats.
This study is part of the project LIFE+ RES MARIS (LIFE13 NAT / IT / 000 433), addressed to the restoration and conservation of marine and terrestrial ecosystems included in the SCI under Habitats Directive 92/43/EEC. The aims is to evaluate the conservation status of the priority habitat 1120 "*Posidonia* beds" through mapping and characterization of the *Posidonia oceanica* meadow in areas that previous studies have identified as the most affected by anchoring, for a total surface of about 400 ha. Acoustic methods (Side Scan Sonar), direct visual surveys in SCUBA diving and underwater towed camera are applied.
Assessments of coverage of *P. oceanica*, types of substrate, continuity of the meadow, presence of dead *matte*, *Cymodocea nodosa* and benthic alien species (e.g. *Caulerpa cylindracea*) are reported. Results are crucial for enhancing the knowledge of the current distribution and status of the priority habitat 1120 and is basic for planning further concrete conservation and monitoring measures.

[32] Monitoring of marine phanerogams' habitats and assessment of areas exposed to anchoring in the International Marine Park of Bonifacio (Sardinia Area)

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The International Marine Park of the Strait of Bonifacio and the National Park of La Maddalena have started a series of investigations in the marine areas under their jurisdiction. Through the European project, GECT (European Group of Territorial Cooperation), studies have been carried out to define the type, the structural characteristics of the *Posidonia oceanica sea*grass and to evaluate the impact of dropping anchors. The study, carried out by a team of experts from the institutions named above, used shared methodologies in relation to the same type of challenges and problems. The study areas on the Sardinian side were Passo Asinelli pass, Porto della Madonna harbor and Cala Portese cove. For each site two stations were identified, a monitoring and a control one. The type of meadow, its morphological and structural characteristics (matte, rocks, degree of fragmentation, height of matte, etc.) and the possible presence of marks/signs caused by the dropping of anchors were assessed in selected areas. The compactness of the matte, estimated using a penetrometer, the percentage of seabed covered by the plant and density were assessed by direct method by divers. The results for the leaf density show the meadows are in regression; however, there are better conditions in Porto Madonna where the monitoring and control stations show density near to normal values. Particularly low values were measured in Passo Asinelli where, despite prohibitions, the high pressure of tourism generates stress to the plant formation. The leaf standing crop, the leaf area index and measures penetrometric lead to conclusions almost similar indicating best ecological conditions in Porto Madonna, confirming previous results. The indicators used show an ecological status of lesser quality for the sites of both Passo Asinelli and, more visible, of Cala Portese. Porto Madonna, on the other hand, shows values equal to the minimum requirements for a meadow surface.

[33] Recent monitoring data of *Posidonia oceanica* meadows distributed along the Apulian coasts (Eastern-Central Mediterranean Sea) according to the 2000/60 EC Directive

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According to the Water Framework Directive (WFD), a specific monitoring of *Posidonia oceanica* meadows was carried out along the Apulian coasts by the Regional Agency for the Environmental Prevention and Protection (ARPA Puglia). A total of 17 sites, 11 in the Southern Adriatic Sea and 6 in the Northern Ionian Sea were investigated during two consecutive monitoring cycles (2009-2011 and 2012-2014). Sampling procedures as well as laboratory analyses (phenology and lepidochronology) were carried out according to a common methodological protocol shared at Italian national level (D.M. 260/2010) for the final ecological classification (*sensu* WFD) using the PREI index. In each meadow, two sampling stations were investigated by scuba divers at the fixed depth of 15 m and in correspondence of the lower bathymetric distribution limit. For each station, 9 shoots counting (40x40 cm square) and 3 covering estimates (around 5 m of radius) were carried out. In addition, 18 orthotropic shoots and a sediment sample were collected as well as some other bio-ecological data (meadow continuity, dead *matte* presence, bottom type, invasive algae presence, flowering, disturbance sources, lower limit type and depth). The results showed that 29% of sites were classified as "GOOD", 59% were classified as "MODERATE" while the remaining 12% as "POOR", with a general slight improvement of the classification in the last monitoring cycle (2012-2014). Although the ecological quality status of the Apulian *Posidonia oceanica* meadows (summarized by the PREI index values) reflects the distribution of anthropic pressures on the coast (harbours, industrial and urbanized areas, river's outlets) along a latitudinal gradient, the classification based on the rules (reference conditions and EQR boundaries for the PREI index) reported in the Italian law (D.M. 260/2010) seems to underestimate the real ecological status. Consequently, a revision of both the actual reference conditions and EQR boundaries is suggested for the BQE *Posidonia oceanica* in the Apulian marine waters, in order to taking account of the environmental features of two different marine basins as the south-western Adriatic Sea and the north-western Ionian Sea.

