

Ecosystem-based approach towards the sustainable management of coastal engineering: compensation and mitigation measures applied to the Civitavecchia harbour

Prof. Marco Marcelli

University of Tuscia, DEB, Laboratory of Experimental Oceanology and Marine Ecology (LOSEM), Civitavecchia, Italy (marcomarcell@unitus.it)

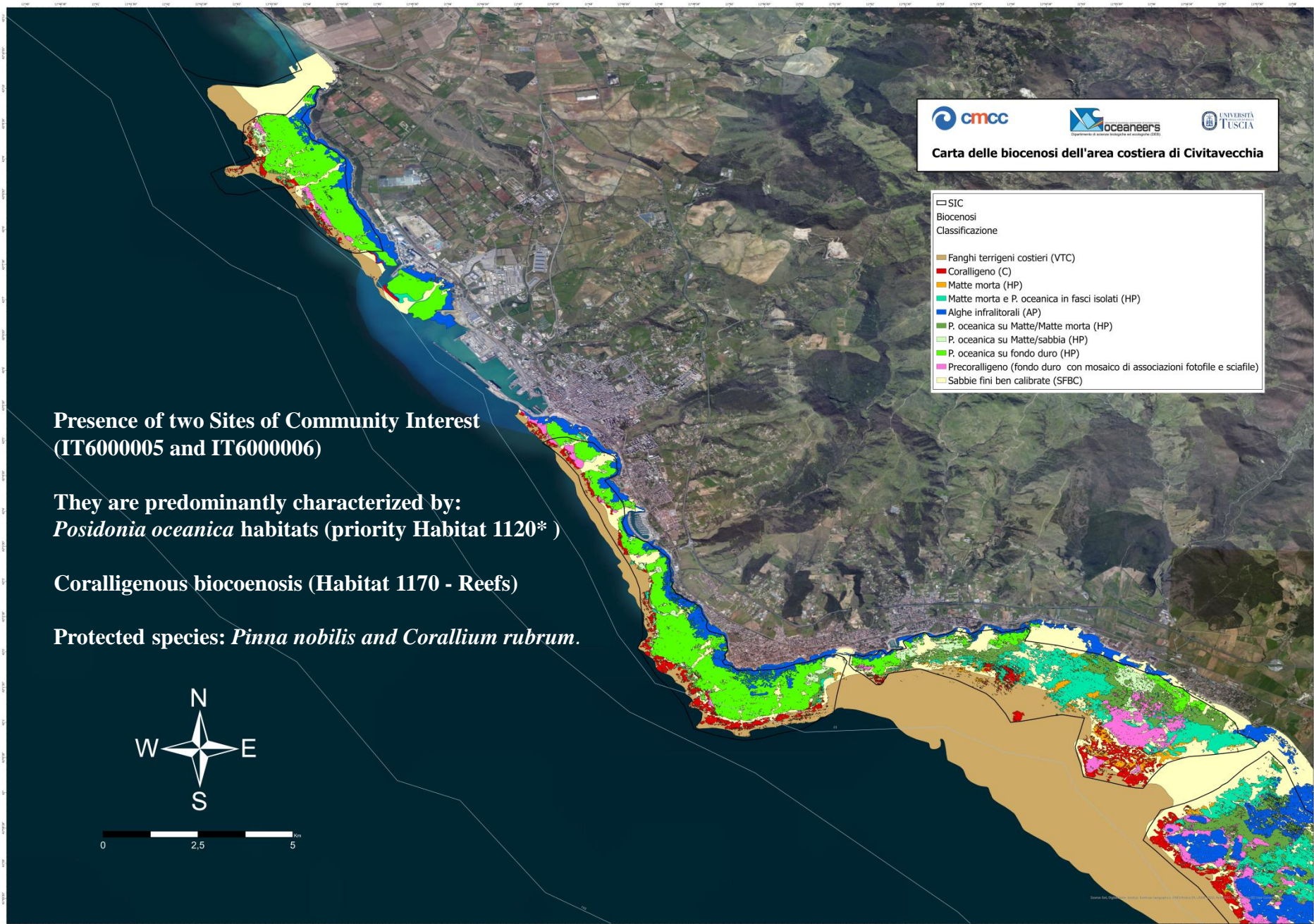
Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici CMCC OPA Division, Lecce

In the last 15 years the Port of Civitavecchia has increased its commercial traffic reaching a total of two million tons of bulk goods. It is also strategic for the access to important Italian tourist destinations and important Mediterranean cruise routes, becoming leader in this field.

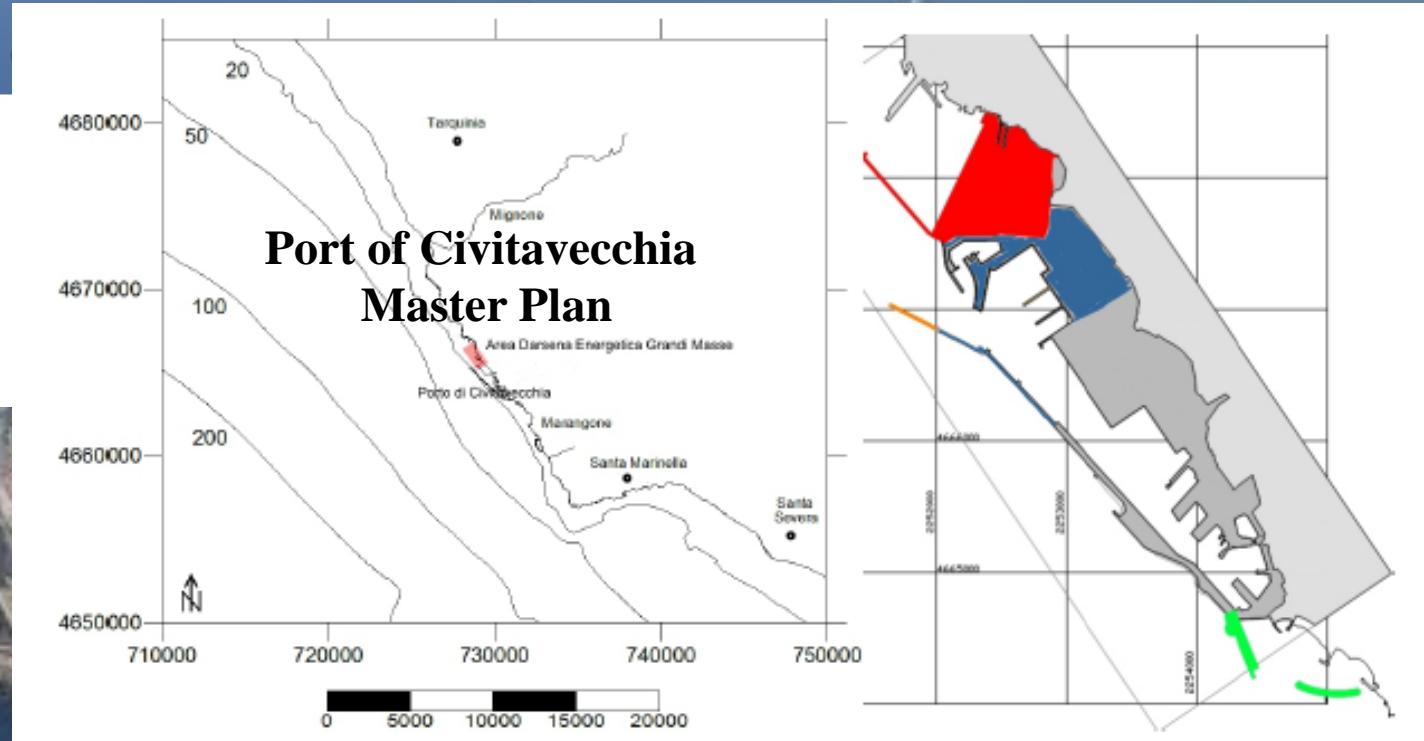
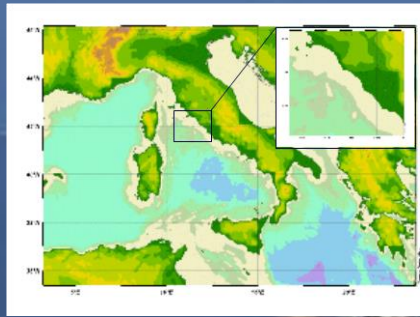


The development works of the wharfs and passenger welcoming structures have granted the possibility of recording a significant increase in cruise liners, going from 50 ships in 1996 to 500 in 2003. Civitavecchia aims at increasing the tourist flow with the target of becoming the most important cruise port in the Mediterranean.

