



Maritime Spatial Planning: Transboundary Cooperation in the Celtic Seas

Workshop on Cumulative Effects Assessment and Marine Spatial Planning



Co-funded by the
European Union





Workshop Overview



How can Cumulative Effects Assessment methodology be incorporated in MSP?

9.15 - 10.15

Presentations

Welcome

Sue Kidd, University of Liverpool

SIMCelt Case Studies

Caitríona Nic Aonghusa, Marine Institute
Ireland

Frédéric Quemmerais, French
Biodiversity Agency

CEA Experience from Elsewhere

Adrian Judd, CEFAS, United Kingdom

Maria da Luz Fernandes, University of
Aveiro, Portugal

Stefano Menegon, CNR-ISMAR, Italy

10.15 – 11.15

Roundtable Discussions

Strengths and challenges of applying
CEA in MSP processes

Possible solutions to challenges

Key messages



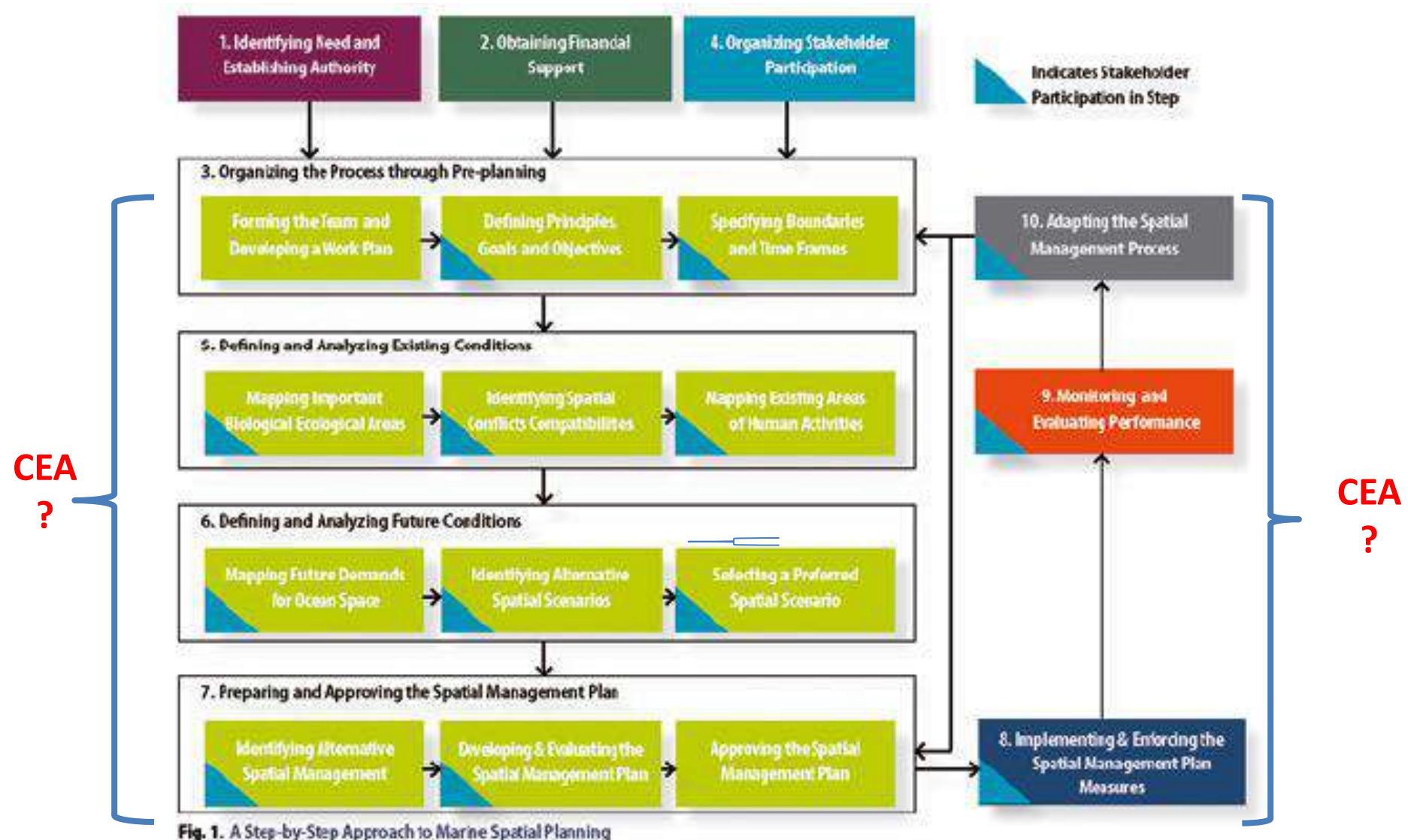
MSP Directive and Cumulative Effects

MSP will contribute to the ***effective management of marine activities and the sustainable use of marine and coastal resources***, by creating ***a framework for consistent, transparent, sustainable and evidence-based decision-making***

MSP should apply an **ecosystem-based approach** with the aim of ***ensuring that the collective pressure of all activities is kept within levels compatible with the achievement of good environmental status and that the capacity of marine ecosystems to respond to human-induced changes is not compromised***, while contributing to the sustainable use of marine goods and services by present and future generations.

The approach will also ***allow for an adaptive management which ensures refinement and further development as experience and knowledge increase***

How can Cumulative Effects Assessment methodology be incorporated in MSP?



How can Cumulative Effects Assessment methodology be incorporated in MSP?

Roundtable Discussions (45 mins)

- Introductions
- Strengths and challenges of applying CEA in MSP processes
- Possible solutions to challenges
- 3 Key messages

Group Feedback (15mins)

11.15 Coffee Break!!!





Addressing cumulative effects assessment in Marine Spatial Planning: Findings from the SIMCelt Irish Sea case study.

Caitríona Nic Aonghusa, Caoimhin Kelly, Eugene Nixon
Marine Institute

Assessment of Cumulative Effects in the Irish Sea

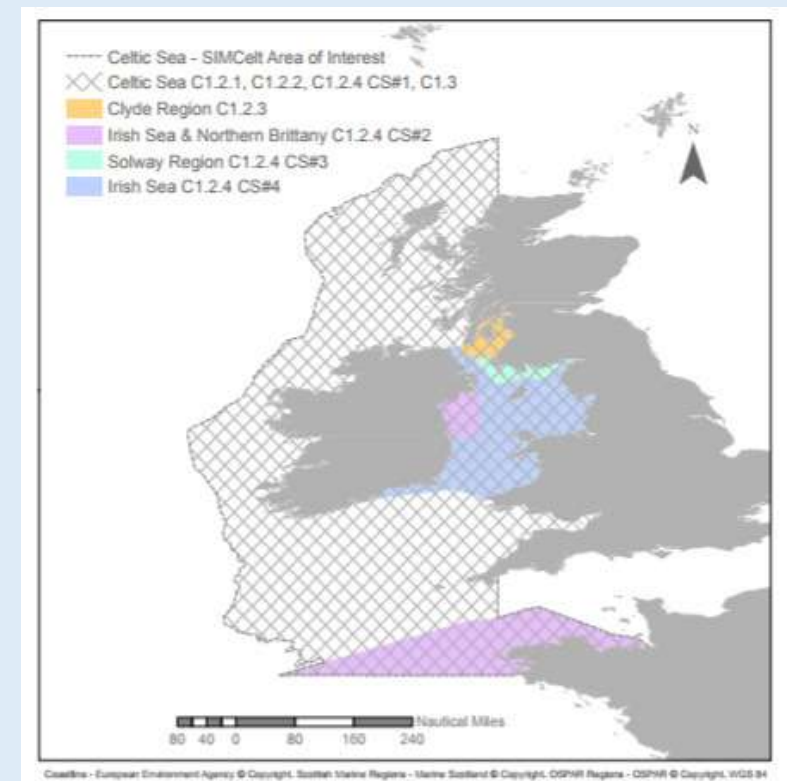


- *Approach:*

- ✓ – Identify and map the human activities, habitats and conservation area;
- ✓ – Assess the resulting pressures;
- ✓ – Determine the cumulative effects relevant to planners.

- *Outputs:*

- ✓ – Maps of human activities, receiving environment (sensitivity) and pressures for the Irish Sea (seabed disturbance);
- Recommendations on cumulative effects assessment methodology



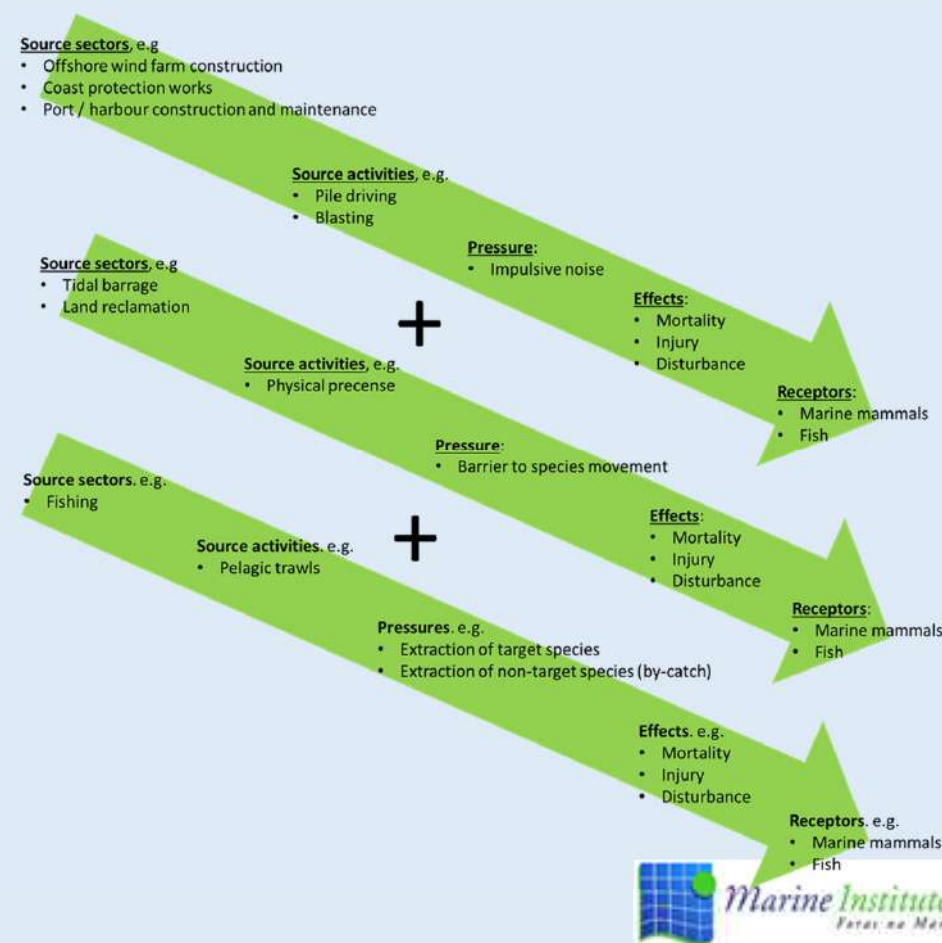
Cumulative Effects Assessment

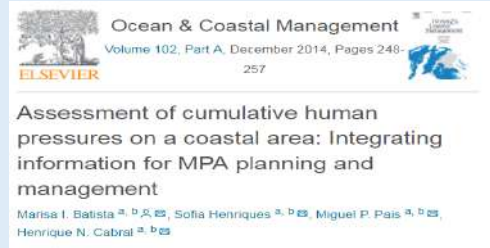
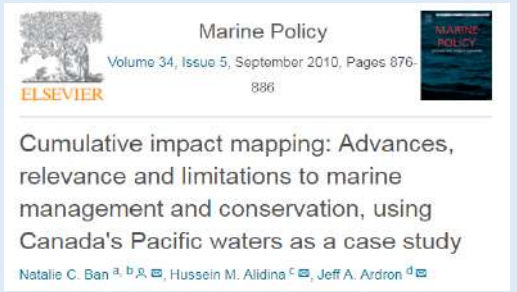
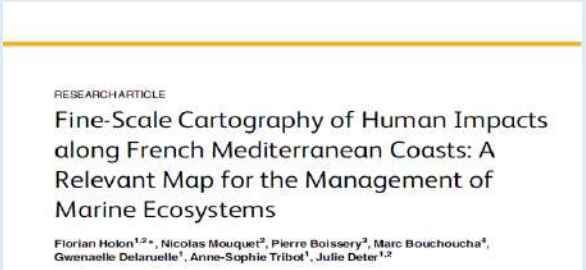
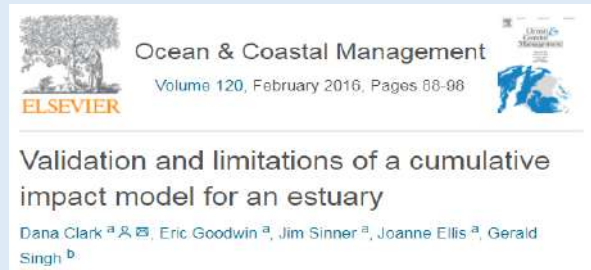
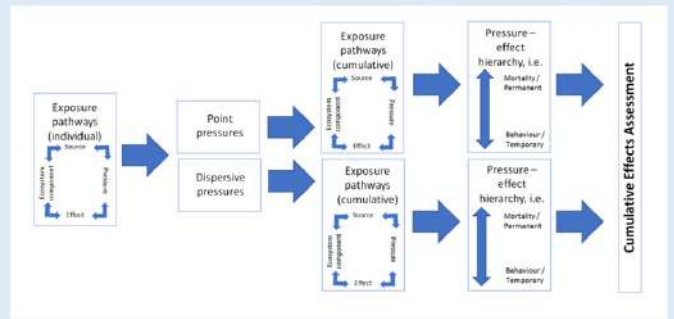
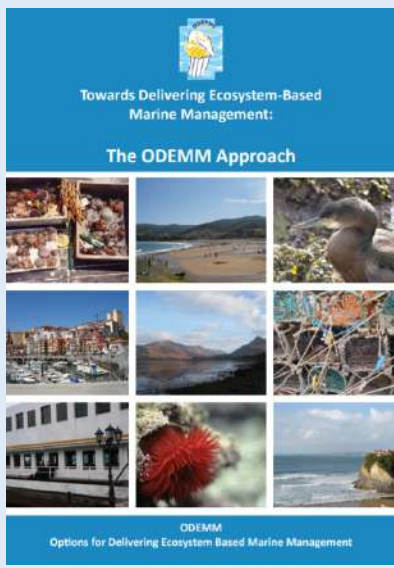
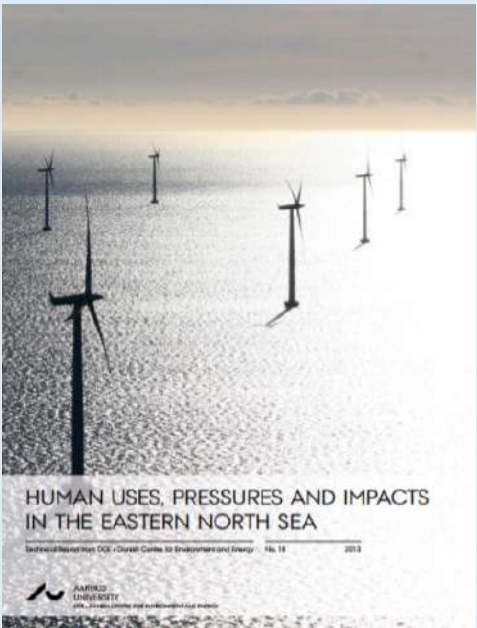
- A systematic procedure for identifying and evaluating the significance of effects from multiple sources and for providing an estimate of the overall expected impact;
- Multiple legislative drivers for CEA;
- The aim of CEA for MSP is to provide a composite of activities, pressures and the ecosystem in a way that the effects can be traced back to causal factors
- Lack of clarity on how 'cumulative effects' are defined with respect to the implementation of MSP Directive;

