Sharing not permitted

EGU General Assembly #EGU23 23 - 28 April 2023

EGU23-15790

# Remote sensing techniques and tools to map marine bioindicators and their potential responses to anthropogenic pollutants: Spectral signatures of *Posidonia* oceanica and *Cystoseira* sp. and first results


Varini F. [1] , Madonia A. [2] , Scanu S. [2] , Piermattei V. [2]

[1] Laboratory of Experimental Oceanology Marine Ecology, e Department of Ecological and Biological Sciences (DEB), University of Tuscia, 00053 Civitavecchia, Italy.
[2] Ocean Predictions and Applications Division, Euro-Mediterranean Centre on Climate Change, 73100 Lecce, Italy.


## Introduction

- Urban settlements have an impact on the coastal marine environment, and it's estimated that more than 40% of the European population resides in coastal regions.
- In these areas, typical pollution of urban agglomerations (waste water, waste and emissions from transport and heating), generated by industrial and agricultural complexes often overlaps, above all by the maritime transport sector, one of the largest sources of pollution on the coast.
- Maritime transport is currently growing compared to air and road transport.
- The objective of the scientific community is to improve current methodologies, integrating measurements at sea with appropriate information provided by remote platforms equipped with multispectral sensors.
- This work was developed within the ASI – STOPP project that is focused on detection of marine bioindicators by new aereal platforms.

## Study Area

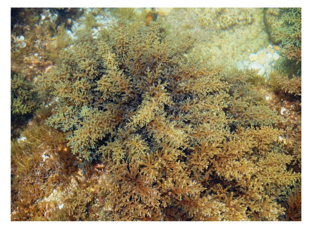
- The submerged area of the Lazio and Campania coasts:
  - Submerged Lazio coast are characterized by a relatively large continental shelf, with seabed that gradually slope towards the open sea. The seabed is composed of a sandy and muddy sediments, with the presence of rocks.
  - Submerged Campania coast are characterized by a narrower and steeper continental shelf, with depths that descend rapidly towards the open sea. The presence of the Vesuvius volcano and other submarine volcanic formations influences the morphology of seabed.
- The points in common regarding the biological aspect between the two coasts are innumerable, above all as regards macroalgae and marine phanerogams
- These similarities allow us to use ubiquitous target species for the study of the Pollutantpresent.

## Methods and instrumentation

### 1) Selection of target species in the study area

| REFERENCE | SPECIES | STUDIED ELEMENTS | PARAMETERS | RESPONSE |
|---|---|---|---|---|
| *Bonanno, G., & Di Martino, V. (2017). Trace element compartmentation in the seagrass Posidonia oceanica and biomonitoring applications. Marine Pollution Bulletin,116(1-2), 196-203.* | *Posidonia oceanica* | As, Cd, Cr, Cu, Hg, Ni, Pb, Zn | Metal concentration, translocation factor (TFs) and bioconcentration factor (BCFs)* | Major uptake from the sediment and major concentration of Ni e Zn in leaves. |
| *Bonanno, G., & Raccuia, S. A. (2018). Comparative assessment of trace element accumulation and bioindication in seagrasses Posidonia oceanica, Cymodocea nodosa and Halophila stipulacea. Marine pollutionbulletin, 131, 260-266.* | *Posidonia oceanica Cymodocea nodosa Halophilastipulacea* | Cd, Cr, Cu, Hg, Mn, Ni, Pb, Zn | Metal concentration, translocation factor (TFs) and bioconcentration factor (BCFs) | Major uptake from the sediment and major concentration of Cu,Mn,Zn in leaves. |
| *Bonanno, G., Borg, J. A., & Di Martino, V. (2017). Levels of heavy metals in wetland and marine vascular plants and their biomonitoring potential: a comparative assessment. Science of the Total Environment, 576, 796-806.* | *Posidonia oceanica Cymodocea nodosa* | AS,Cd,Cr,Cu,Hg,Mn,Ni,Pb,Zn | Metal concentration, translocation factor (TFs) and bioconcentration factor (BCFs)* | Major uptake from the sediment and major concentration of Cu e Zn in roots and leaves. |
| *Campanella, L., Conti, M. E., Cubadda, F., &Sucapane, C. (2001). Trace metals in seagrass, algae and molluscs from an uncontaminated area in the Mediterranean. Environmental Pollution, 111(1), 117-126.* | *Posidonia oceanica.,* | Zn, Cu, Cd,Cr,Pb | Metal concentration | Major concentration of Cu and Zn in *Posidonia oceanica*, and in leaves. |
| *Zhao, J. S., Zhang, Q., Liu, J., Zhang, P. D., & Li, W. T. (2016). Effects of copper enrichment on survival, growth and photosynthetic pigment of seedlings and young plants of the eelgrass Zostera marina.* | *Zostera marina* | Cu | Pigments analysis and leaf growth analysis | Major concentration of Cu leads to decrease of pigments and growth. |