Biocoenosis of the Civitavecchia marine coastal area



The expansion of the Civitavecchia Hub Port



Within Strategic Environmental Assessment procedures (SEA), a series of complex activities has been implemented to reduce the potential impacts on the marine environment:

- 1) analysis of the different habitats ecosystem services;
- 2) assessment of direct and indirect impacts of the expansion works on marine habitats;
- 3) **design of an ecosystem-based program of mitigation and compensation measures based on the restoration of the lost ecosystem services .**

North wharfs development



Fase I 2019 - 2022

I.A. Completamento I lotto Opere strategiche 2019-2021

- Pontile Darsena Traghetto
- Banchinamento Darsena Servizi
- Opere di Urbanizzazione
- Ottemperanze Ambientali

I.B. Infrastrutture Marittime 2019-2022

- Prolungamento Banchina 13 1° lotto
- Prolungamento Banchina 13 1° lotto
- DEGM 1° fase esecutiva - Molo Petrolifero
- Bunkeraggio Darsena Servizi
- Cantieri Navali Buca di Nerone

I.B. Ultimo Miglio 2019-2021

Ferro

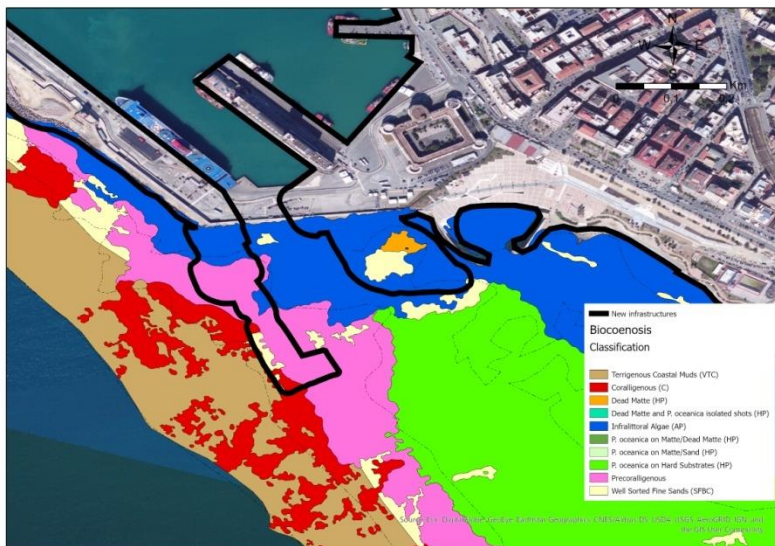
- Fascio binari e Collegamento Terminal Container

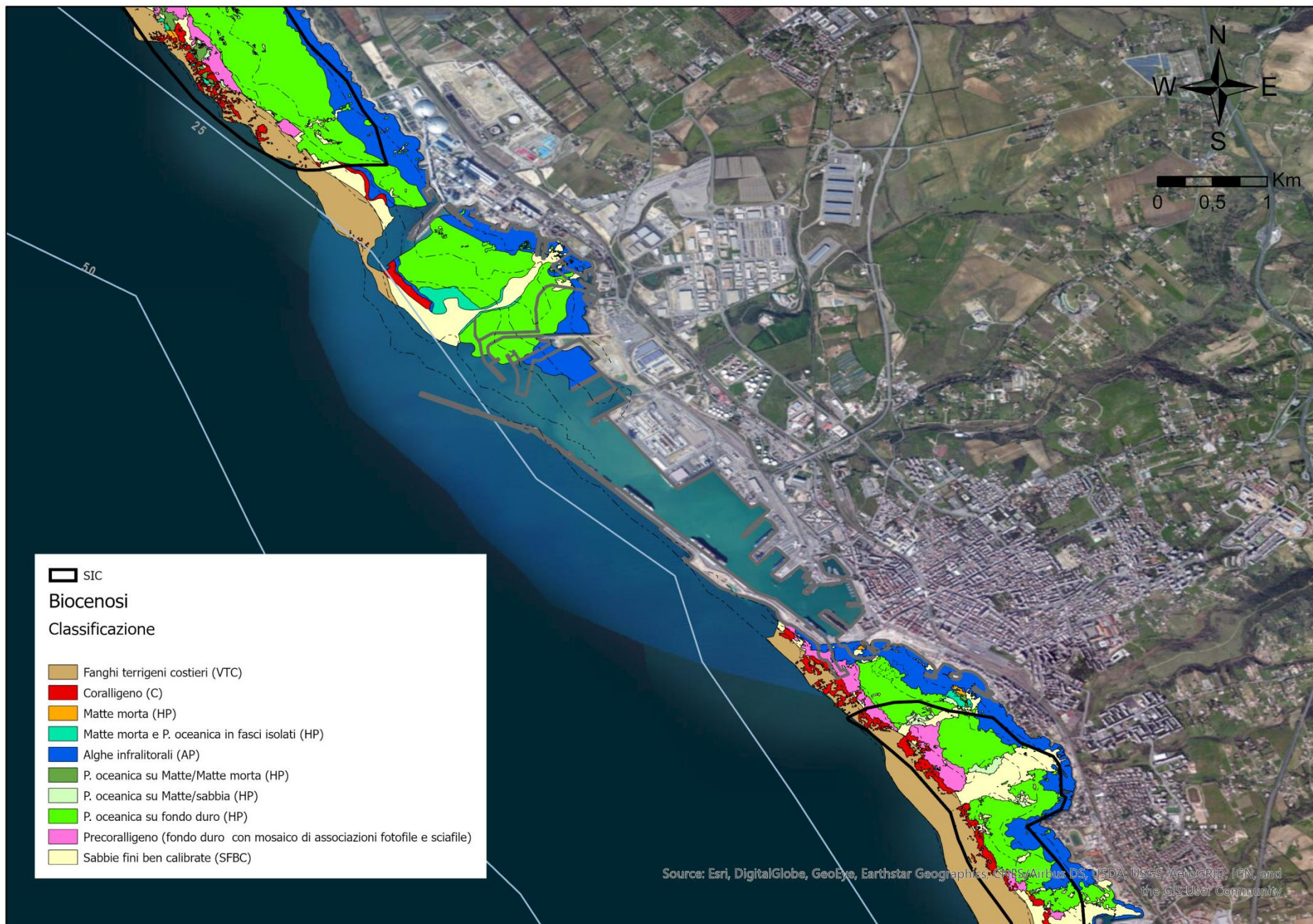
Gomma

- Nuovo Accesso Fiumaretta Nord
- Nuovo Accesso Vespucci
- Nuove Rampe Accesso Enel

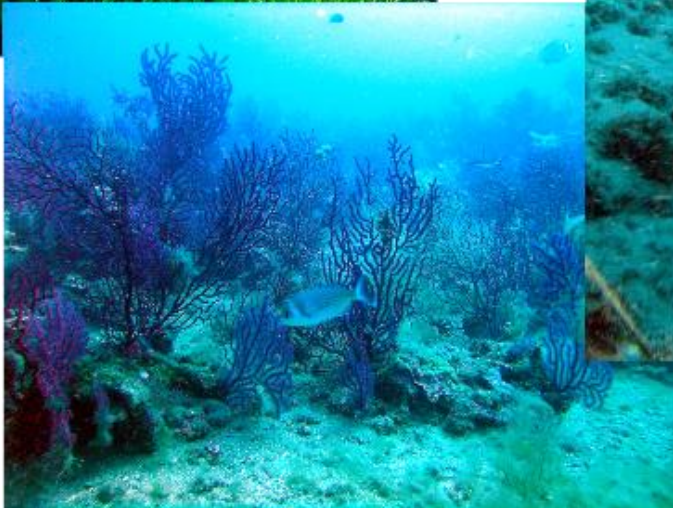
South Opening

- Opening to the south of the historic port and connection with the breakwater: interventions needed to separate the Historic Port from the Commercial Port with consequent recovery of the historical, cultural and archaeological values of the Roman port.
- The connection with the breakwater allows the enhancement of the internal viability of the port and is functional to the intermodality connections.
- Project review completed and final design approval March 31st, 2021