(Judd et al., 2015)



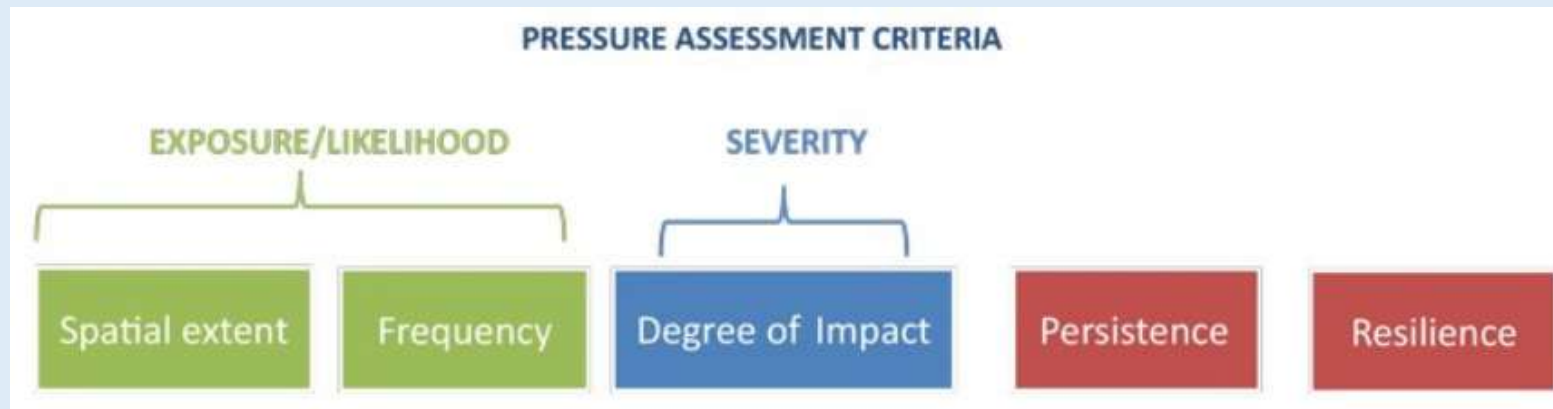
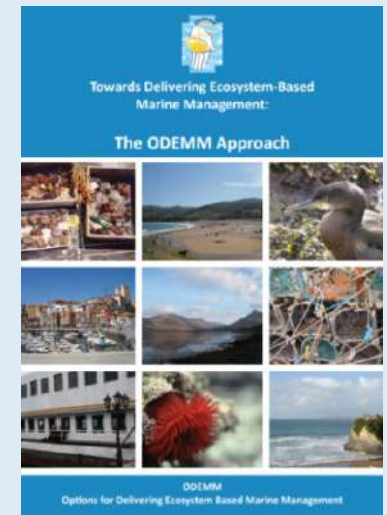
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ODEMM Tool

- *Options for Delivering Ecosystem Based Marine Management (ODEMM)* is an ecosystem-based marine management tool.
- SIMCelt is using ODEMM Pressure Assessment to
 - Identify the activities causing pressure in the Irish Sea
 - Prioritise pressures in the Irish Sea.
 - Assess sensitivity of receiving environment



(Robinson et al., 2014)

ODEMM Irish Sea Pressure Assessment

Human Activities

Aggregates
Agriculture
Aquaculture
Beam Trawling
Bottom Trawling
Coastal Infrastructure
Dredging
Harvesting/Collecting
Land-based Industry
Military
Non-renewable (oil & gas)
Nuclear
Pelagic Trawling
Potting
Renewable Energy
Research
Shipping
Telecommunications
Tourism/Recreation
Waste Water

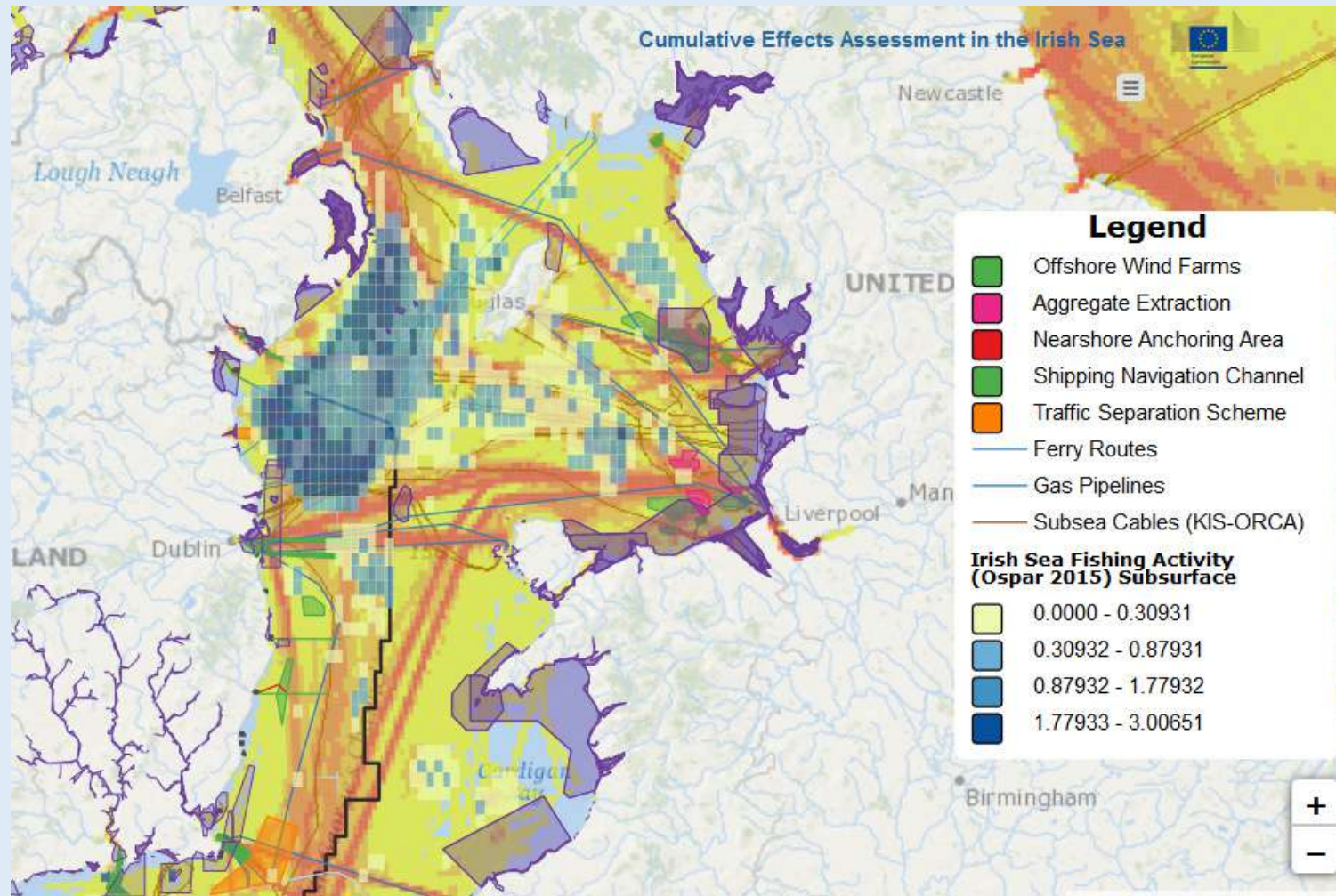
Pressures

Abrasion
Barriers
Bycatch
Current Changes
Discards
Emergence Regime
EMF
Incidental Loss
Invasive Species
Litter
Noise
Non-living Resources
Non-synthetic Compounds
Organic Enrichment
pH Changes
Radionuclides
Salinity Regime
Sealing
Siltation
Smothering
Species Extraction
Synthetic Compounds
Thermal Regime
Wave Exposure

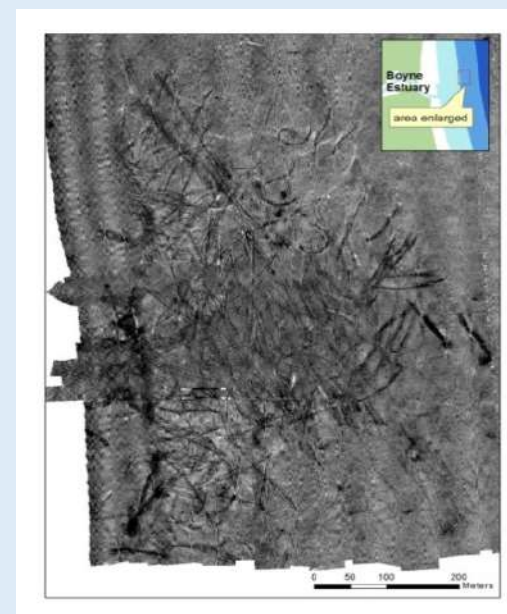
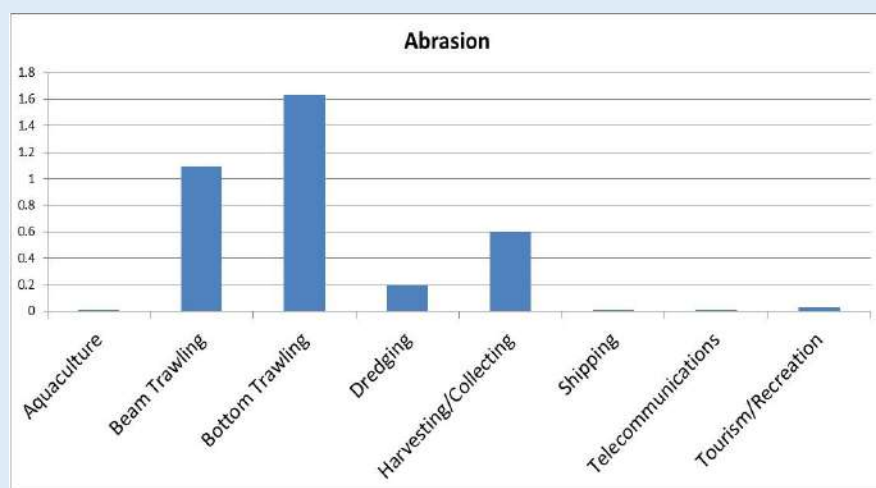
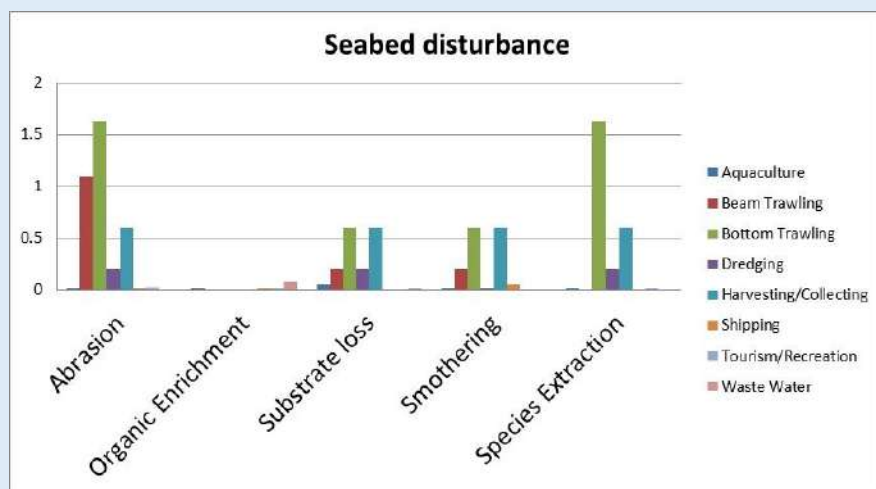
Ecosystem Components

Baleen Whales
Cephalopods
Coastal Pelagic
Demersal Elasmo
Demersal Fish
Littoral Rock & Reef
Littoral Sediment
Pelagic Elasmo
Pelagic Fish
Reptiles
Seabirds
Seals
Shallow Mud
Shallow Rock & Reef
Shallow Sediment
Shelf Pelagic
Shelf Rock & Reef
Shelf Sediment
Toothed Whales

Human Activities



Pressure Assessment









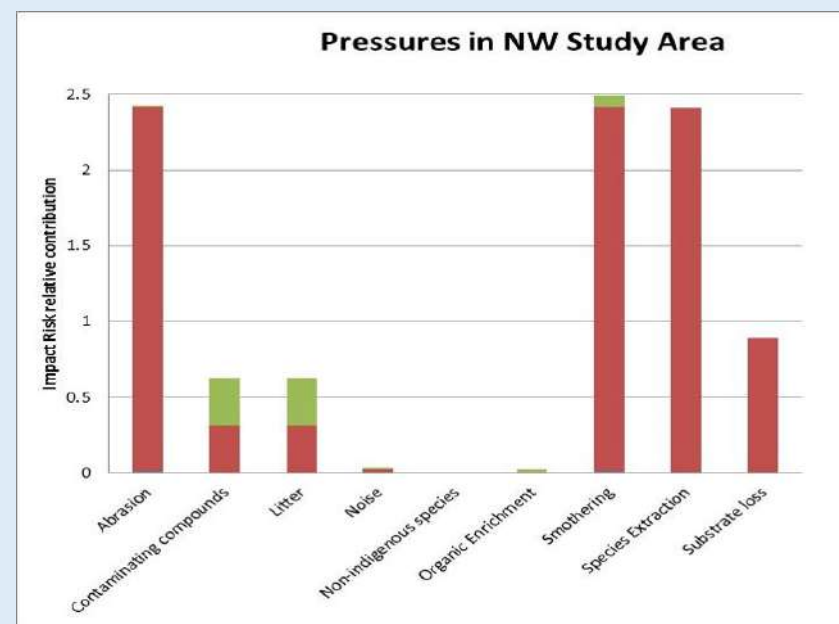
Backscatter (INFOMAR)

ODEMM Pressure Assessment tool was used to identify and weight the interactions between human activities, resultant pressures and ecological components and helps to determine which activities to prioritise for management.