[34] Seagrass *Zostera noltei* as bioindicator of ecological status of Croatian transitional waters

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During the implementation phase of the EU Water Framework Directive, CYMOX method (*Cymodocea nodosa* index) was used to determine the ecological status of Croatian transitional waters. During the monitoring program, it was found that *C. nodosa* does not sufficiently inhabit some of Croatian transitional waters and that it can not be used as indicator species for the whole area. In contrast, seagrass *Zostera noltei* is very abundant in almost all Croatian transitional waters therefore slightly modified CYMOX method was applied on this species. In total, 9 meadows from different transitional waters located along entire Croatian coast, were analyzed. For calculation of ecological quality ratio (EQR) values, 12 parameters were considered: total leaf weight, root weight ratio, and percentage of N, ratio of isotope ^{15}N, ratio of isotope ^{34}S, amounts of Cu, Cd, Zn, Ni, Mn, Fe and Pb in rhizomes. Obtained EQR values showed that 3 meadows were in bad ecological status, 4 in good and 2 were in very good ecological status. Significant correlation (R^2=0.87; $p<0.01$) between obtained EQR values and measured abiotic parameters (NO_3^-, NO_2^-, NH_3, PO_4^{3-}, SiO_4^{2-}, organic matter in sediment) at sampling location was found. The obtained results show and suggest that seagrass *Z. noltei* could be used as a bioindicator of ecological status of transitional waters in Croatia.

[35] Assessment of the environmental health status of the Marchica lagoon (Morocco, Mediterranean) using *Cymodocea nodosa* meadows and its associated macrofauna: preliminary results

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The Marchica lagoon is the single lagoon on the Mediterranean coast of Morocco. Beside its ecological and socio-economic values, the lagoon is under pressure of a complex mixture of human-mediated stressors (urbanization, pollution, overfishing, tourism, etc.). Nowadays, many institutional efforts have been undertaken to establish a sustainable management plan of the lagoon in the context of an Integrated Coastal Zone Management (ICZM) approach. Thus, understanding how these stressors impact upon ecological status and ecosystem services is a sound step for any efficient integral management.

Based on sampling performed on June 2014, the present work aimed at assessing the ecological quality status (ES) of the northern part of the lagoon using *Cymodocea nodosa* (Ucria) Ascherson meadows and benthic macrofauna. 16 stations (11 with *C. nodosa* and 5 on bare sediment) were sampled using a Van Veen grab.

Preliminary results showed differences between stations. Shoots biomass fluctuated between 8.02 and 61.2 g dw m^{-2} while the roots-rhizomes biomass oscillated between 10.8 and 235.5 g dw m^{-2}. The root-rhizome and leaf biomass ratio revealed high values (up to 10.8) in the central sector suggesting a potential nutrient enrichment.

Benthic macrofauna revealed the presence of 90 species belonging to six zoological groups and dominated by crustaceans, molluscs and polychaetes. The assessment of the ecological quality status, based on benthic macrofauna, was evaluated using Biotic Indices (AMBI, M-AMBI, Benthix, BITS). The results showed partial agreement between single index-derived ES and underlined the dependency of these biotic indices on the habitat characteristics, on the one hand, and the necessity to define specific reference conditions to the Marchica lagoon.