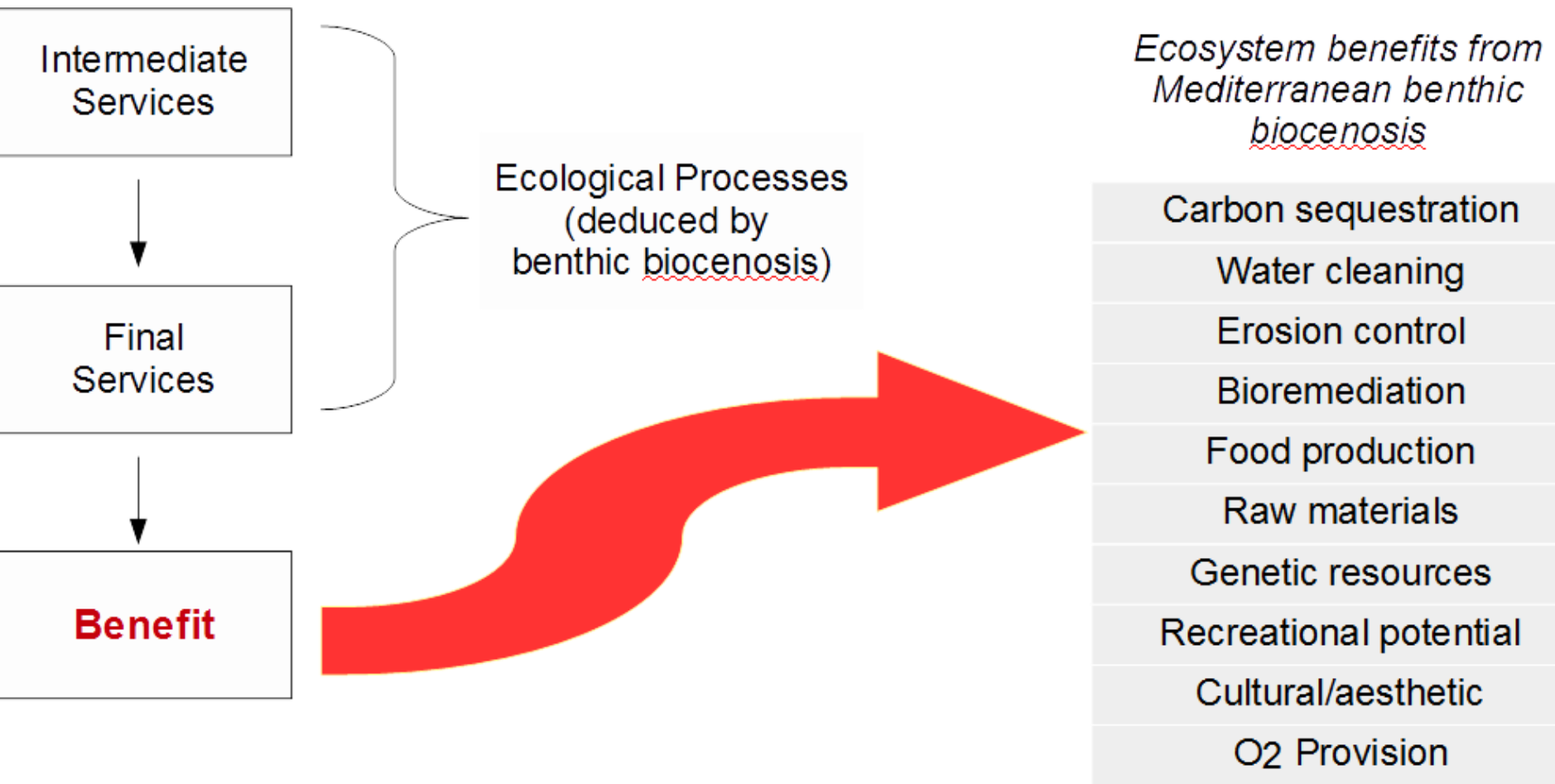


Environmental sustainability is based on the relationship between development and impact on the Natural Capital. An action is sustainable from an environmental point of view when it does not involve a decline in the Natural Capital



EVALUATION OF ECOSYSTEM SERVICES FOR IMPACTED HABITATS AND SPECIES

Ecological economy is an attempt to assess the value of the Natural Capital through the evaluation of ecosystem services it provides (Costanza 2008)



Ecosystem benefits economic evaluation

P.oceanica impact

Habitat	Surface (ha)	Impacted surface (ha)
<i>P.oceanica</i> on hard substrates	64.3	9
<i>P.oceanica</i> other substrates	11.6	6
Total <i>P.oceanica</i>	75.8	15