Mapping Pressures

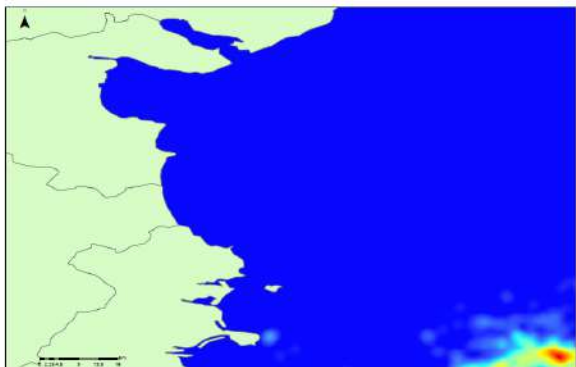


Human Activity	Abrasion Weighting*	
Aquaculture		0.002
Beam Trawling		0.273
Bottom Trawling		0.608
Dredging		0.042
Shipping		0.001
Tourism/Recreation		0.004

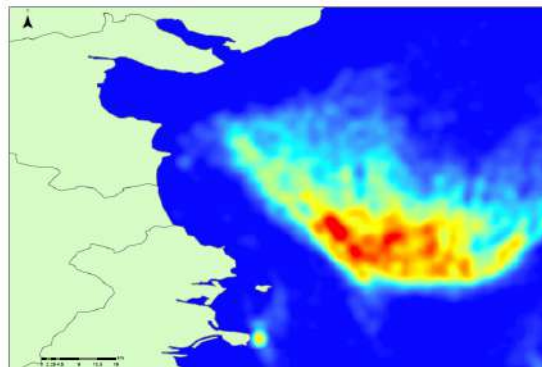


- Each activity was weighted based on an impact risk score calculated using the ODEMM pressure assessment tool
- The GIS methodology to model pressures was based on Lee et al. (2010).

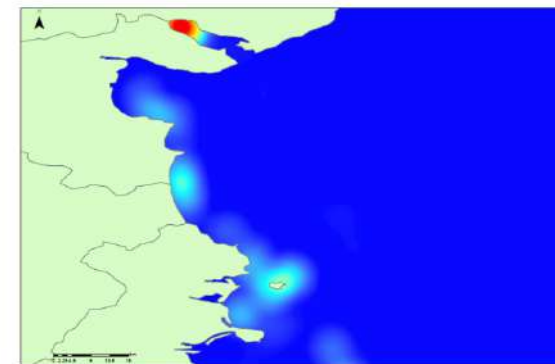
*ODEMM Impact Risk Score



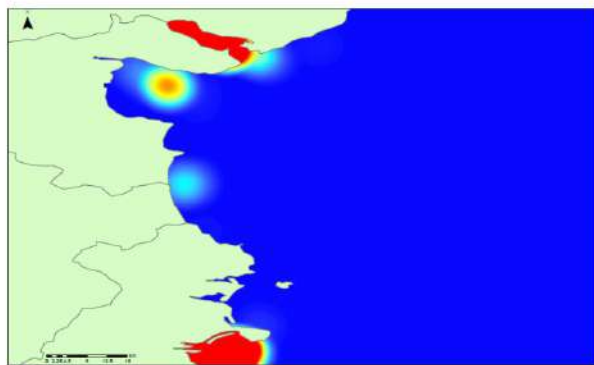
Beam trawling



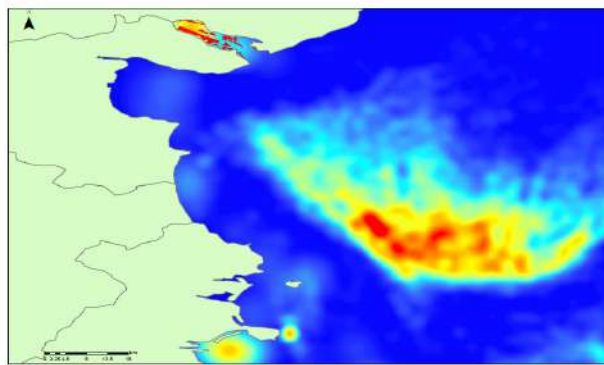
Bottom trawling



Dredging



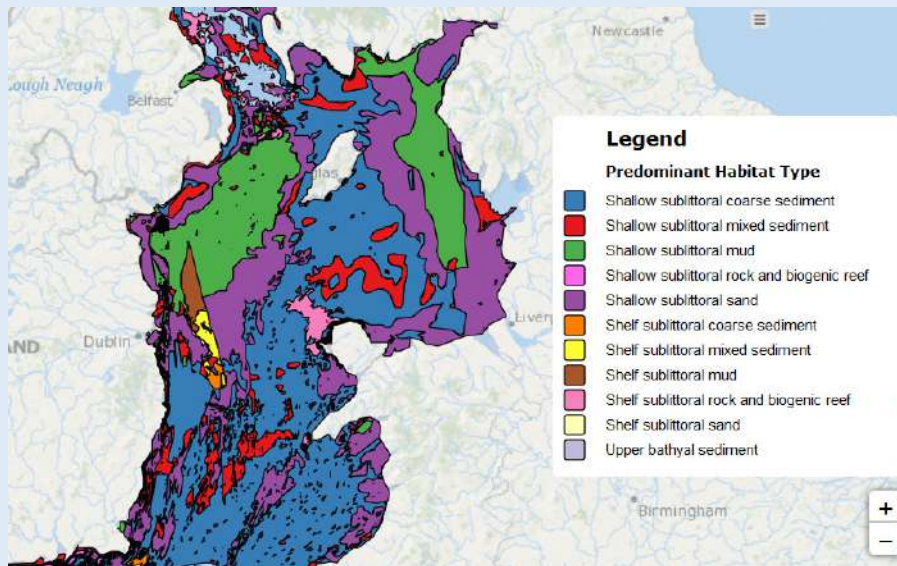
Shipping



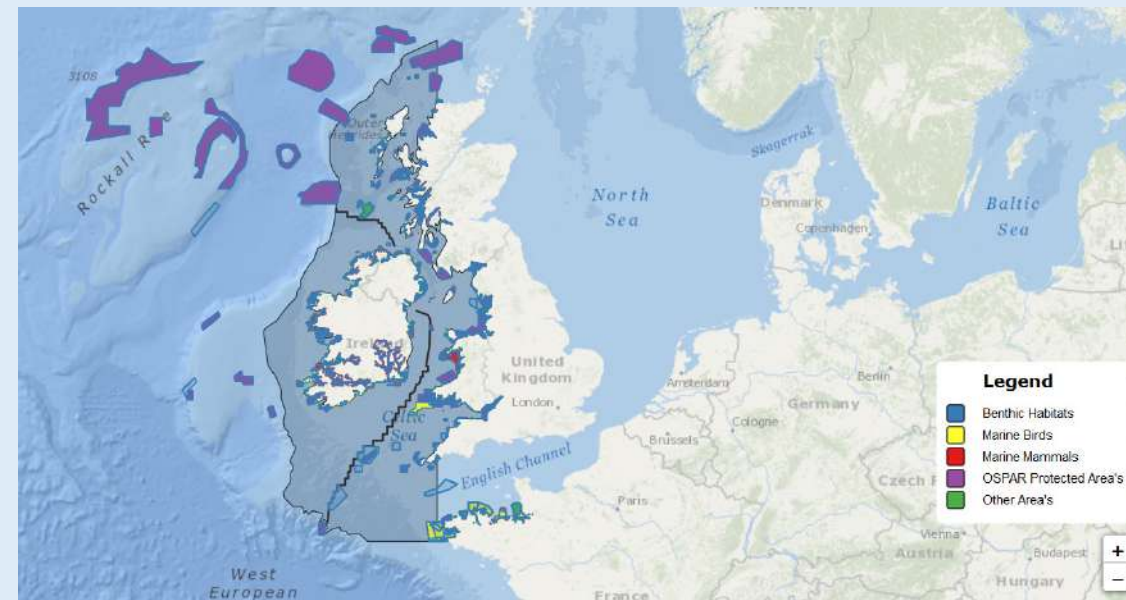
All Activities

Mapping Abrasion Pressure

Receiving Environment

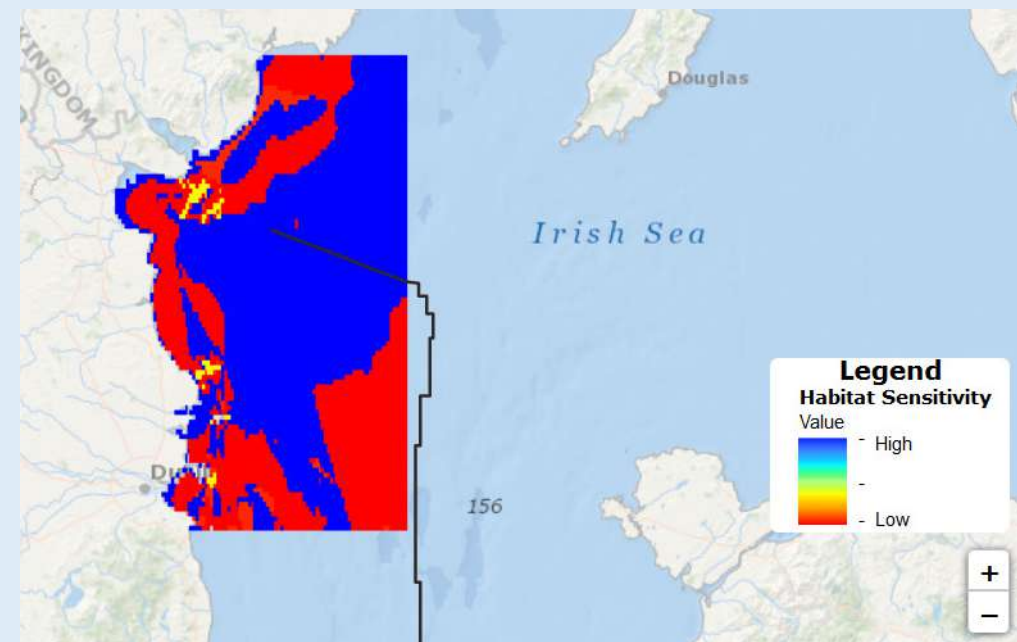
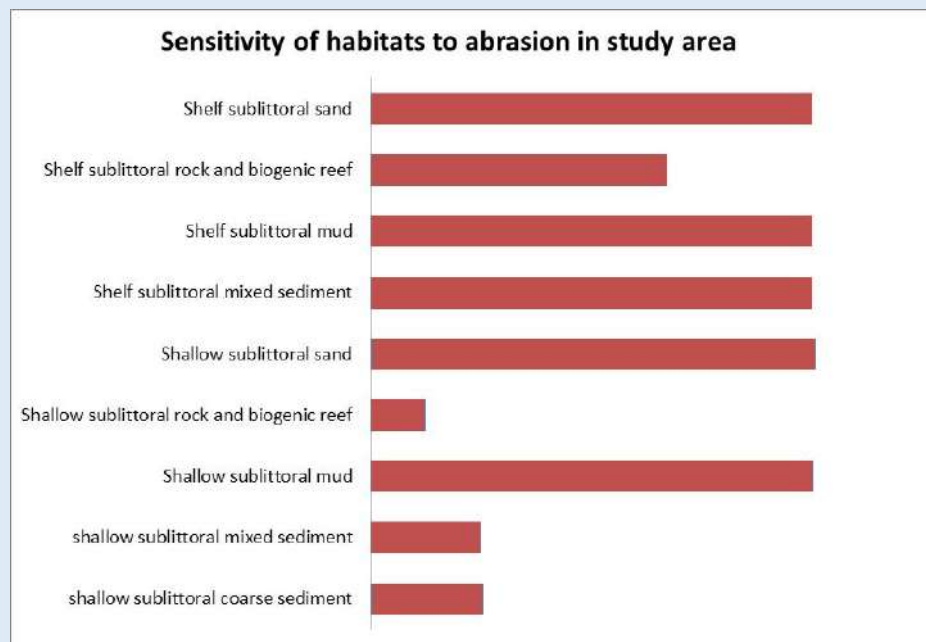


Predominant Habitat Types



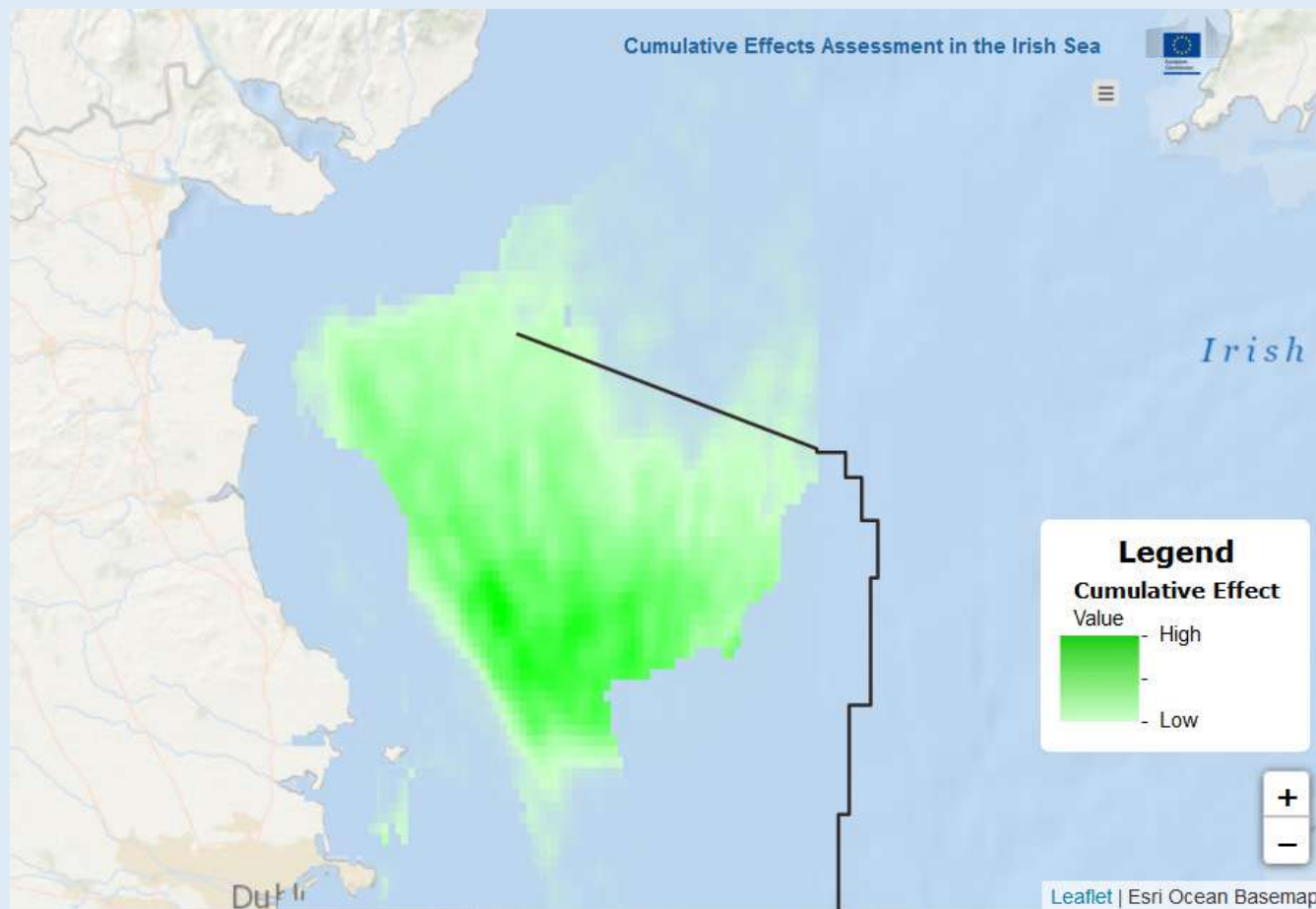
SIMCelt database of MPAs in the Celtic Seas

Mapping the Sensitivity of the Receiving Environment



Cumulative Effects Assessment for MSP needs to consider both the exposure to the activity and the capacity of the receiving environment to assimilate the pressure.