[36] Effect of dredging activities on the health status of *Posidonia oceanica* meadows along the north Latium coast (Tyrrhenian Sea)

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Coastal areas are characterized by several disturbances due to the presence of numerous anthropic activities that may alter the health status and ecological functioning of *Posidonia oceanica* meadows. The reduction of seawater transparency and the increase of sedimentation rate are among the main causes of their regression.
This work is focused on the northern Latium coast (Central Tyrrhenian Sea), from Marina di Tarquinia to Santa Severa. Over time, alteration of river run-off (change in land use, captation along rivers, etc.) and dredging activities carried out within the Civitavecchia harbour, have led to the dispersion of a large amount of fine materials in the marine environment. In this area, four Sites of Community Importance were identified according to the Habitats Directive (92/43/EEC), due to the presence of *P. oceanica* beds. Meadows are fragmented and discontinuous also because the high geomorphological heterogeneity.
The aim of this work has been to evaluate the effects of the reduction of seawater transparency and the alteration of sedimentation rate on the meadows due to dredging activities. The evaluation of meadows health status from 2002 to 2013 was performed by structural (shoot density and coverage) and functional (leaf biometry) standard descriptors analysis. In the same period, the water transparency and the sedimentation rate have been analysed using numerical models able to distinguish between river and dredging contributions.
The simulations of dredged sediments transport have highlighted as the plume is transported mainly to the north, with high concentration values near the shoreline; for this reason the evaluations of shoot density of *P. oceanica* meadows located near the harbour and far from the coast have not shown a decrease over the years. In the meadow further north, where the concentration of dredged suspended materials is decreasing, the reduction in shoot number is mainly due to the sediment plumes of the Marta and Mignone rivers.

[37] Assessment of *Posidonia oceanica* status along the north Croatian coast (Adriatic Sea)

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Monitoring of *Posidonia oceanica* was carried out in the framework of the MedMPAnet Project in eight meadows not formerly explored in an area along the north coast of Croatia (Primorje-Gorski Kotar County, Northern Adriatic Sea). The survey was aimed to collect preliminary data as a baseline for future surveillance cycles of the priority habitat 1120 "Posidonia beds" within the framework of the National Monitoring Programme, according to the requirements of the EU Habitats Directive.
Fieldwork was carried out in 2013 and 2014 through direct SCUBA diving surveys. At each site, general information on coastal features and potential human pressures was recorded and the following descriptors of meadow conditions were assessed at three depth ranges: shoot density, percent coverage of *Posidonia oceanica*, dead *matte* and substrate type; depth and type of lower limits were also recorded for each meadow. Two meadows, located in the island of Rab (Uvala Planka and Frkanj), were investigated during both years of survey in order to test any differences due to the methodological approach we used.
Overall, results indicated signs of distress for several meadows. Density ranged from 355±22 to 629±21 shoot per m^2 at shallow stations (<10 m depth), from 141±8 to 324±23 shoot per m^2 at intermediate depth (about 15 m), and from 79±5 to 157±10 shoot per m^2 at the lower limit. Regression was also testified by high coverage of dead *matte* (locally >40%) especially at the lower limit, which was regressive in four meadows and in no case did it exceed 27 meters in depth. The temporal comparison provided consistent results between the two years for investigation of shoot density, at all sites and throughout the bathymetric range. However, some changes were detected in the deepest portions of both meadows in the coverage of *Posidonia oceanica* (lower than 50% in 2014).

Further monitoring and research campaigns are recommended to improve the level of knowledge on the status of meadows in this area, to develop a baseline for assessing trends on a long-term temporal scale as requested by Habitats Directive, and to shed light on the relevance of both environmental and anthropogenic factors in determining the health status of the meadows. Intercalibration among operators is also suggested to ensure reliable data in implementing the National Monitoring Programme.