Reef impact

Habitat	Surface (ha)	Impacted surface (ha)
coral reef	/	3.5

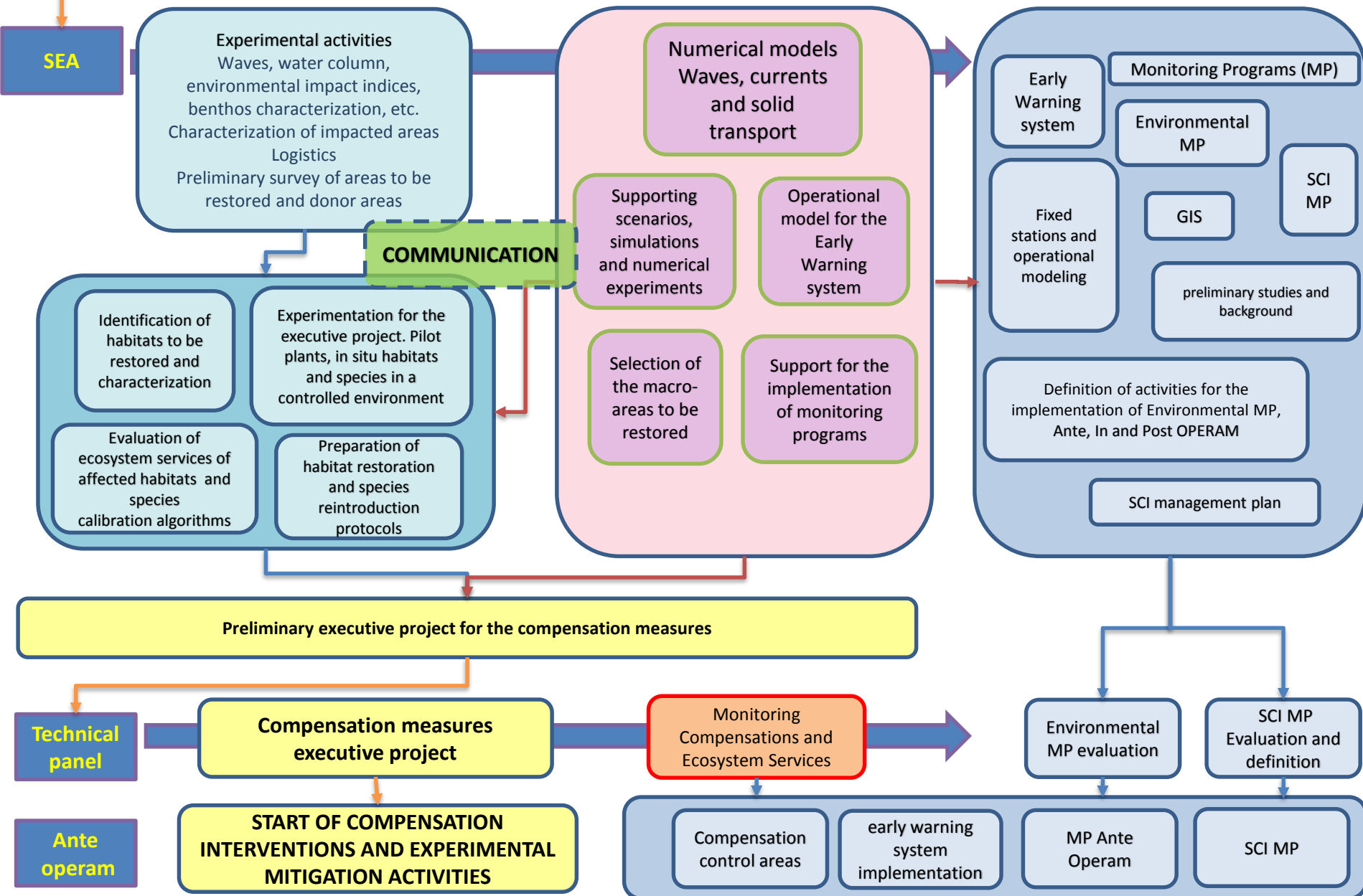
Posidonia oceanica

Ecosystem Service	Euros ha/yr
Carbon sink	3.4
Erosion prevention	8950
Bioremediation	2794
Food production	4391
O2 supply	87.6
Total Benefit	16135

Ecosystem Service	Dollars ha/yr (de Groot et al.)	Dollar ha/yr (Civitavecchia)
Provisioning Services	55724	33725
Food	677	677
Water	0	0
Raw materials	21528	0
Genetic resources	33048	33048
Medicinal resources	0	0
Ornamental resources	472	0
Regulating Services	171478	14471
Air quality	0	0
Climate regulation	1188	1188
Disturbance moderation	16991	4248
Regulation of water flows	0	0
Waste treatment	85	85
Erosion prevention	153214	8950
Nutrient cycling	0	0
Pollination	0	0
Biological control	0	0
Habitat Services	16210	16210
nursery services	0	0
genetic diversity	16210	16210
Cultural Services	108837	1145
Esthetic information	0	0
Recreation	96302	0
Inspiration	0	0
Spiritual experience	0	0
Cognitive development	1145	1145
Total Benefit	352249	65551

Marcelli et al. 2018

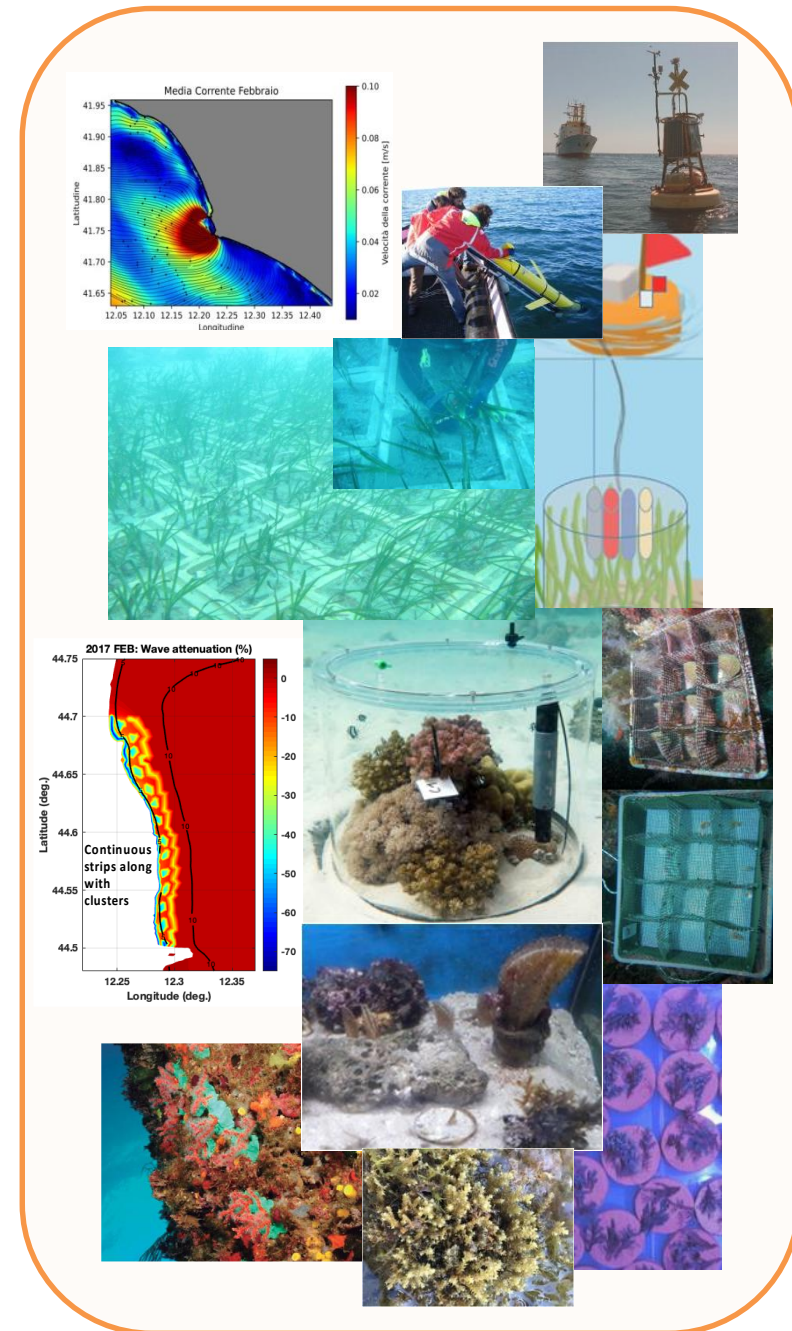
EVALUATION OF ECOSYSTEM SERVICES AND PRELIMINARY PROJECT BASED ON THE COMPENSATION OF THE VALUE OF 1120 * AND 1170 HABITATS AND OF *Pinna nobilis* and *Corallium rubrum* SPECIES AFFECTED BY THE REALIZATION OF THE WORKS




```
graph LR; CMCC[CMCC  
Centro EuroMediterraneo  
sui Cambiamenti Climatici] --- Coordination[Coordination  
Numerical modeling  
Transplanting of 1120*  
Habitat]; PALERMO[PALERMO UNIVERSITY] --- Ecosystem[Ecosystem Services and  
Functional Measurements  
of habitats and species  
Pinna nobilis transplanting]; OGS[OGS  
Istituto Nazionale di  
Oceanografia e Geofisica  
Sperimentale] --- Habitat[1170 Habitat and Pinna  
nobilis transplanting  
SIC Monitoring]; TUSCIA[TUSCIA UNIVERSITY] --- Logistics[Logistics for transplanting  
Environmental monitoring  
Early Warning System]; BOLOGNA[BOLOGNA UNIVERSITY] --- Modeling[Numerical modeling]; SASSARI[SASSARI UNIVERSITY] --- Corallium[1170 Habitat and  
Corallium rubrum  
transplanting]; CNR[CNR ORISTANO] --- Bycatch[Support to bycatch  
recovery program];
```

The diagram illustrates the organizational structure of the 1170 project, showing the roles of various institutions. The institutions are listed on the left, and their specific tasks are listed on the right, connected by lines.