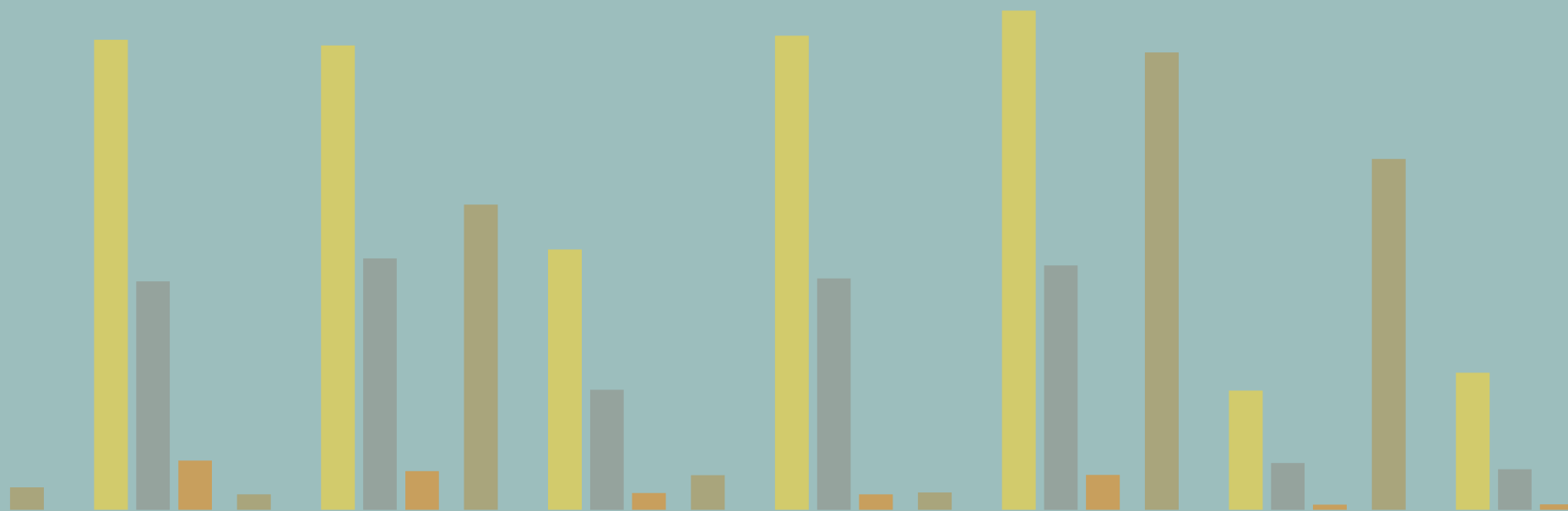
Spatial Distribution of the Cumulative Effect





What have we learnt about CEA in MSP?

- Generating maps to report CEA does not fully address the requirements of MSP;
- Need to consider scale, baseline conditions and temporal changes;
- Addressing Cumulative Effects Assessment in MSP is a process:
 - Purpose of the cumulative effects assessment
 - Scoping process using ecosystem-based approach
 - Collation of data
 - Risk of impact
 - Environmental Effect
 - Development scenarios
 - Reporting and visualising cumulative effects
 - Identify management options



29th November 2017

How the cumulative impacts approach supports Maritime Spatial Planning?

The Portuguese Case Study

Maria da Luz Fernandes
Fátima L. Alves

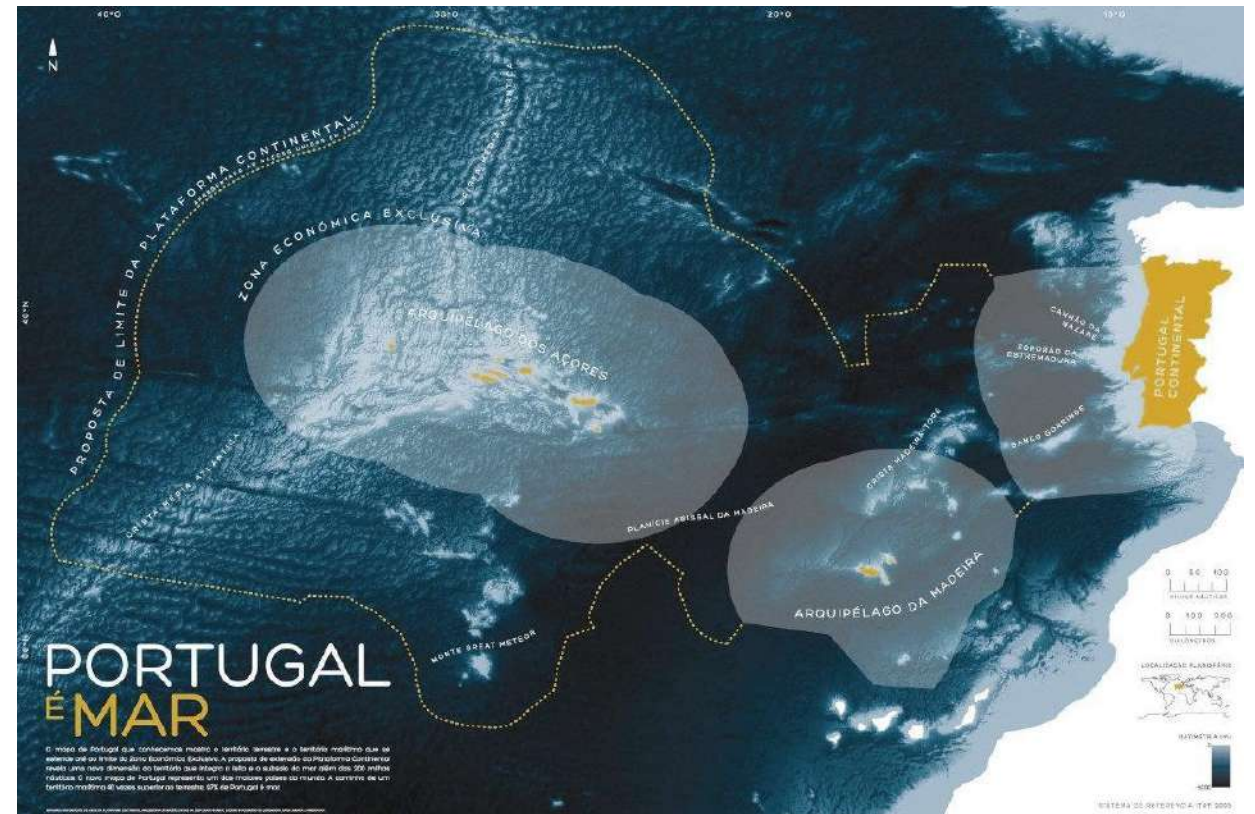
CONTENTS

Aims and Study Area

Method

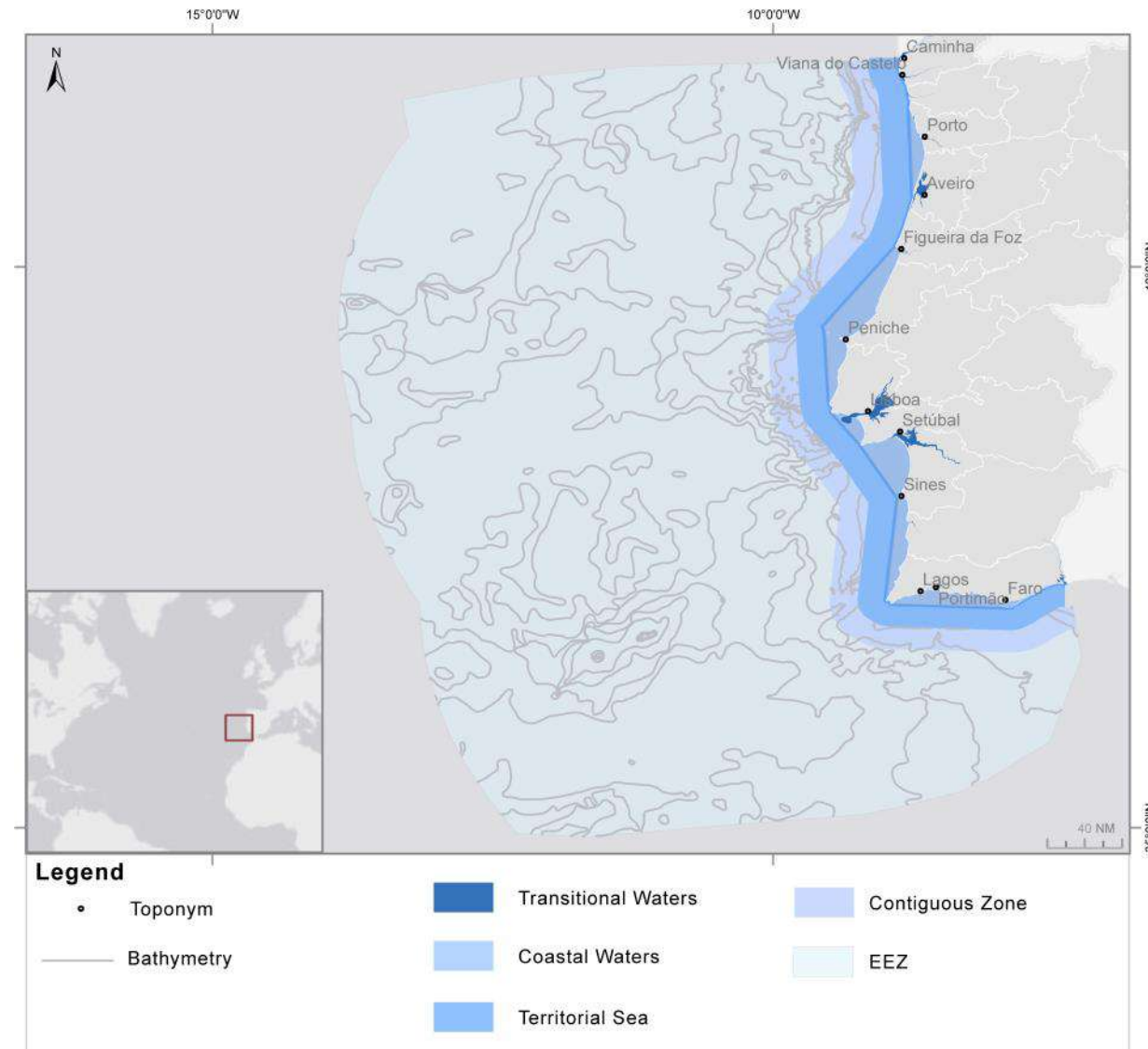
Results

Strengths and Challenges



AIMS AND STUDY AREA

- ✓ To adapt a Cumulative Impacts Model (CIM) for the Portuguese Maritime Space
- ✓ To analyze to which extent such models can be used to aid spatial planning

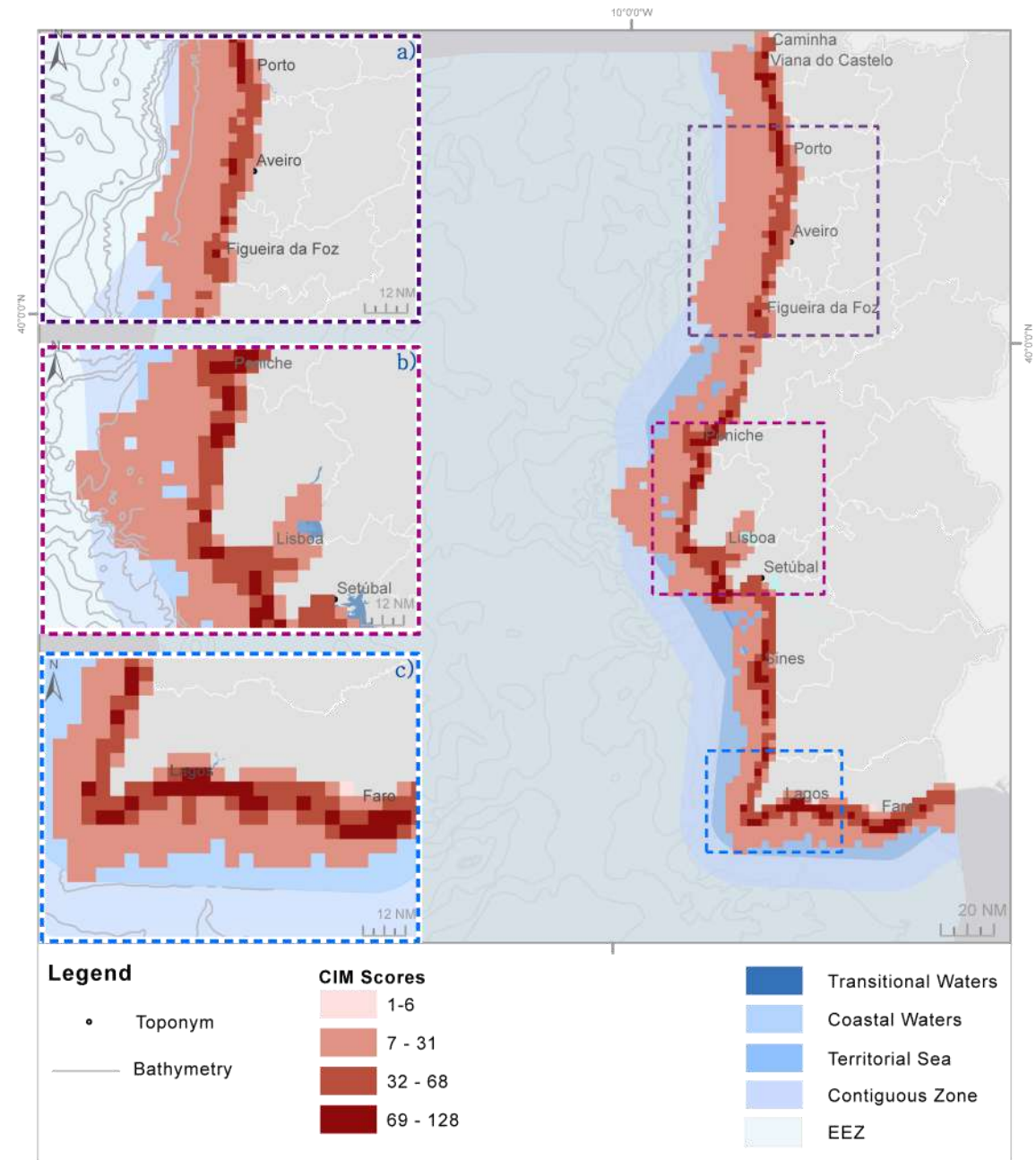


Results

✓ Cumulative Impacts Model (CIM)