[38] Monitoring of *Posidonia oceanica* meadows in the Telašćica Nature Park (Croatia)

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Monitoring of marine priority habitats has been recently undertaken in the Telašćica Nature Park (Croatia) in compliance with the management plan developed within the MedPAN South project. Assessment of the state of *Posidonia oceanica* meadows was made in 2011, 2012 and 2014, in five locations subjected to different anthropogenic pressure. The monitoring was mainly aimed to establish the presence of disturbance in locations that are highly frequented by recreational boaters.
Using an empirical assessment of frequent boat use, meadows were defined as “anchoring” (four locations - Čuška Dumboka, Kobiljak, Lučica, Sestrica – that are potentially subjected to high pressure from boating activities) or “no-anchoring” (one location - Garmenjak - where boating activites are considered negligible since the area is not a preferred destination for boater). Structural descriptors of the meadows (i.e shoot density and the Conservation Index) were assessed at different sites at each location, by means of direct surveys in SCUBA diving.
Results indicate clear signs of deterioration at the locations that are subjected to high pressure of anchoring. Overall, shoot density at the "no-anchoring" sites had significant higher values than the "anchoring" sites, by around 31% to 45% higher, over the three years of investigations. Changes in values of the Conservation Index were smaller; 10% to 15% higher in “no-anchoring” than "anchoring" sites. Among the “anchoring” locations, Čuška Dumboka and Kobiljak showed the lowest values of shoot density and Conservation Index (as a consequence of the highest cover of dead *matte*), over the three years of monitoring.
The combined use of the two descriptors seems to be effective in obtaining information on the condition of the seagrass meadows and strengthens the *a priori* assumption that mechanical disturbance of anchors affects *P. oceanica* adversely by enhancing regression of the meadows.
The management authority is now implementing a series of actions to reduce human pressures and promote a more sustainable approach to nautical tourism. Monitoring of boating frequency and activities (number and size of boats, anchor type), is recommended to assess the effective pressure of anchoring and understand whether the different conditions of meadows under pressure correspond to the different levels of disturbance or if other factors along with anchoring are influencing the seagrass beds.

[39] Detection and mapping of "blue carbon" reservoir storage in *Posidonia oceanica* dead *matte* in front of an extensive industrial area

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The endemic Mediterranean seagrass *Posidonia oceanica* is the only marine phanerogam able to form *matte*, a biogenic structure representing important long-term "blue carbon" reservoir. Natural and/or anthropogenic factors can lead to the formation of a regressive structure, called "dead *matte*", resulting from the disappearance of living shoots in the upper part of the *matte*. In the framework of TETIDE project (PON01_03112, www.progettotetide.it) a multiple sensors acoustic survey - multibeam sonar (MBS), side scan sonar (SSS), sub-bottom profiler (SBP) - was carried out in a portion of the Gulf of Augusta (Sicily, Southern Ionian Sea). The aim of investigation was to estimate the extent of dead *matte* that are present in this area due to pollution from industrial activities over the last several decades. The investigated area covers a surface of about 141 ha from 3.5 m to 21.5 m of depth. MBS and SSS showed an irregular seabed morphology with rock, sand and dead *matte* structures delimited by walls up to 2 m high. Dead *matte* covers about 58 ha, corresponding to 41% of seabed. The seismo-acoustic data, recorded by SBP, allowed to estimate the thickness of the *matte* and then to calculate its volume per unit surface area of seabed. The volume of *matte* varies from 0.83 m^3/m^2 to 2.68 m^3/m^2 with a mean value of 1.46 m^3/m^2. The total seabed surface affected by industrial activities concerns an area of about 3,000 ha. Considering the percentage of dead *matte* coverage and its volume per unit surface area, a total volume of $18 \cdot 10^6$ m^3 was estimated. From literature data, the amount of carbon storage inside the *matte* is 0.034 tons/m^3 on average, thus we extrapolated that total carbon accumulated is about 612 tons. These "blue carbon" reservoirs should be put into preserving in order to contrast their erosion and the consequent potentially massive CO_2 release into the atmosphere.