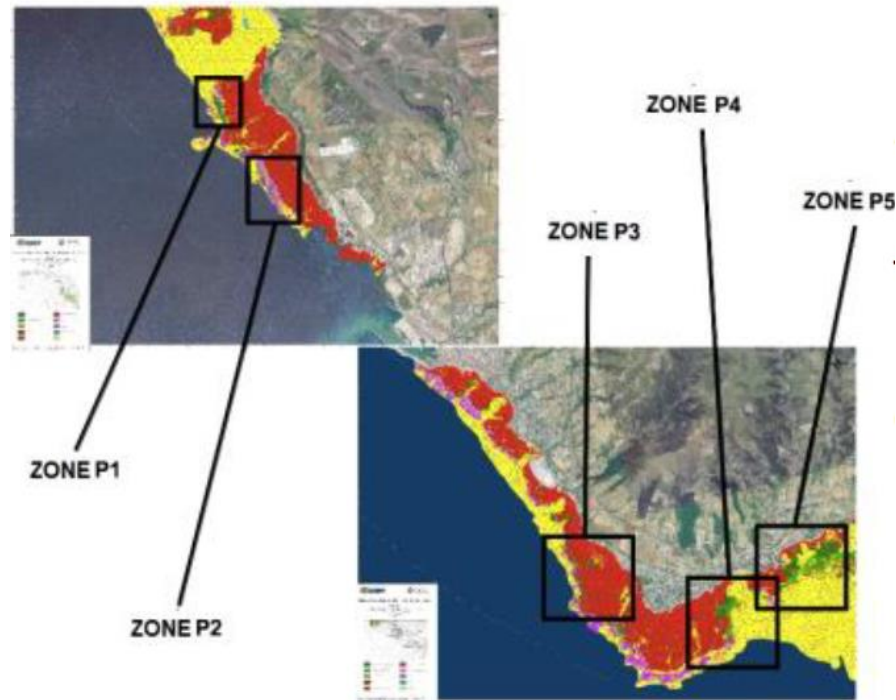
Institution	Task
CMCC Centro EuroMediterraneo sui Cambiamenti Climatici	Coordination Numerical modeling Transplanting of 1120* Habitat
PALERMO UNIVERSITY	Ecosystem Services and Functional Measurements of habitats and species <i>Pinna nobilis</i> transplanting
OGS Istituto Nazionale di Oceanografia e Geofisica Sperimentale	1170 Habitat and <i>Pinna nobilis</i> transplanting SIC Monitoring
TUSCIA UNIVERSITY	Logistics for transplanting Environmental monitoring Early Warning System
BOLOGNA UNIVERSITY	Numerical modeling
SASSARI UNIVERSITY	1170 Habitat and <i>Corallium rubrum</i> transplanting
CNR ORISTANO	Support to bycatch recovery program



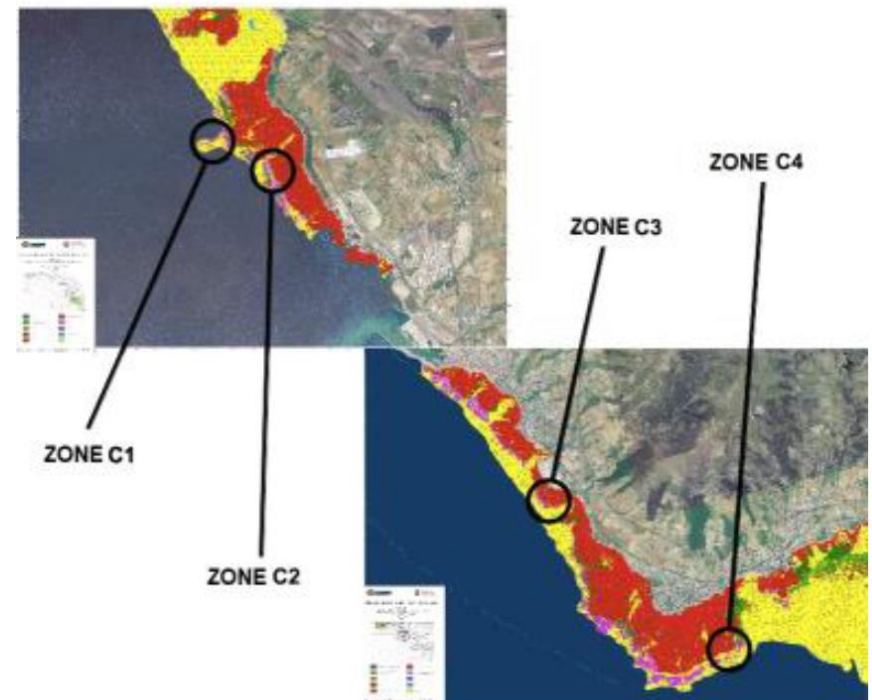
Restoration and compensation measures

Direct impacts on *P. oceanica* and coral reefs are computed considering the impacted surfaces and 10 years time interval for recovery (**2.4 million euros for *P.oceanica*** and **2 million euros for coral reefs** for a total of **4.4 million euros** for the value of lost benefits from direct impact).

P.oceanica



Reefs



Restoration of the ecosystem services provided by impacted habitats. The compensation is of about **120 ha after 10 years**
Restoration of damaged *P. oceanica* meadows by transplanting cuttings
Installation of n.100 antitrawling barriers and n.40 mooring buoys to protect the habitat.

Recovery, through bycatch campaigns and reintroduction in selected hotspots of **6000 individuals** of the different impacted species.
The compensation is of about **24 ha after 10 years**
Installation of n.50 reef balls for restocking.

IN CONCLUSION...