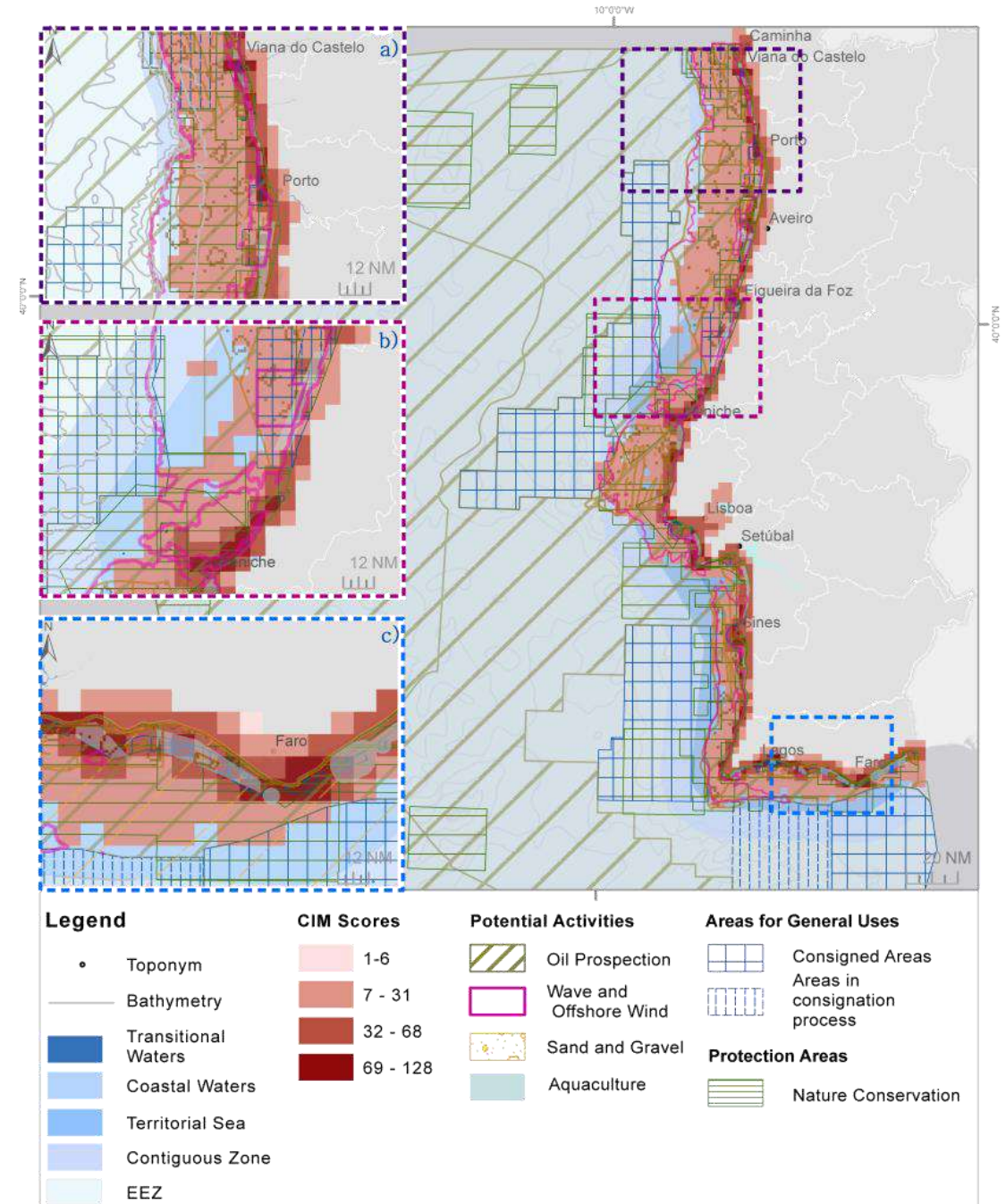
Higher CIM values in:

- Viana do Castelo/Figueira da Foz
- Peniche/Setúbal
- Lagos /Faro



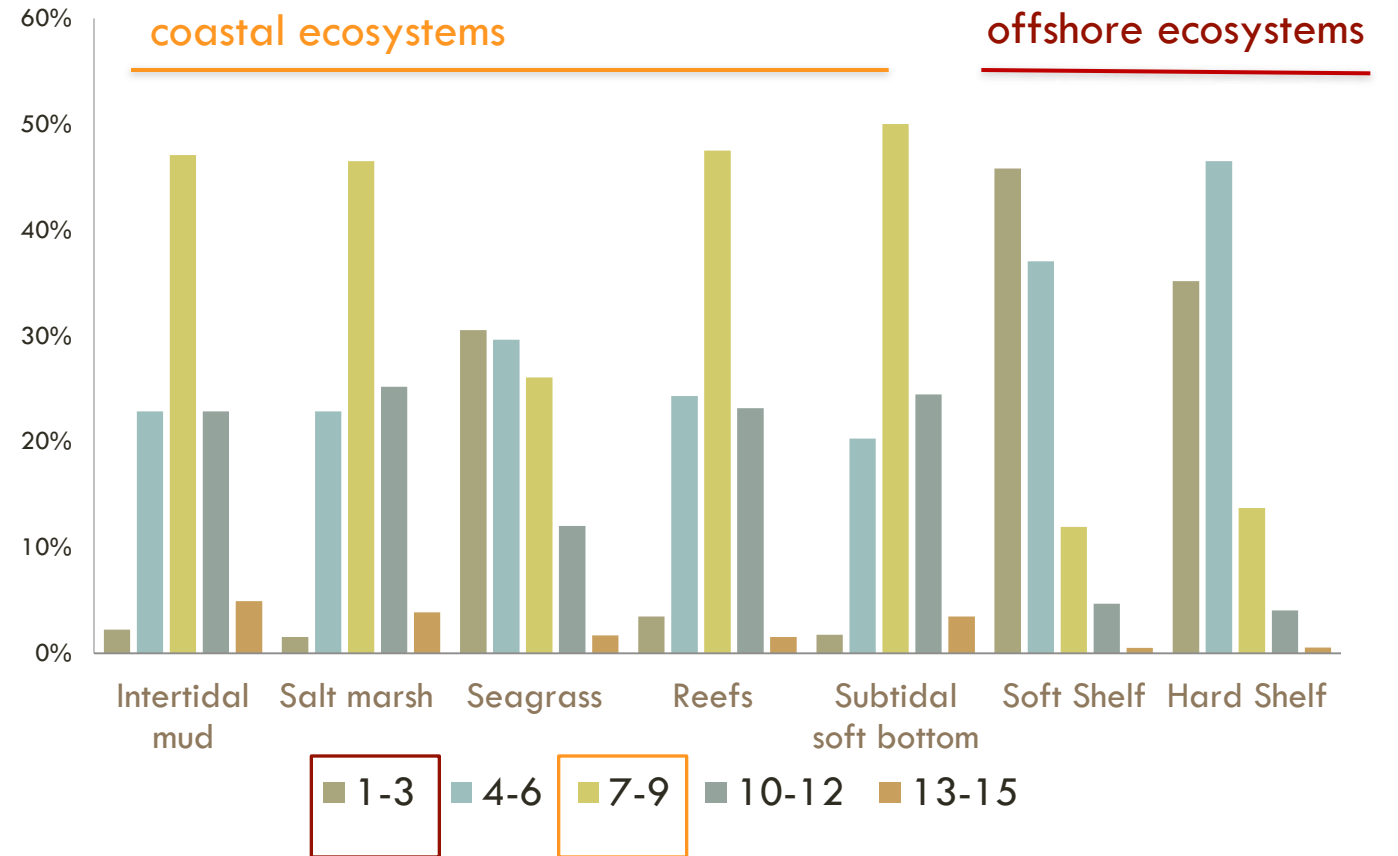
RESULTS

- ✓ Overlapping of CIM scores with the POEM MSP Proposal
 - Higher CIM values ranks occurring in places with nature conservation interest; and potential activities may still occur on top of existing ones



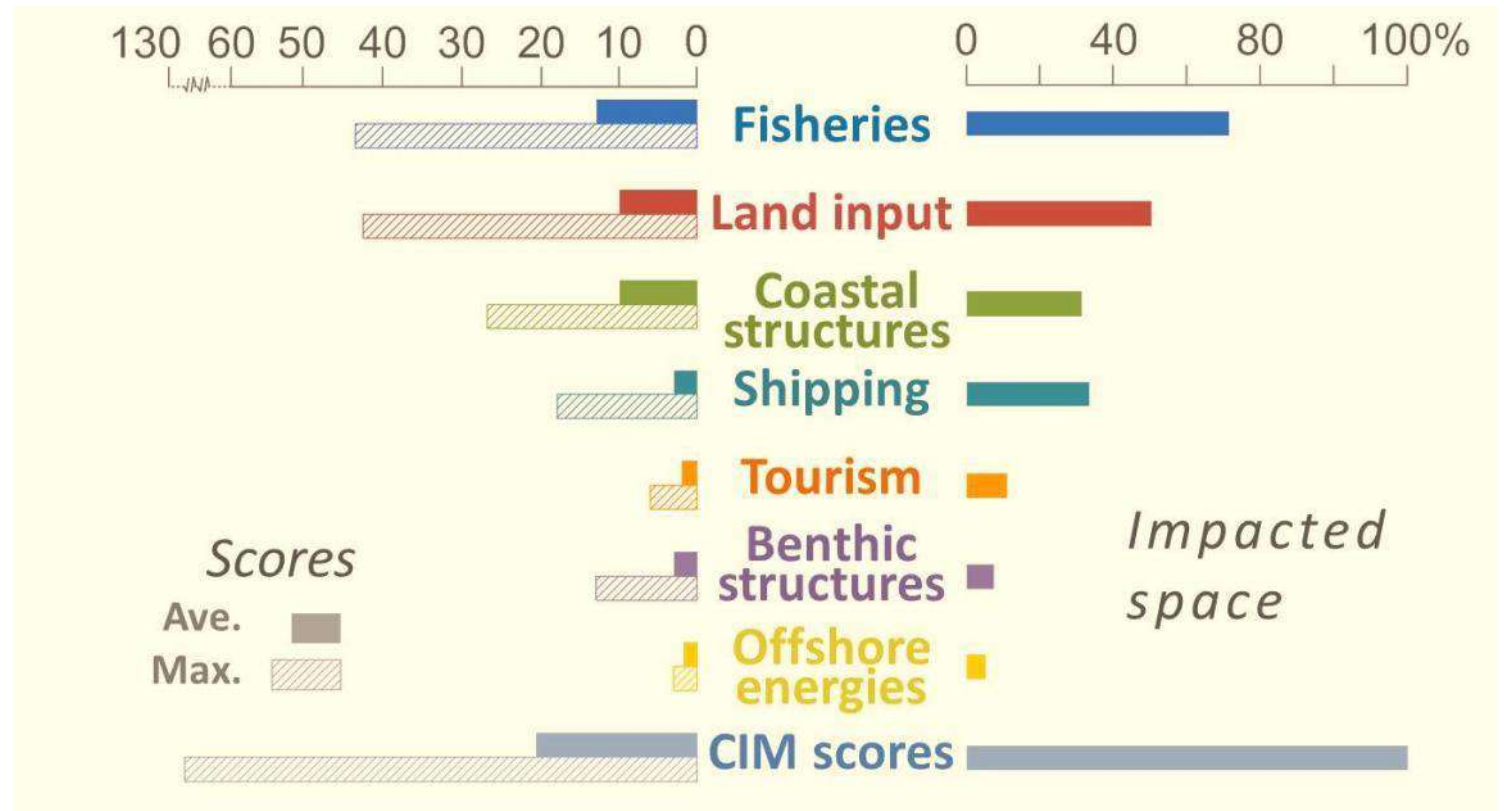
RESULTS

- ✓ Number of activities and uses occurring simultaneously within each ecosystem



RESULTS

- ✓ Scores and impacted space grouped by theme



RESULTS

✓ Compatibility matrix
activities/uses and
species; habitats
according with POEM

Activities/ uses	MPA (Total)	MPA (P or C)	SIC	ZPE	MIBA	Partial/total submerged caves ²	Reefs	Sandbanks	River mouths submarine canyons;	Underwater heritage
Energy Production	I		RPM						I	I*
Offshore Wind Parks	I	I		I	I					
Wave energy Parks		RPM	RPM	RPM	RPM					
Mineral resources exploration prospection		RPM	RPM	RPM	RPM	RPM	I		I	I*
Oil Prospection Exploration	I	RPM	RPM	RPM	RPM/ N	RPM	RPM		RPM SP	
Carbon Sequestration	I	I(P)/ RPM (C)	RPM	RPM	RPM	RPM	I		I	I
Coastal Defense	I						I			I
Navigation Channels	I					R/D	R/D	R/D		I*
Infrastructures	I									RPM**
Harbors / Port works	I					R/D	R/D	R/D		
Dredging	I					I	I			RPM**
Commercial Harbors						R/D	R/D	R/D		
Fishing harbors	E					E		E		
Fishing Trawling										RPM**
Aquaculture Floating						I		I		RPM**
Tourism										I*/RPM**
Defense										RPM**
Submarine cables										RPM**