[40] Evaluation of the ecological status in Liguria's water bodies applying the PREI index

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The Water Framework Directive 2000/60/EC, implemented in Italy by Legislative Decree 152/06, provides that all water bodies achieve a "good ecological status" by 2015. The ecological status is obtained by considering jointly the compliance of environmental quality standards of reference (EQS) for non-priority chemical pollutants and the evaluation of the Biological Quality Elements (BQE).
Posidonia oceanica is chosen by Ministerial Decree 260/2010 as the BQE for the definition of ecological status of coastal water and the PREI (*P. oceanica* Rapid Easy Index) is identified as an index to be applied for the evaluation of the BQE *P. oceanica*.
This index includes the calculation of five descriptors: shoot density (number of shoots/m^2), shoot leaf surface area (cm^2/shoot), ratio between epiphytic biomass (mg dw/shoot) and leaf biomass (g dw/shoot), depth of the lower limit (m) and type of this limit. The first four parameters are measured through surveys in situ and laboratory testing; the depth and the type lower limit are identified through an underwater georeferred towed camera.
P. oceanica meadows lie in 15 of the 26 water bodies the Ligurian marine coast is divided into. Since 2009, all the meadows are monitored every 3 years; in 2014 the second monitoring cycle came to an end.
This study describes the results from the monitoring activities performed since 2009 and the classification of the ecological status of water bodies on the basis of the PREI index.
Although the data for 2014 are currently under processing, the second cycle of monitoring confirms the classes identified in the first cycle. Most of the water bodies have already achieved the goal of ecological status "Good" or "High"; few are "moderate" and therefore do not comply with the goals set for 2015.

[41] A new methodology for monitoring *Posidonia oceanica* meadows in Tavolara Punta Coda Cavallo MPA using GIS

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Marine Protected Areas (MPAs) are acknowledged globally as effective tools for the protection and management of the marine environment; however, to get effective results it is necessary to set up a proper and continuous mapping of the marine territory, in order to gain detailed knowledge of its different aspects. Therefore, the implementation and maintenance of a modern GIS (Geographic Information System) has become an indispensable task for the MPA of *Tavolara - Punta Coda Cavallo* to collect, aggregate, classify, and track the conducted mapping activities.
Between 2011 and 2012 the sea bottom of the MPA was surveyed using different methods: by means of a multi-beam echo sounder and of a side scan sonar, as well as conducting fast scientific scuba divings with re-breathers and underwater position system technologies. High resolution geodatasets, characterized by a significantly high quality in representing and describing the sea bottom and its habitats, were produced in both feature (scale up to 1:1.250) and raster formats (up to 30 cm/pixel for sonar images and 1 m/pixel for bathymetry) and they currently constitute the basis of the MPA's GIS, including its 3D applications and its web map services for desktop and mobile devices (iPhone & Android).
To update the above described geodatasets during time, acquiring new data on the conservation targets considered in monitoring activities, among which the status of *Posidonia oceanica* meadows is of the most important ones, a long term mapping plan was realized on the basis of an innovative methodology elaborated by the MPA considering both the wideness of the area and the limited funds available at present. The whole MPA was divided in territorial units by means of a regular grid of square cells having a 100 m side with the logic of starting the mapping activities from the most important areas and then to spread the surveys up to fill the whole mosaic. All the new data acquired with this methodology could then be mixed, compared and indexed within the same cell and/or in the many already available geodatases, starting from those dated 2006 having a regular grid with square cells of 500 m *per* side.