| REFERENCE | SPECIES | STUDIED ELEMENTS | PARAMETERS | RESPONSE |
|---|---|---|---|---|
| *Celis-Plá, P. S., Brown, M. T., Santillán-Sarmiento, A., Korbee, N., Sáez, C. A., & Figueroa, F. L. (2018). Ecophysiological and metabolic responses to interactive exposure to nutrients and copper excess in the brown macroalga Cystoseira tamariscifolia. Marine pollution bulletin, 128, 214-222.* | *Cystoseira* | Cu | - Chla fluorescence<br>-pigments content<br>-fenolic compounds and antioxidants<br>-Cu accumulation | -antioxidant response with increasing in Cu concentration<br>-increase in pigments content with high Cu concentration |
| *Bonanno, G., Veneziano, V., Raccuia, S. A., & Orlando-Bonaca, M. (2020). Seagrass Cymodocea nodosa and seaweed Ulva lactuca as tools for trace element biomonitoring. A comparative study. Marine PollutionBulletin, 161, 111743.* | *Cymodocea nodosa, Ulva lactuca* | Cd, Cr, Cu, Ni, Pb, Zn | Metal concentration | *Cymodocea* absorbes more than *Ulva* |
| *Luy, N., Gobert, S., Sartoretto, S., Biondo, R., Bouquegneau, J. M., &Richir, J. (2012). Chemical contamination along the Mediterranean French coast using Posidonia oceanica (L.) Delile above-ground tissues: a multiple trace element study.Ecological Indicators,18, 269-277.* | *Posidonia oceanica* | Cd, Cu, Cr, Pb, Zn, Fe and Ni | Metal concentration | Zn > Ni > Cu >Cd, Pb > Cr |
| *Richir, J., Luy, N., Lepoint, G., Rozet, E., Azcarate, A. A., & Gobert, S. (2013). Experimental in situ exposure of the seagrass Posidonia oceanica (L.) Delile to 15 trace elements.Aquatic* | *Posidonia oceanica* | Al, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Mo, Ag, Cd, Pb and Bi | Study on the uptake of the seagrass | -Uptake of metals from the water column<br>-high contamination in the leaves |



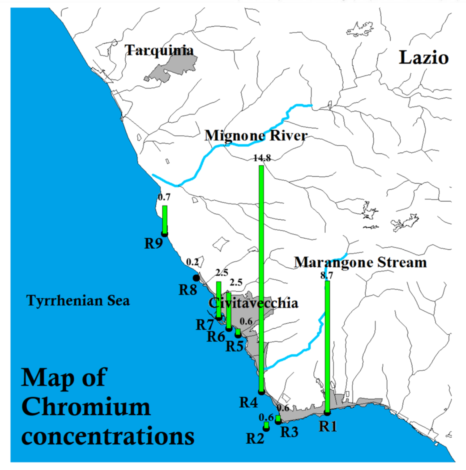
*Cystoseira* sp.