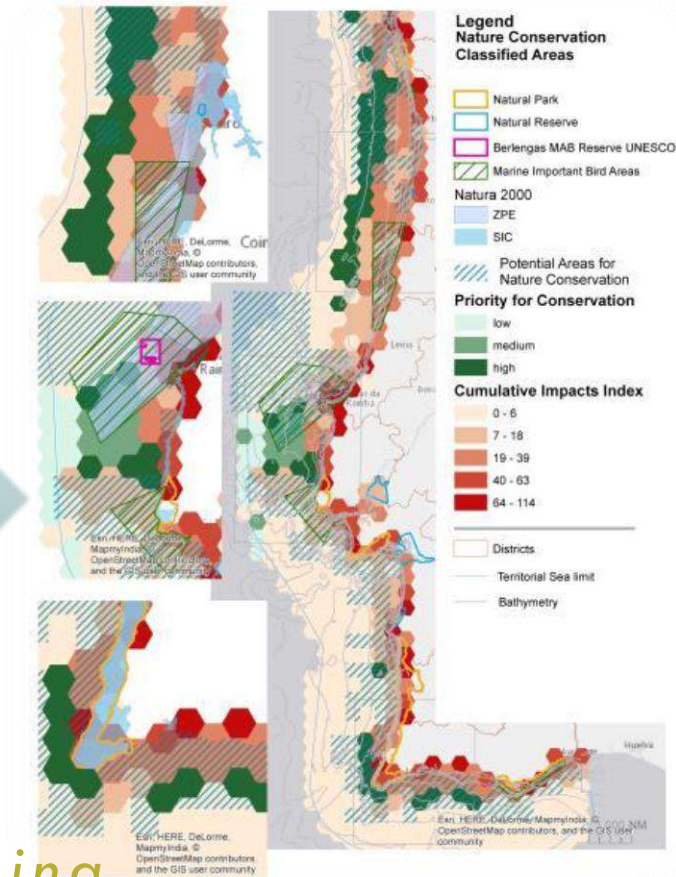
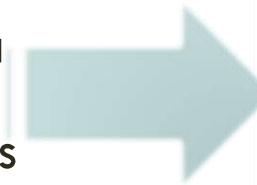
I not compatible E Exclusion RPM Requires Protection Measures R/D Substantial Limitations/Restrictions

STRENGTHS AND CHALLENGES

- ✓ Informs on patterns of impacts
- ✓ Provides inputs on the ecosystems conditions and carrying capacity (although a DPSIR analysis is needed)
- ✓ Informs where reductions in anthropogenic pressures should be an explicit goal
- ✓ Is a flexible tool that can be used for managing and monitoring the measures already in place
- ✓ Assists in management scenarios within EBM approach

STRENGTHS AND CHALLENGES

- ✓ Better spatially available data on ecosystems, pressures and indicators
- ✓ CIM approach with addition of habitats and species data would improve marine management; i.e. using tools such as Marxan/Marxan with Zones



Ongoing...



Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind



How does the cumulative impacts approach support Maritime Spatial Planning?



Maria da Luz Fernandes*, Tanya C. Esteves, Eduardo R. Oliveira, Fátima L. Alves*

Department of Environment and Planning & CESAM-Centre for Environmental and Marine Studies, University of Aveiro, Campus de Santiago, 3810-193 Aveiro, Portugal

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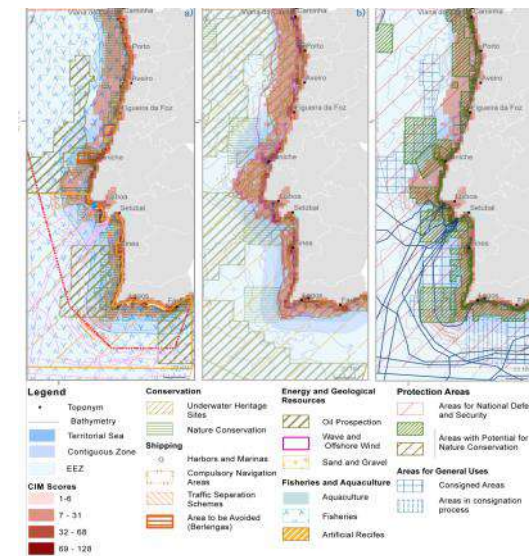
Ocean activities and uses

Conflicts

Ecosystem based management

Ocean management

Portugal



<http://dx.doi.org/10.1016/j.ecolind.2016.09.014>

THANK YOU



maria.luz@ua.pt



<http://www.cesam.ua.pt/marialuz>

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We are thankful to Direcção Geral de Política do Mar (DGPM) for supplying of data within the scope of POEM



OSPAR: risk-based cumulative effects assessment

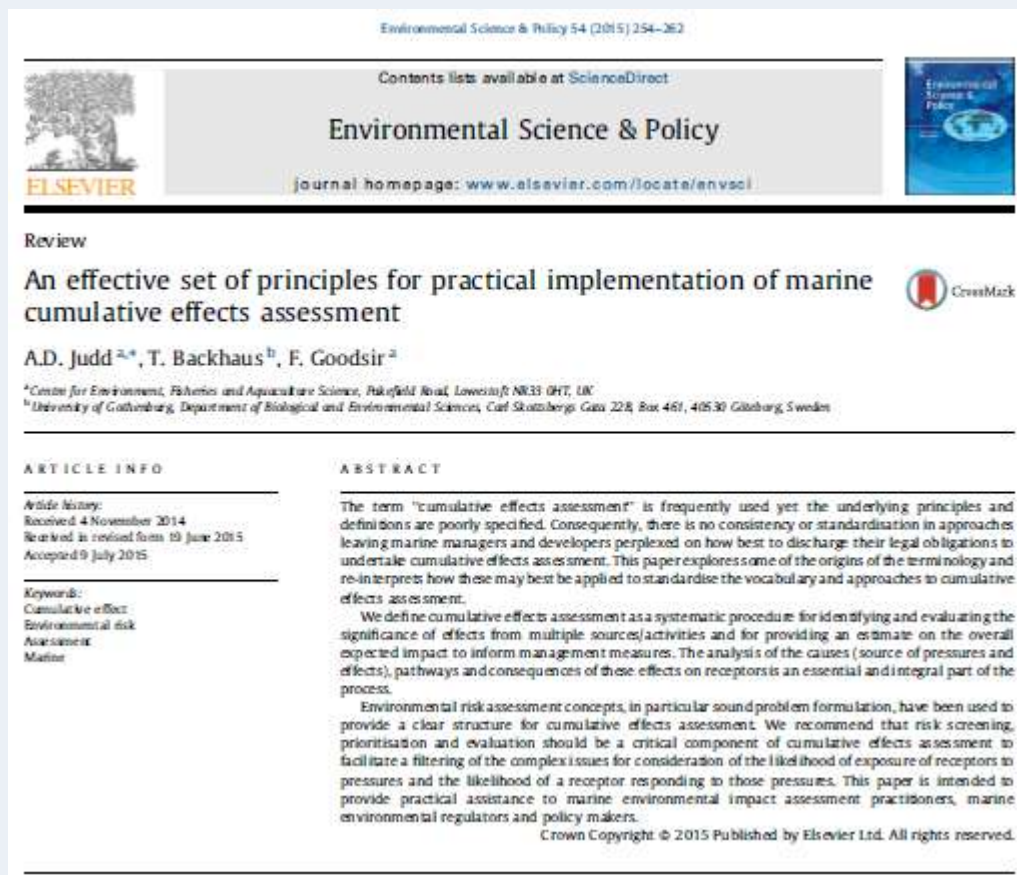
Adrian Judd



Centre for Environment
Fisheries & Aquaculture
Science



Cefas



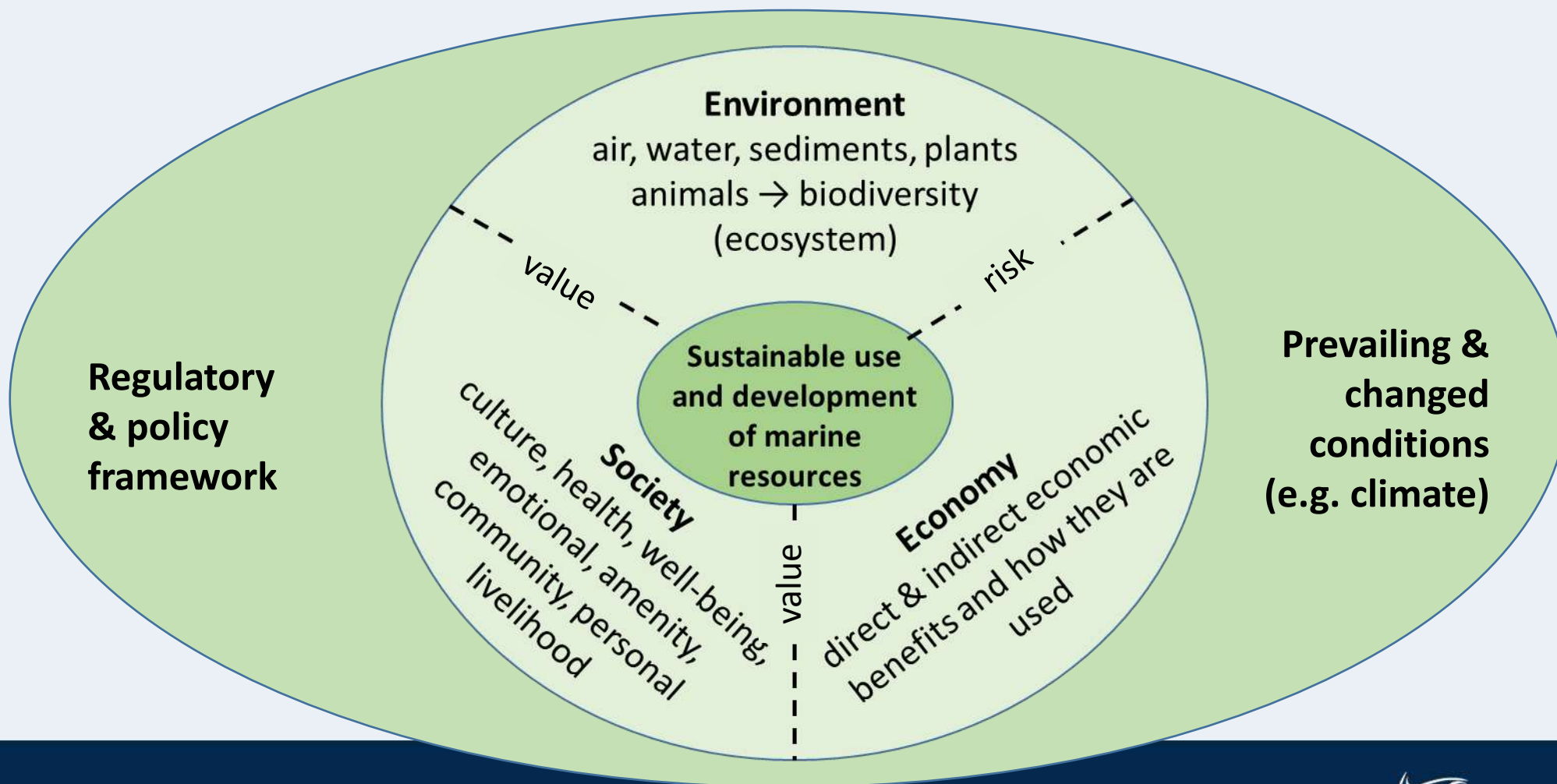
- Robinson, L. A., Culhane, F. E., Baulcomb, C., Bloomfield, H., Boehnke-Henrichs, A. Breen, P., Goodsir, F., Hussain, S. S., *et al.* 2014. Towards delivering ecosystem-based marine management: The **ODEMM** Approach. Deliverable 17, EC FP7 Project (244273) '**Options for Delivering Ecosystem-based Marine Management**'. University of Liverpool. 96 pp.
- ICES. 2014. Report of the Joint Rijkswaterstaat / DFO / ICES Workshop : Report of the Risk Assessment for Spatial Management (WKRASM), 24-28 February 2014, Amsterdam, the Netherlands. ICES CM 2014/SSGHIE:01. 38 pp.



- Common principles for CEA
- Risk-based CEA
- Consideration of environmental, social and economic parameters
- Incorporation of management measures (including consideration of effectiveness)
- Consideration of prevailing and changing conditions
- Aligned with amended Annex III (2017/845) of the EC Marine Strategy Framework Directive (MSFD)
- Focus assessment on cumulative effects