[42] Large-scale *Posidonia oceanica* restoration in a Site of National Interest using an innovative bio-plastic transplant system

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Along the Italian coasts there are many areas affected by industrial activities defined as "Sites of National Interest" (SNI), which require urgent and effective remediation and restoration actions. In the framework of TETIDE project (PON01_03112 www.progettotetide.it) a restoration program was developed in SNI Priolo (Sicily) in response to a dramatic decline and regression of *Posidonia oceanica* meadow, caused by several years of petrochemical industries dumping. In particular, a large scale *P. oceanica* restoration plan was carried out in four steps: (1) habitat selection, by calculation of the Preliminary Transplant Suitability Index (PTSI); (2) field assessments and test-transplanting, to evaluate the site suitability; (3) identification of suitable restoration sites, by calculation of the Transplant Suitability Index (TSI); (4) finally, according to TSI results, a large *P. oceanica* transplant was performed. Cuttings were anchored by using an innovative system (patented by Biosurvey Srl, Spin-off University of Palermo) made of a new generation bio-plastic (Mater-Bi), totally biodegradable after 5 -10 years in the field, maintaining the same physical characteristics of plastics. This system consists of a radial structure that can be anchored on the seabed by a picket. The structure is modular with five arms on which a variable number of clips for fixation of *P. oceanica* cuttings occurs. A total of 20'000 cuttings corresponding to about 70'000 shoots, were anchored at a depth of 12 m over 2'500 m^2 of *P. oceanica* dead *matte*. After six months of monitoring, cuttings survival was 93.3 % with visible roots production, while mortality and detachment were about 1.7% and 5% respectively with a consequent slight decrease of shoot density. These results suggested that the modular bio-plastic system can be successfully employed for restoring damaged meadows allowing the natural anchoring of plants before structure degradation, without realising harmful residues in the environment.

[43] Setting up of monitoring systems for *Posidonia oceanica* meadows in the Bou Ismaïl bay (Algeria, southern Mediterranean Sea)

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Through initiatives of the Regional Activity Center for Specially Protected Areas (RAC/SPA, UNEP), many monitoring systems for *Posidonia oceanica* meadows were set up along the Mediterranean coast. The purpose of these networks is twofold: enhanced monitoring of *P. oceanica* meadows and its use as biological indicators of coastal water quality.
Based on these standardized methods, three monitoring sites were selected along Bou Ismaïl Bay: two sites located in sensitive areas which are subject to urban effluents – Sidi Fredj and Bou Ismaïl –, and the third – Kouali –, a reference area which is free of any human impact. The Sidi Fredj monitoring system was set up in 2012 and consists in the installation of permanent quadrat within the *P. oceanica* meadow. The Bou Ismaïl and Kouali monitoring system were set up respectively, in 2007 and 2008 and includes the installation of cement markers along the meadow lower limits. The parameters measurements that provide information on the healthiness of *P. oceanica* are also taken at the level of the fixed markers: shoot density, meadow cover, phenology, lepidochronology and epiphyte biomass. The monitoring network has allowed confirming, in one side, the efficiency of these systems and in the other side it revealed a regressive tendency of Sidi Fredj and Bou Ismaïl *P. oceanica* meadows and a steady meadow at Kouali. These results are linked to the degree of human disturbance at Bou Ismaïl bay.

[44] Some historical records of *Posidonia oceanica matte* in surrounding of Bar, Montenegro

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Although the Montenegrin coast was not subject of systematic monitoring of *Posidonia oceanica* meadows in recent decades, and little information is available on their distribution and features, documents found in archives related to drilling of sea bottom in Bar during construction works for the new port in 1977 pointed out an outstanding facts. Underwater engineers then described the problem they had with standard drilling heads for hard bottom that were entangled with organic matter – "roots", which were significantly slowing down their work. Sediment analysis showed that they were drilling through 14 meters of *Posidonia oceanica* matte.
In recent years, meadows distribution mapping performed through satellite imaging Planetek – Worldwiew2, and underwater surveys in this particular area, indicated that on several places meadow matte thickness above sea bottom is over 2 meters. Specific investigations would be relevant to shed light on meadow's age in this area and understand if we are faced with one of the oldest *Posidonia oceanica* meadows in Adriatic. Planned activities in establishing MPA Ratac, that includes parts of this meadow, could bring additional data about the history of *Posidonia oceanica* distribution in this part of Adriatic Sea.