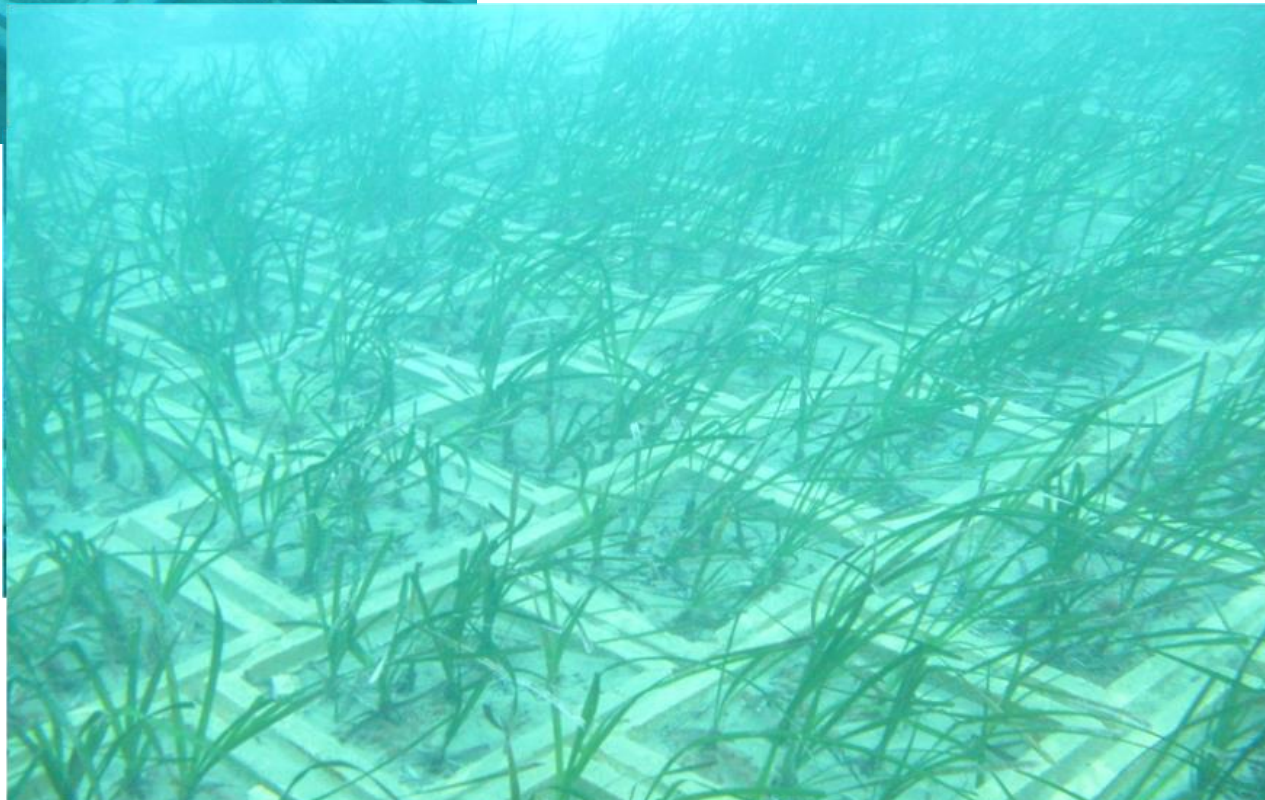
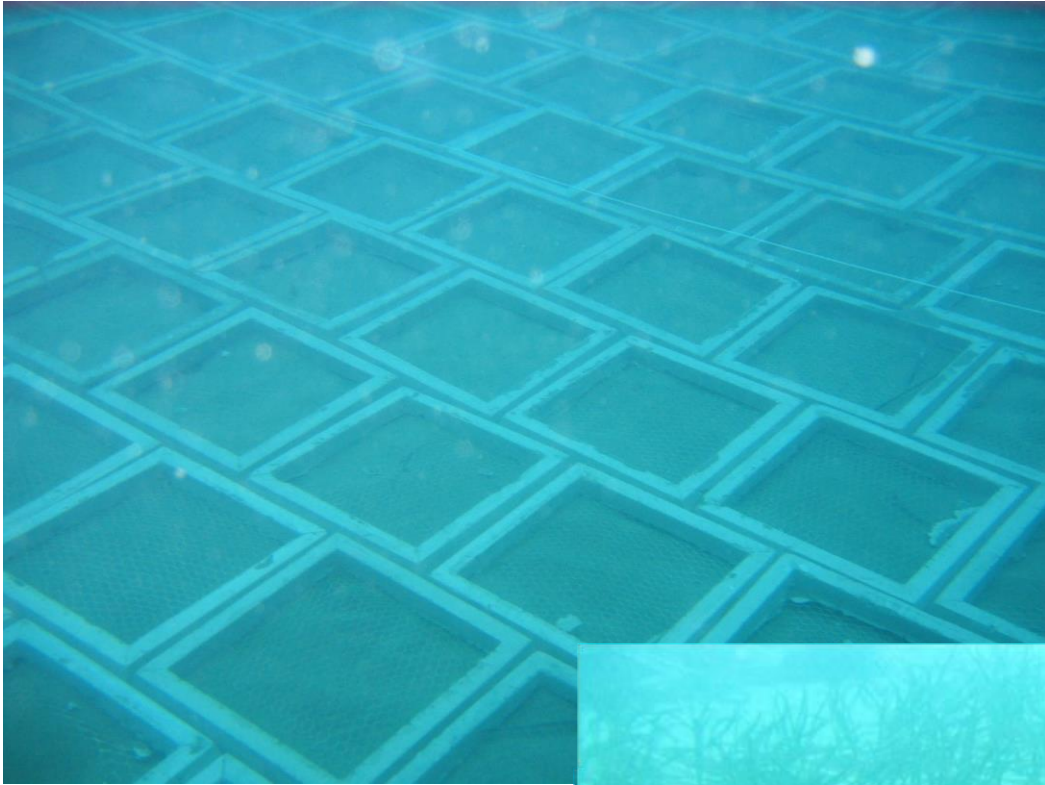
While the nature value always grows...

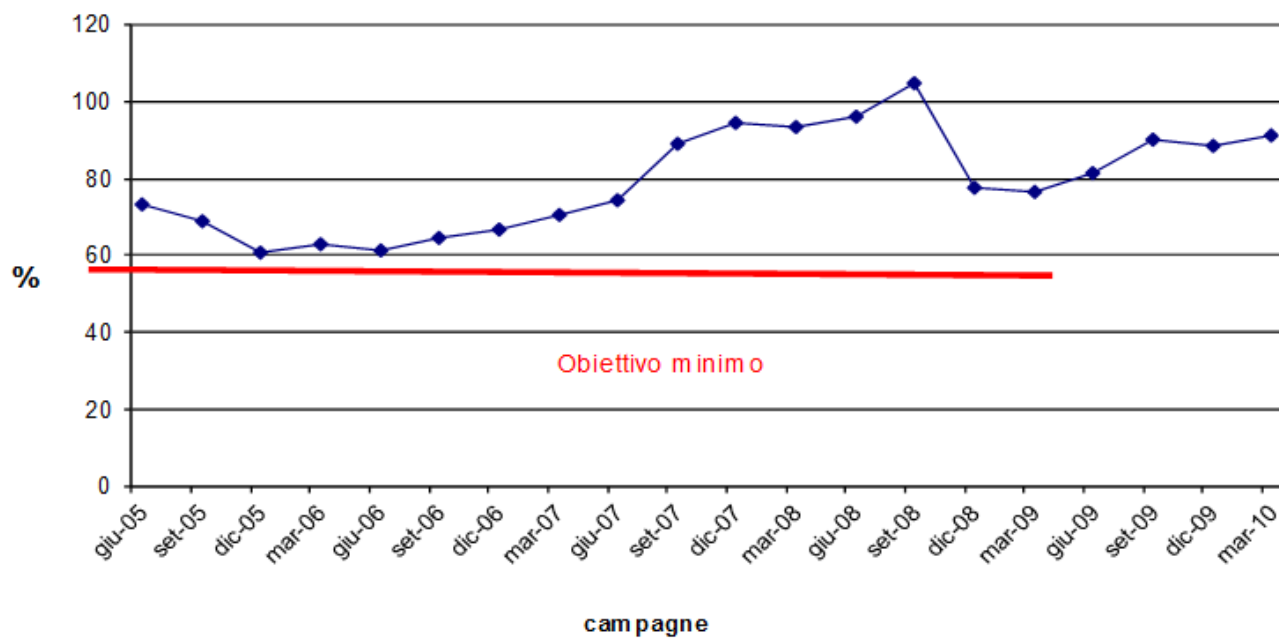
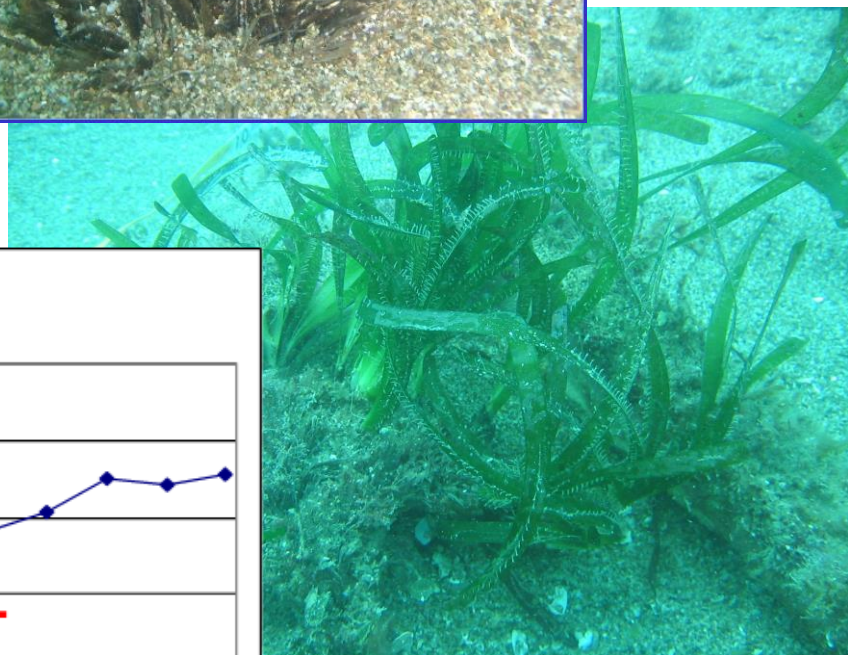
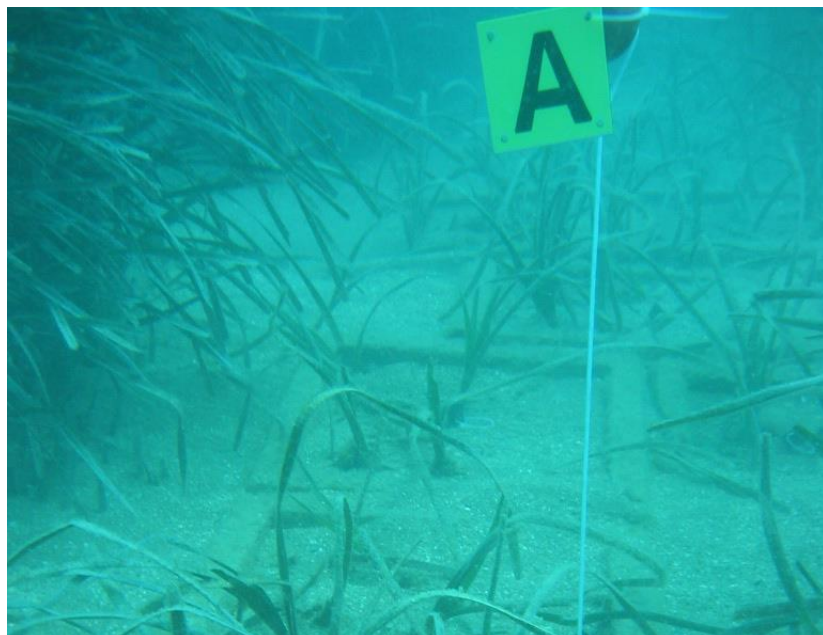