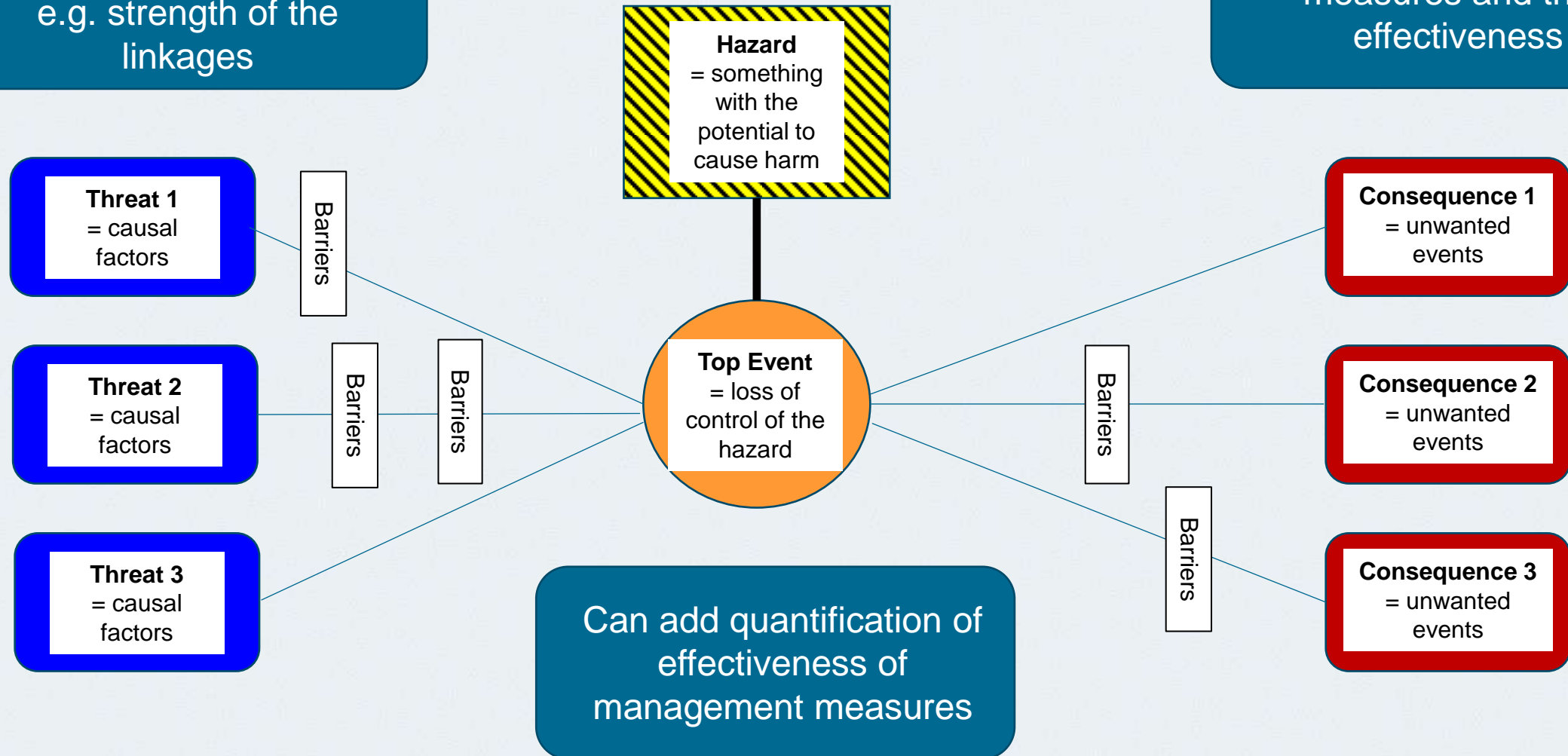


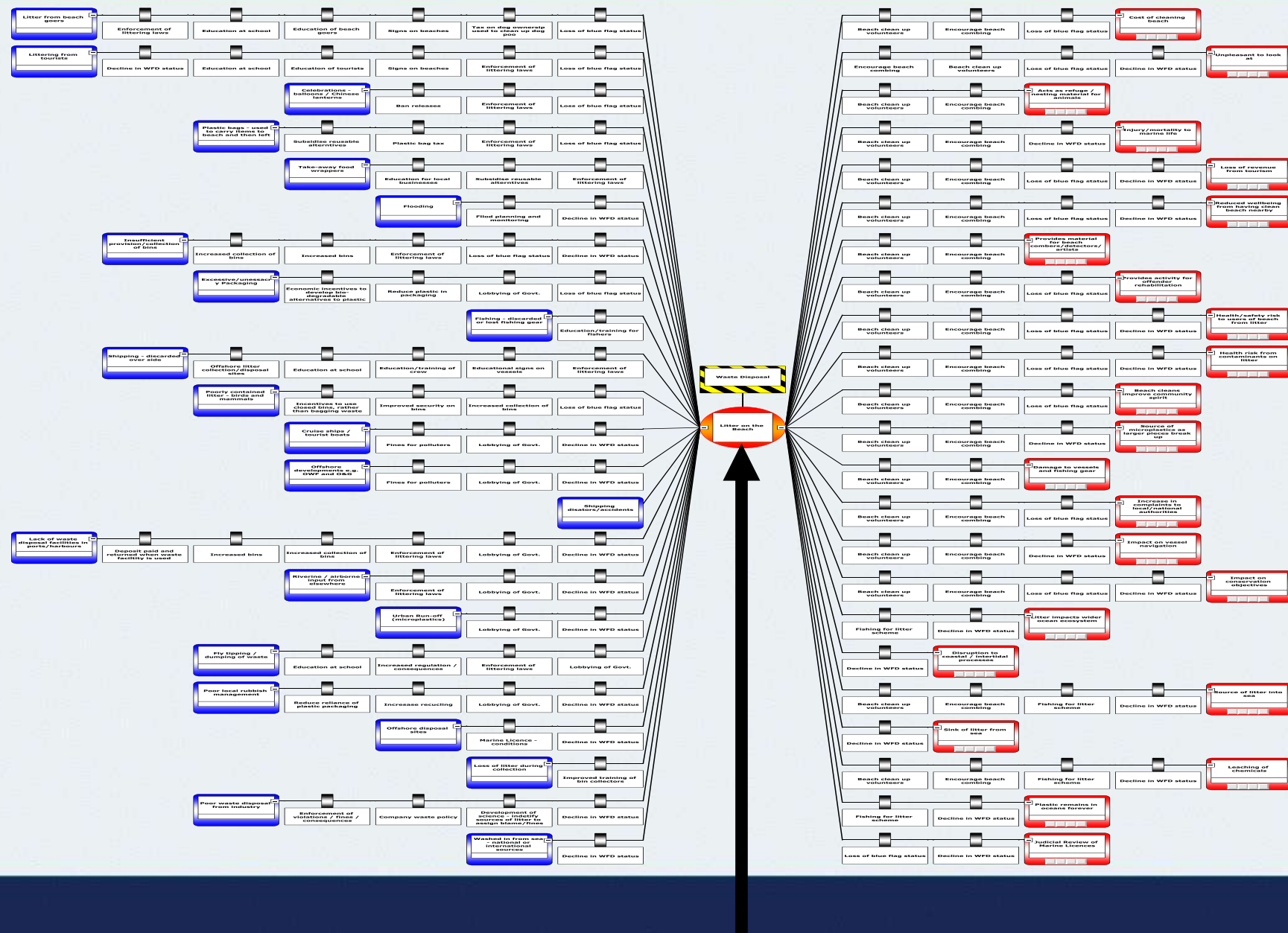
CEA: Ecosystem / Risk Based Approach



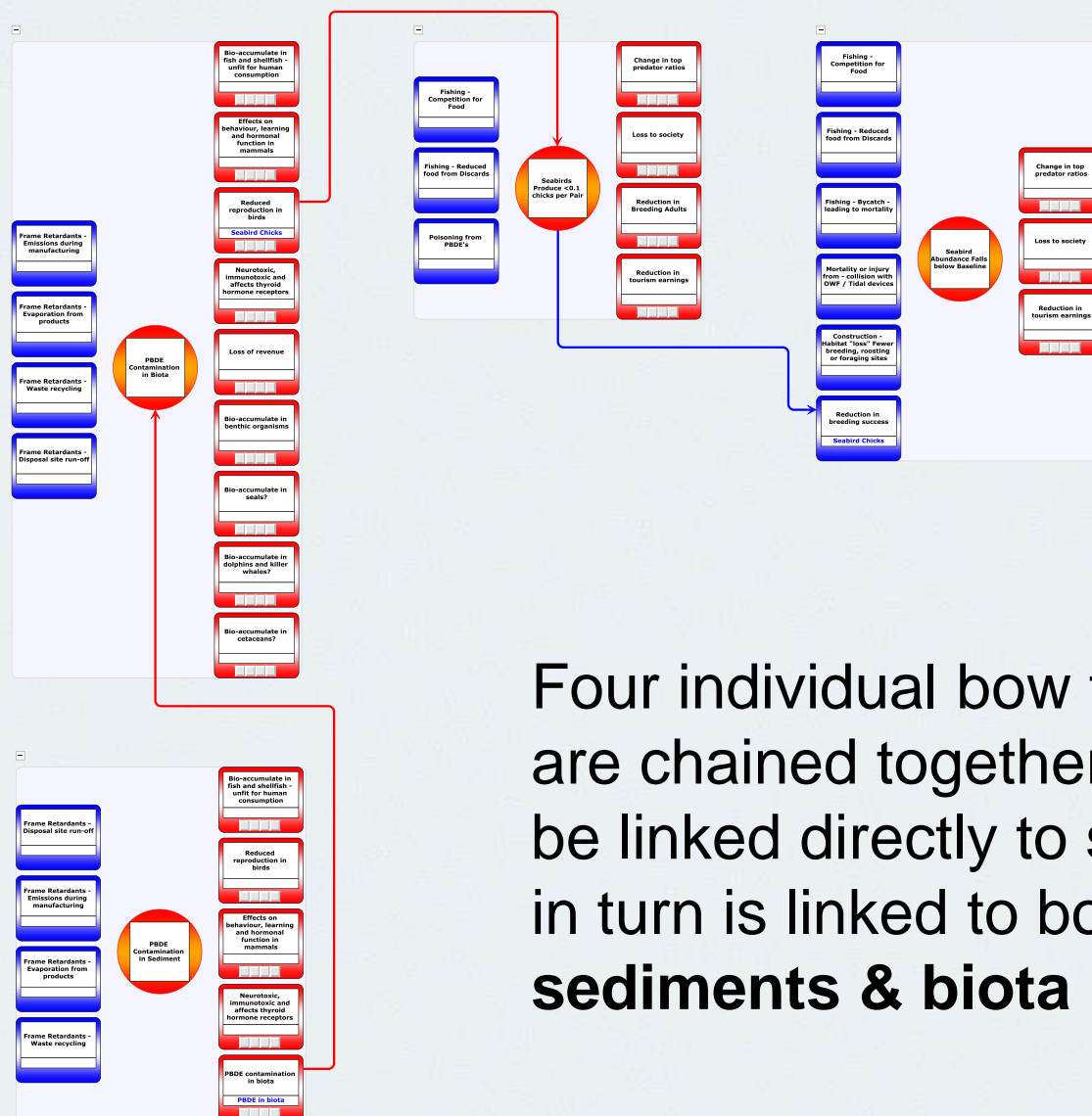
Catalogues audit trail of supporting evidence, e.g. strength of the linkages

Considers management measures and their effectiveness





OSPAR indicator: marine litter



Four individual bow tie analyses of OSPAR indicators are chained together. **Seabird abundance** is shown to be linked directly to **seabird breeding success** which in turn is linked to bow ties on **contaminants in sediments & biota**

Thank you

Questions?

adrian.judd@cefas.co.uk





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Mapping risk of concomitant effects

Methodological overview and first results

Frédéric Quemmerais

French Agency for Biodiversity

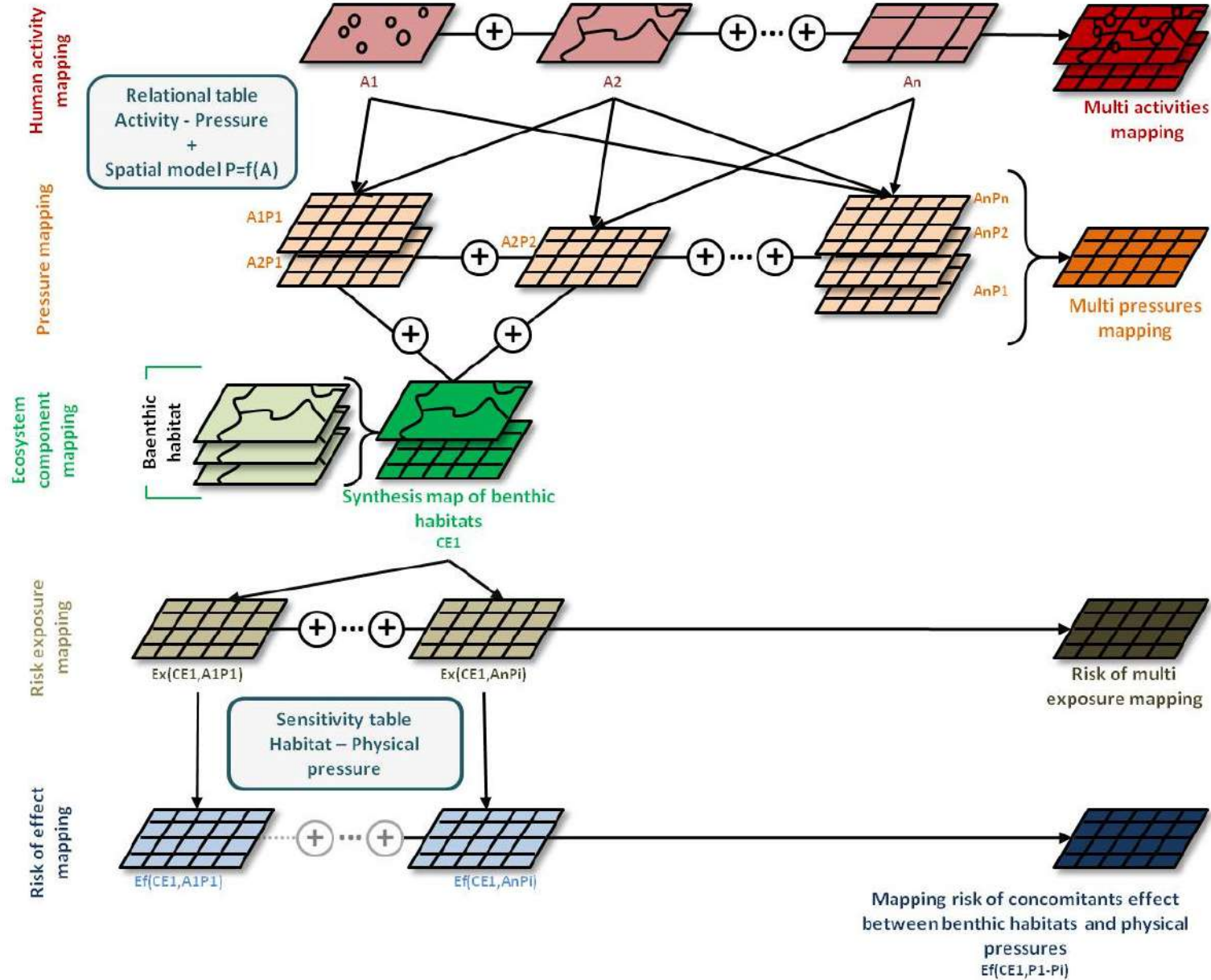
Objective



Develop tool which can help decision making process and address multi-objective purposes in the context of MSFD & MSP i) synthesis map of human activities and pressures ii) assessment of risk of concomitant effects

Develop a methodology and tool able to :