*Posidonia oceanica*

### 2) Identification of pollutants present in the study areas

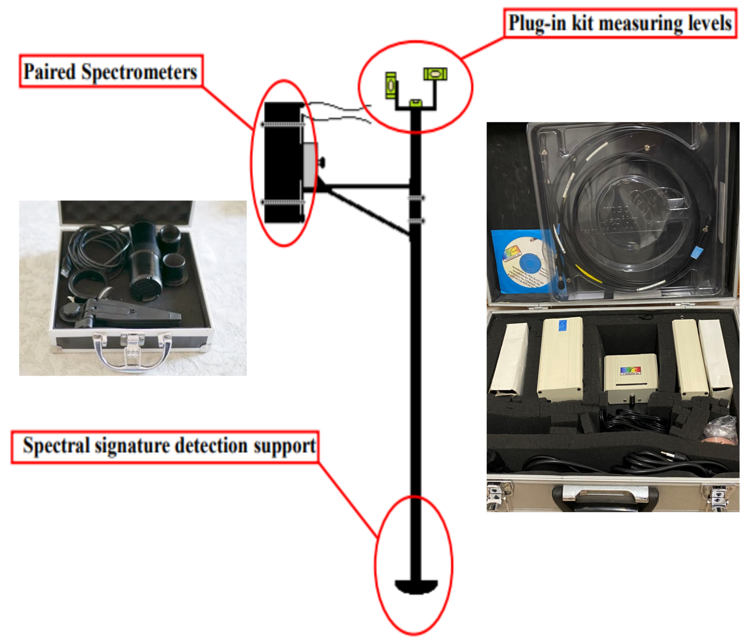
- Hexavalent chromium is taken up by seagrass and marine algae species alters the functions of chlorophyll photosynthesis and the spectral signature, the latter allowing us to detect the polluted species.
- The presence of hexavalent chromium in the marine waters of Campania is due to the industrial activities along the coast and at the mouths of rivers.
- High concentrations of hexavalent chromium can also be found in waters of the sea of Lazio identified by the analysis of Paracentrotus lividus (Scanu et al., 2015).

| Elements | Seagrass ecosystems | | Macroalgal ecosystems | | References |
|---|---|---|---|---|---|
| | Marine waters [μg L⁻¹] | Marine sediments [mg kg⁻¹] | Marine waters [μg L⁻¹] | Marine sediments [mg kg⁻¹] | |
| As | <0.10–3.52 | <0.90–19.7 | 2.03 ± 0.20 | 1.84 ± 0.17 | Malea et al. (2015); Stanković et al. (2015); Bonanno and Di Martino (2017); Bonanno et al. (2017). |
| Cd | <0.10–16.0 | 0.01–87.0 | 0.01–3.40 | <0.01–8.09 | Malea et al. (1994); Malea and Haritonidis (1995, 1999); Lafabrie et al. (2007); Abdallah and Abdallah (2008); Boubonari et al. (2008a, 2008b); Akcali and Kucuksezgin (2011); Bravo et al. (2016); Bonanno and Di Martino (2017). |
| Cr | 0.11–616 | 4.37–1194 | 0.12–2.42 | 8.15–231 | Haritonidis and Malea (1995); Campanella et al. (2001); Conti et al. (2007); Lafabrie et al. (2007); Akcali and Kucuksezgin (2011); Bonanno and Di Martino (2017); Bonanno et al. (2017). |
| Cu | 0.82–123 | 0.05–397 | 0.40–24.0 | 0.85–710 | Malea et al. (1994); Malea and Haritonidis (1995); Conti et al. (2007); Boubonari et al. (2008a, 2008b); Akcali and Kucuksezgin (2011); Allam et al. (2016); Zakhama-Sraieb et al. (2016); Bonanno and Di Martino (2017). |
| Hg | Data not available | 0.01–1.79 | 0.08–0.49 | 0.01–0.28 | Storelli et al. (2001); Akcali and Kucuksezgin (2011); Di Leo et al. (2013); Stanković et al. (2015). |
| Mn | 0.10–0.29 | 132–924 | 0.28–12.0 | 52.8–262 | Malea and Haritonidis (1999); Abdallah and Abdallah (2008); Shams El-Din et al. (2014); Malea et al. (2015); Stanković et al. (2015); Bonanno and Di Martino (2016); Bonanno et al. (2017). |
| Ni | 1.46–1380 | 0.81–1325 | 3.61–38.8 | 2.13–9.53 | Haritonidis and Malea (1995); Lafabrie et al. (2007); Malea and Kevrekidis (2013); Malea et al. (2015); Allam et al. (2016); Zakhama-Sraieb et al. (2016). |
| Pb | <0.20–75.0 | 0.68–11,000 | 0.14–52.9 | 1.75–219 | Marín-Guirao et al. (2005); Lafabrie et al. (2007); Boubonari et al. (2008a, 2008b); Akcali and Kucuksezgin (2011); Bravo et al. (2016); Bonanno and Di Martino (2017). |
| Zn | 0.09–51.0 | 2.32–7000 | 0.40–116 | 0.72–305 | Malea and Haritonidis (1995, 1999); Marín-Guirao et al. (2005); Boubonari et al. (2008a, 2008b); Akcali and Kucuksezgin (2011); Zakhama-Sraieb et al. (2016). |