...the value of industrial settlements often collapses!

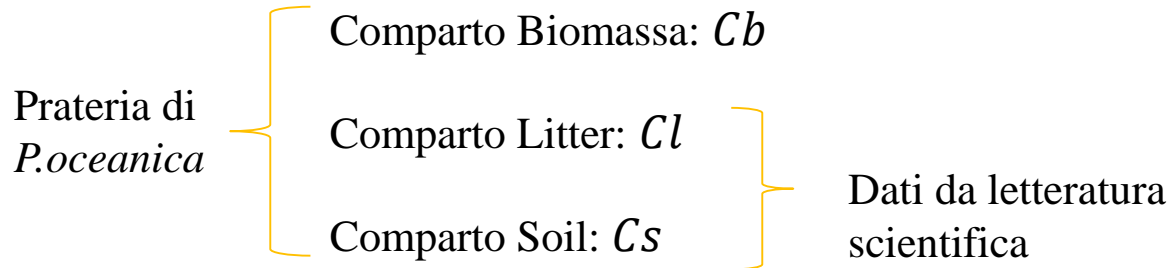








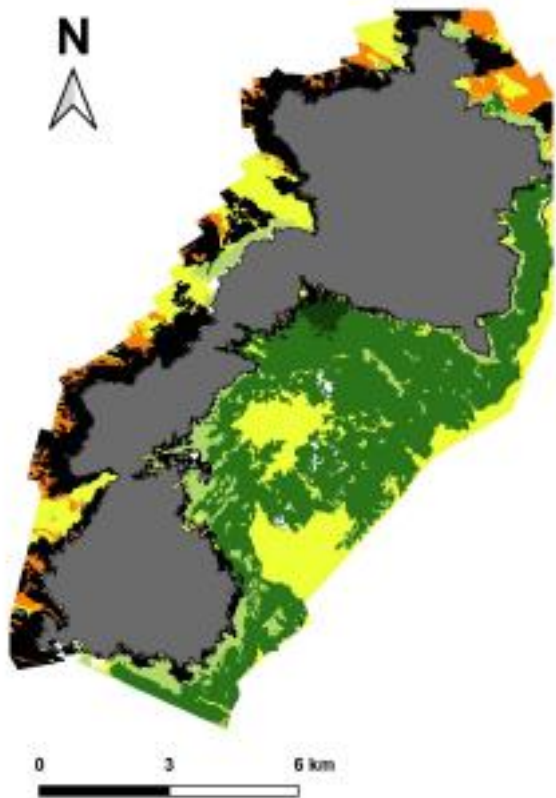
Sequestro di Carbonio



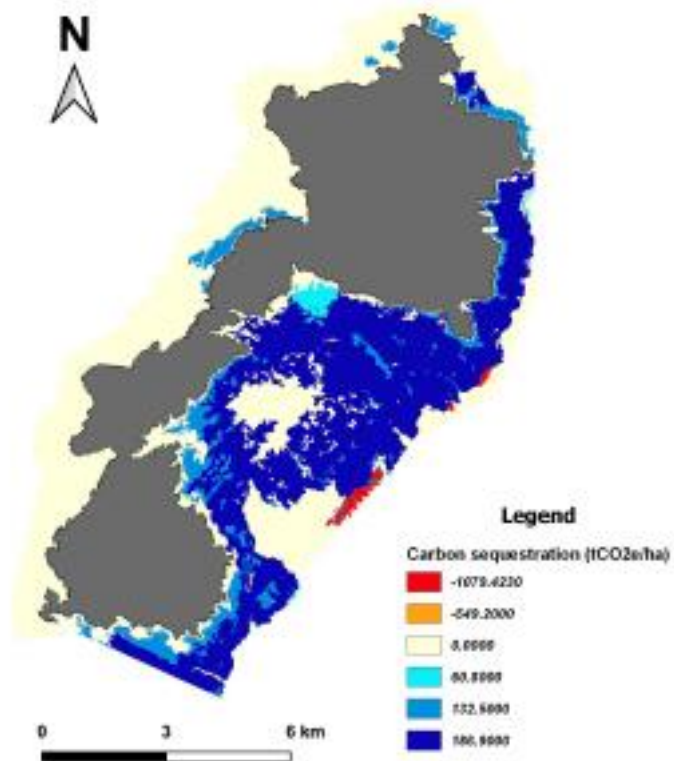
Il Sequestro di Carbonio totale è dato da : $Ct = Cb + Cl + Cs$

Per il trasferimento del valore economico del benefit:

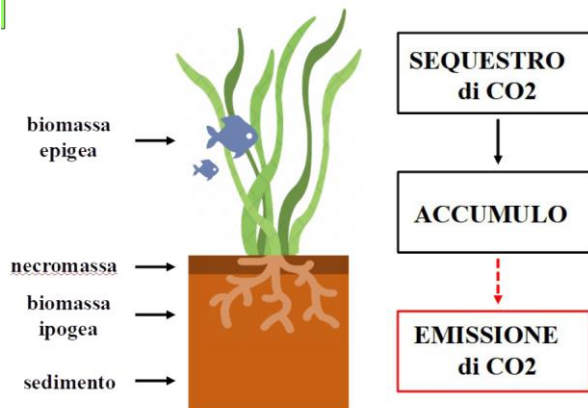
$$C = 0.01 * Ct * 24.7\text{€}$$



Example: Asinara Park

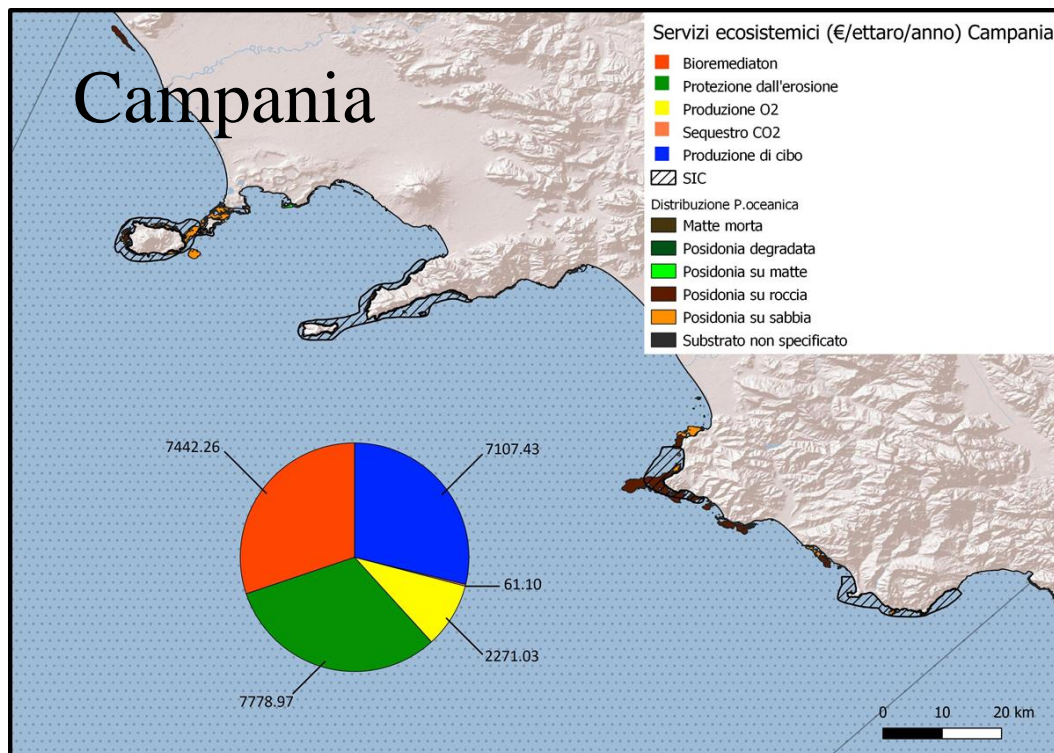


Modello InVEST Coastal Blue Carbon

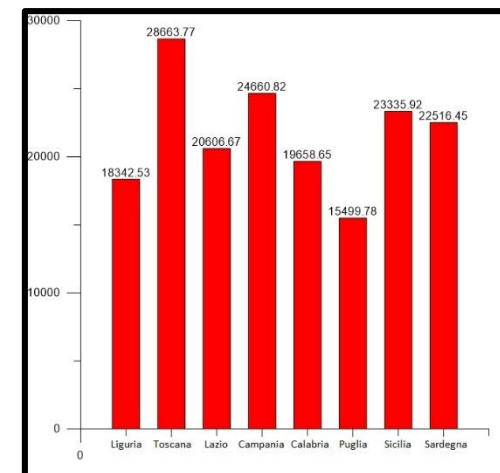
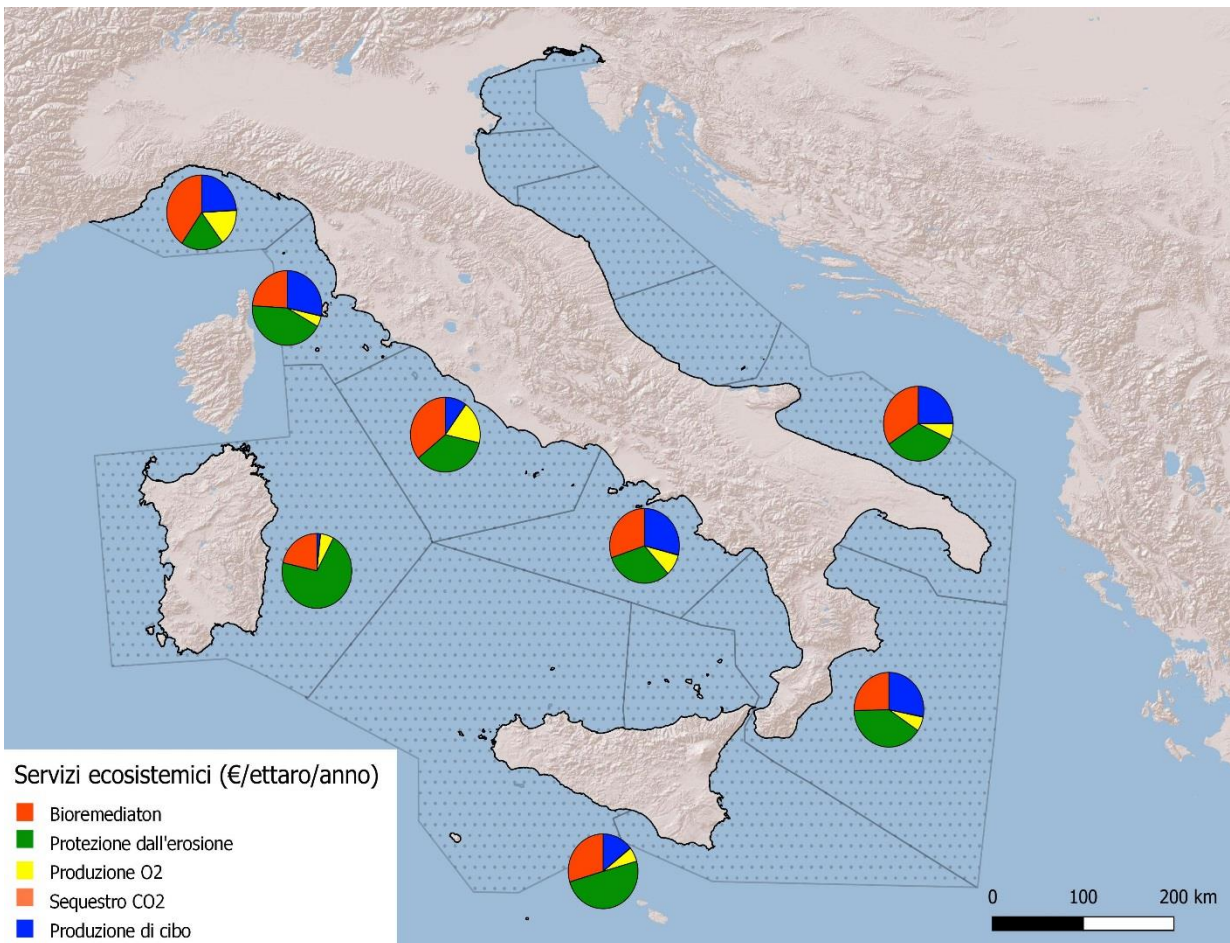


Regione	Sequestro CO2 (€/ha/anno)
Liguria	40.10
Toscana	41.88
Lazio	22.60
Campania	61.10
Calabria	41.77
Puglia	28.60
Sicilia	40.60
Sardegna	34.50

Regione	Produzione O2 (€/ha/anno)
Liguria	2869.01
Toscana	1334.84
Lazio	3809.90
Campania	2271.04
Calabria	1220.46
Puglia	1074.98
Sicilia	1462.66
Sardegna	1392.16



Benefit (%)	Campania
Sequestro CO2	0.25%
Produzione O2	9.21%
Bioremediation	30.18%
Protezione erosione	31.54%
Produzione cibo	28.82%



8 miliardi di euro

Regione	Benefit totali (€/ha/anno)	Estensione <i>P. oceanica</i> (ha)	<i>P. oceanica</i> SIC (ha)	% valore SIC	Valore economico totale (€)	Valore economico SIC (€)
Liguria	18342.5	5050.1	4644.5	92.0	92,632,110.5 €	85,192,384.4 €
Toscana	28663.8	31587.3	10475.9	33.2	905,411,388.8 €	300,277,641.6 €
Lazio	20606.7	21563.6	12156.1	56.4	444,352,939.7 €	250,496,085.9 €
Campania	24660.8	9684.7	4192.4	43.3	238,831,657.0 €	103,386,788.7 €
Calabria	19658.7	7749.9	6170.1	79.6	152,352,375.0 €	121,295,246.6 €
Puglia	15499.8	33842.9	33842.9	100.0	524,557,349.6 €	524,557,349.6 €
Sicilia	23335.9	74928.4	18020.4	24.1	1,748,521,698.8 €	420,522,432.6 €
Sardegna	22516.4	174489.7	44186.4	25.3	3,928,879,205.6 €	994,918,882.1 €
ITALIA	21660.6	358896.5	133688.6	56.7	8,035,538,725.0 €	2,800,646,811.5 €

Regione	Totale dei benefit (€/ha/anno)
Liguria	18342.5
Toscana	28663.8
Lazio	20606.7
Campania	24660.8
Calabria	19658.7
Puglia	15499.8
Sicilia	23335.9
Sardegna	22516.4