[45] A GIS-based tool to protect seagrasses in the Gulf of Aqaba – mapping their distribution, ecosystem services and potential threats

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Within the Gulf of Aqaba (Red Sea), coral reefs have been considered the dominating ecosystem, attracting not only scientific attention, but also restoration efforts, aquarium exhibits and outreach educational programs. Seagrasses, which are known worldwide as a highly important ecosystem, have not received much attention by the public, scientists or authorities involved in conservation and management in this region. This is surprising considering the value of ecosystem services associated with seagrasses and the fact that many of these services are important to adjacent coral reefs.

The absence of comprehensive seagrass maps for this region, prohibits other downstream activities such as evaluations of the associated ecosystem services and implementation of potential conservation and management tools.

Here we present efforts to map seagrass meadows along the Israeli coast of the northern Gulf of Aqaba. Mapping was done by snorkeling with a GPS and a handheld echo-sounder. Transects perpendicular to the shore were conducted with measurements taken every 10-20 meters that included water depth, GPS position and percent of seagrass cover estimated visually up to 13-23m depending on visibility. In addition to these transects, we also tracked the shallow boundary of the meadows parallel to shore, usually at 3-5 m depth. Both data sets were then fed into Arc-GIS to create an interpolated GIS layer.

Out of 11 km available shoreline, we swam along 9.7 km and collected a total of 2830 data points. Seagrasses were found growing along 7.5 km of these shores, with seagrass meadows covering 707,000 m^2, estimated to be worth = US$ 2,000,000 $year^{-1}$ in associated ecosystem services.

In addition to mapping the seagrass meadows themselves, we also mapped the potential dangers to seagrasses in the region. Disturbances were ranked as low, medium or high according to severity and frequency.

Taken together, we expect that these maps (GIS layers) will allow us to not only understand the current distribution of seagrasses in the area, but also to develop a GIS-based tool that will improve our understanding of how changes in the Gulf could affect the cover and state of seagrasses, and thus improve conservation efforts in the region.

[46] Seasonal variation of metallic trace elements concentration in *Posidonia oceanica* leaves in El Kantaoui (Eastern coast of Tunisia)

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Posidonia oceanica meadows are a powerful indicators of water quality in the marine environment. This plant has been used especially as a metal bioindicator in the Mediterranean Sea because its capability to accumulate metals. Besides, literature suggest that several factors could influence the metal trace element accumulation in *P. oceanica* such as the metal examined, the availability of trace metal in the environment and the sampling period.
In the present work, five metallic trace elements (MTEs) concentration have been measured in blades of adult leaves of the endemic Mediterranean seagrass *P. oceanica* and compared according to the seasons. Potential relationships between several variables are also investigated.
Sampling was carried seasonally out in four locations around the touristic port of El Kantaoui from March to December 2012. Leaves were collected by scuba diving between 8 to 10 m depth. MTEs concentration was analysed using inductively coupled plasma optical emission spectrometry (ICP-OES).
Results show that, whatever the season, mean MTEs concentration in the blades of *P. oceanica* decreased in the following order: Zn > Ni > Cu > Pb > Cd. A clear significant difference for the concentration of the five MTEs in blades between seasons was recorded using one-way ANOVA test. The concentration of Cd and Cu in the blades of *P. oceanica* showed a seasonal pattern; Cd concentration decreased from spring to winter versus to Cu concentration. Highly significant correlation was found between Cd/Cu and Cd/Pb. A significant correlation was also observed between Cd/Ni. A relationship was recorded between blades leaf adult area and Zn accumulation.

Author Index

In bold MSW '15 participants.

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