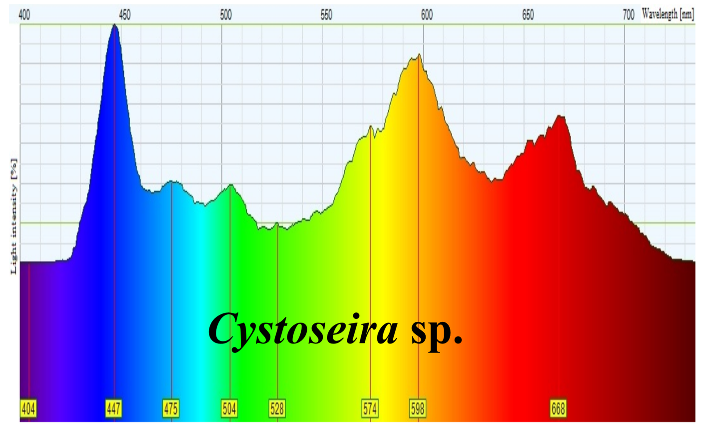


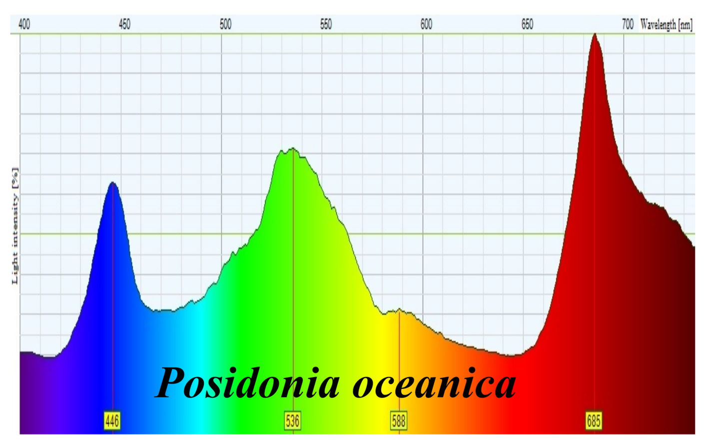

### 3) How to Study the spectral response of selected species to pollutant

- Stellarnet EPP2000 and Theremino SPEC3 USB spectrometers are portable instruments that analyze the spectral response of many biological and environmental species sensitive to pollution and have been used to measure the reflectance or emission of electromagnetic radiation in different wavelengths of the spectrum, allowing to obtain information on the absorption and scattering of light by the two phyto-species.



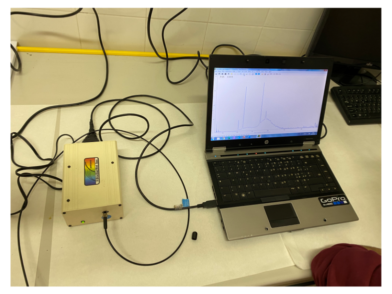

## First results

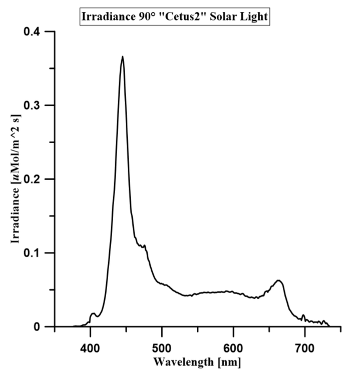


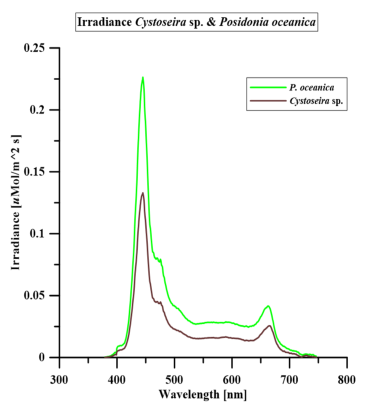



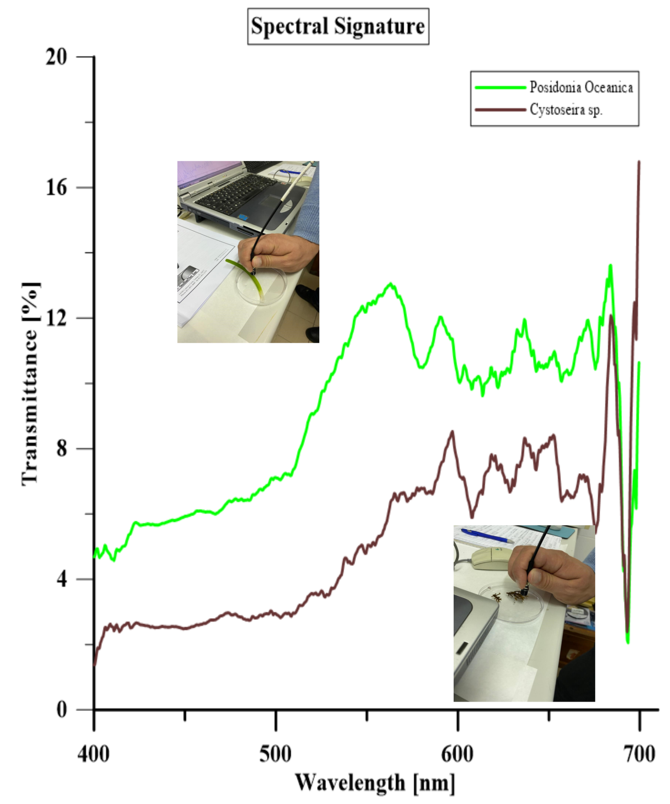

By Theremino Spec 3 USB

By Stellarnet EPP2000






- The spectral signature of Cystoseira sp. is charactrerized by a peak in the red/orange region of the visible spectrum due to the presence of photosynthetic pigments such as chlorophyll and fucoxanthin in algal cells, which can be used to monitor changes in macroalgae cover and health by remote sensing.
- The spectral signature of Posidonia oceanica show a dominate peak in the green region of the visible spectrum given by leaves chlorophyll pigment and can be used to monitor changes in seagrass cover health and variation by remote sensing (LAI - Leaf Area Index).
- within stopp's Project the future experimental activities will be conduct to analyze the variation of Posidonia oceanica and Cystoseira sp. spectral signature in laboratory controlled condition after exposure to different chromium concentration.

## Conclusions

- Spectral signature of macroalgae and phanerogams allow to detect the occurrance of potential pollution phenomena on coastal marine ecosystems through remote sensing thecnologies
- Spectral signature will be used to identify the presence of pollutants such as chromium (a toxic heavy metal that can be released into the marine environment by industrial activities) in the coastal waters of Campania and Lazio.
- The spectral signatures could also be used to assess the health of Posidonia oceanica meadows in the areas of Campania and Lazio.
- The evaluation of spectral signatures identify the presence of polluted coastal areas contributing to the sustainable management of marine habitats and their protection against anthropogenic stressor.
- The spectral signature of these two species can be measured by satellite or aircraft remote sensing instruments capable to capture reflected sunlight through multispectral sensors.


Corresponding author: Fabrizio Varini, Ph.D Student
fabrizio.varini@unitus.it
Laboratory of Experimental Oceanology
and Marine Ecology DEB University of Tuscia


oceaneers

Agenzia Spaziale Italiana

UNIVERSITÀ DEGLI STUDI DELLA TUSCIA