- link activity - pressure - ecosystem component
- run assessment of confidence
- be repeatable



$$IMA = \sum_{i=1}^{ni} A_i$$

$$P_j A_i = N \left[\log \left[A_i \times \gamma_{P_j A_i} \times f(\text{Dist}_{P_j A_i}) + 1 \right] \right]_{z=1, n_z}$$

$$P_j = \sum_{i=1}^{ni} P_j A_i \times c_{i,j} \longrightarrow IPC = \sum_{j=1}^{nj} P_j$$

$$REX_{P_j E_k} = P_j \times E_k$$

$$REF_{P_j E_k} = REX_{P_j E_k} \times u_{j,k}$$

$$REFC = \sum_{j=1}^{nj} \sum_{k=1}^{nk} REF_{P_j E_k}$$

Human activities

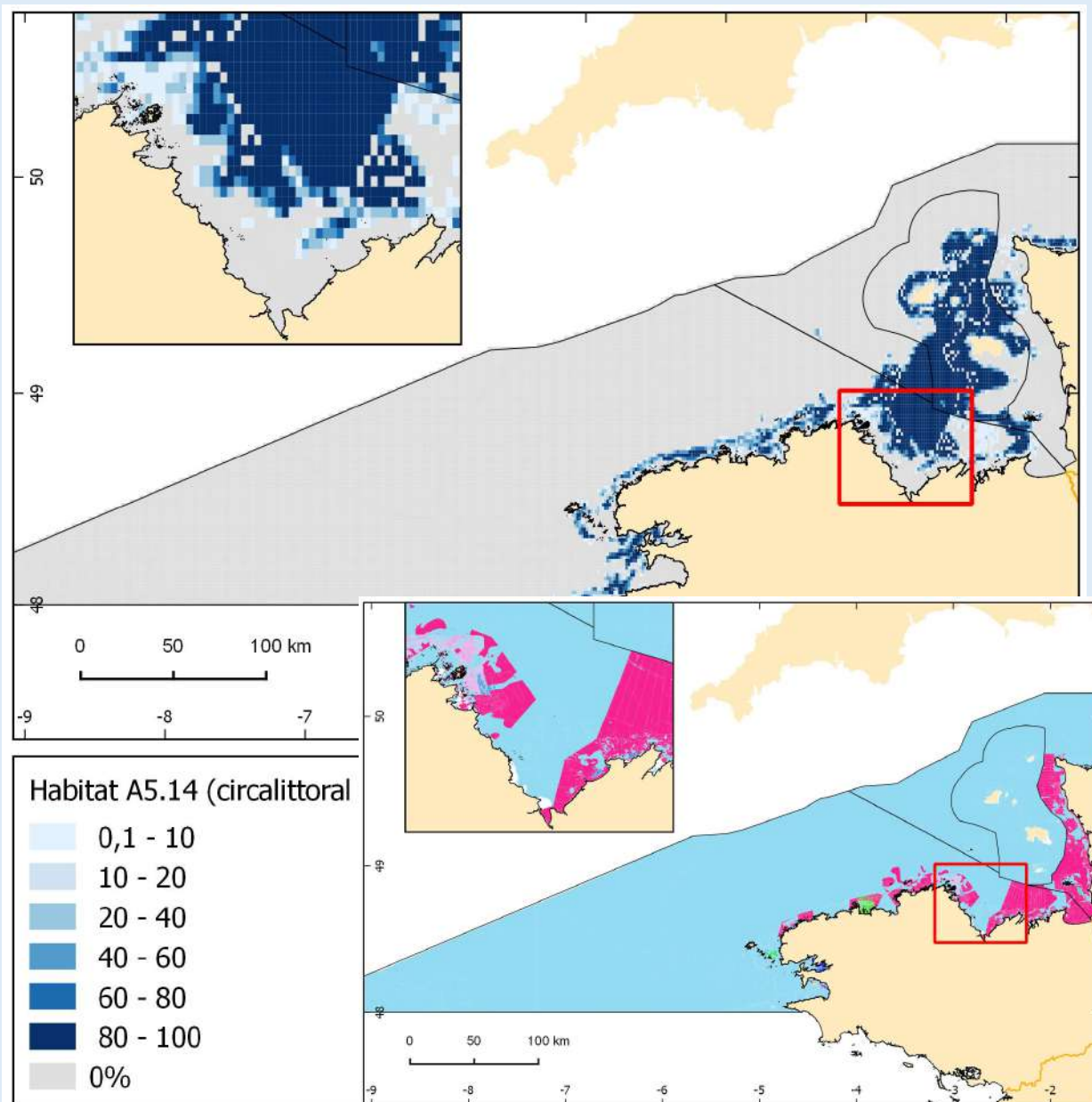
Human sector of activity	Intensity parameters	Unit per cell	Period of available data
Aggregate dredging	Interannual average quantity of dredged material	tons / year	2011-2014
Submarine cables	Sum of linear cables	linear km	continuous
Navigational dredging	Interannual average quantity of dredged material	tons / year	2011-2015
Immersion of dredged material	Interannual average quantity of dumped material	tons / year	2005-2013
Aquaculture (oyster, mussel)	estimation of maximum quantity of livestock farming	tons	unknown
Benthic trawls	Interannual average fishing effort	hours / year	2013-2016
Bottom nets	Interannual average fishing effort	hours / year	2013-2016
Bottom longlines	Interannual average fishing effort	hours / year	2013-2016
Scoubidou	Interannual average fishing effort	hours / year	2013-2016
Dredge	Interannual average fishing effort	hours / year	2013-2016
			2013-2016
Maritime transport	Number of ship by type	Nb of ship/year	2012

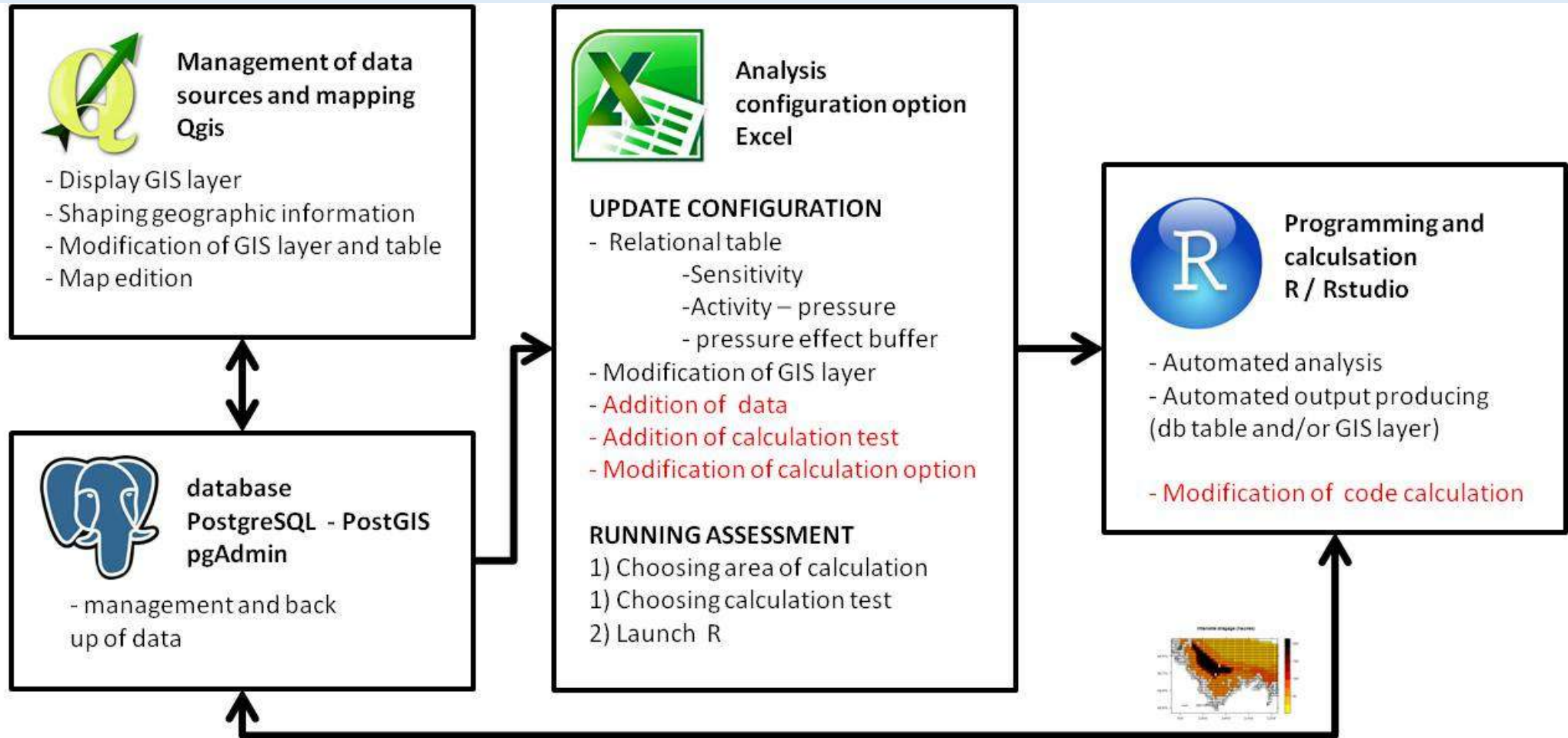
Physical pressures

Pressure code	Pressure
pr_p1_1	removal of substratum (extraction)
pr_p1_2 & pr_p1_6	Penetration and/or disturbance of the substrate below the surface of the seabed
pr_p1_3	Abrasion/disturbance of the substrate
pr_p1_7	Smothering and siltation rate changes (Light)
pr_p1_8	Smothering and siltation rate changes (Heavy)
pr_p2_1	Physical loss
pr_p2_2	Physical change
pr_p3_1	Water flow (tidal current) changes, including sediment transport considerations
pr_p3_2	Changes in suspended solids (water clarity)
pr_p3_3	Temperature change (decrease or increase)
pr_p3_4	Salinity change (decrease or increase)



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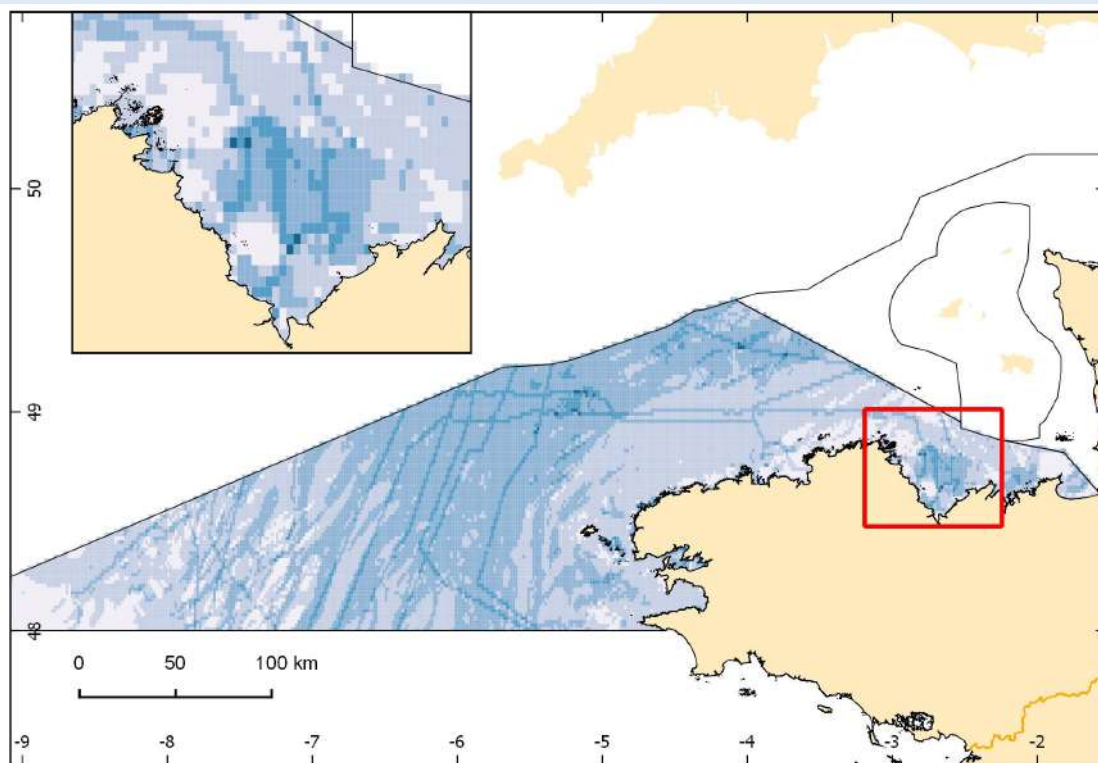




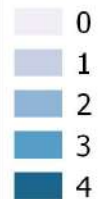
Non expert user

Expert user

Map of human activities

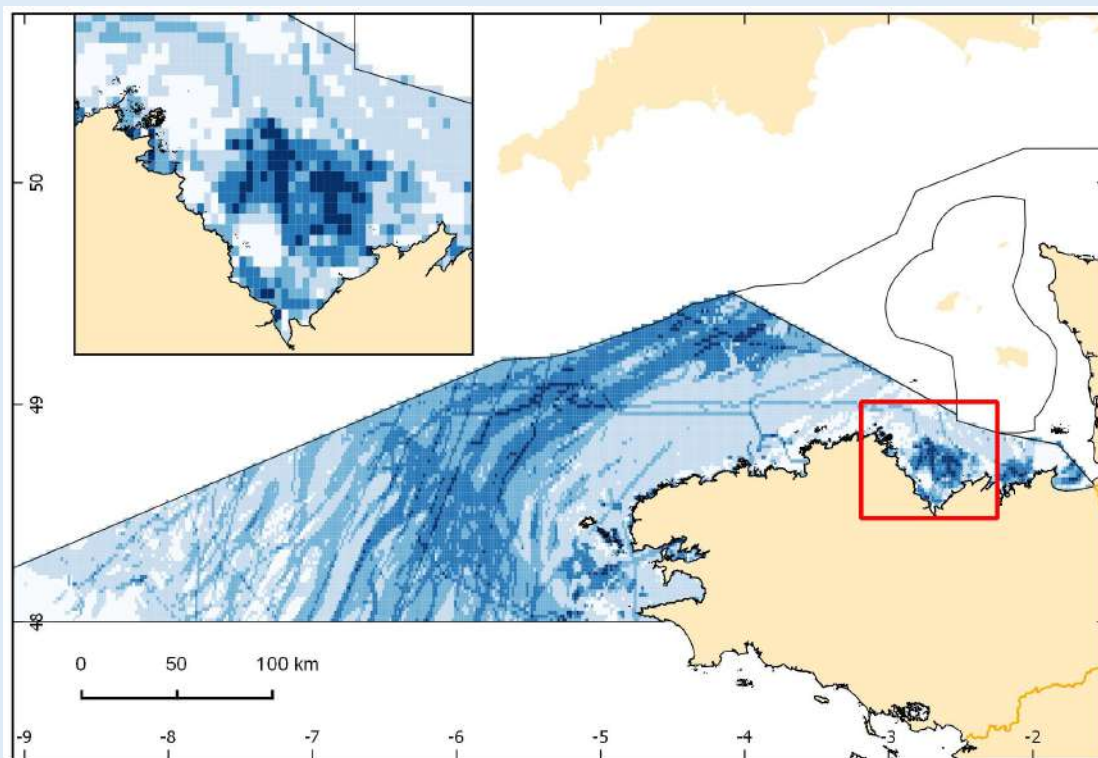


IMA 1 (Index of Marine Activities n°1 : Sum of marine activities presence at sea)

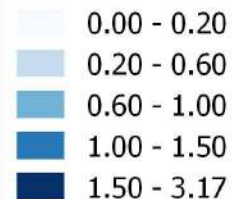


Map background : SHOM, IGN, AFB
Coordinate system : WGS 84 / Pseudo Mercator

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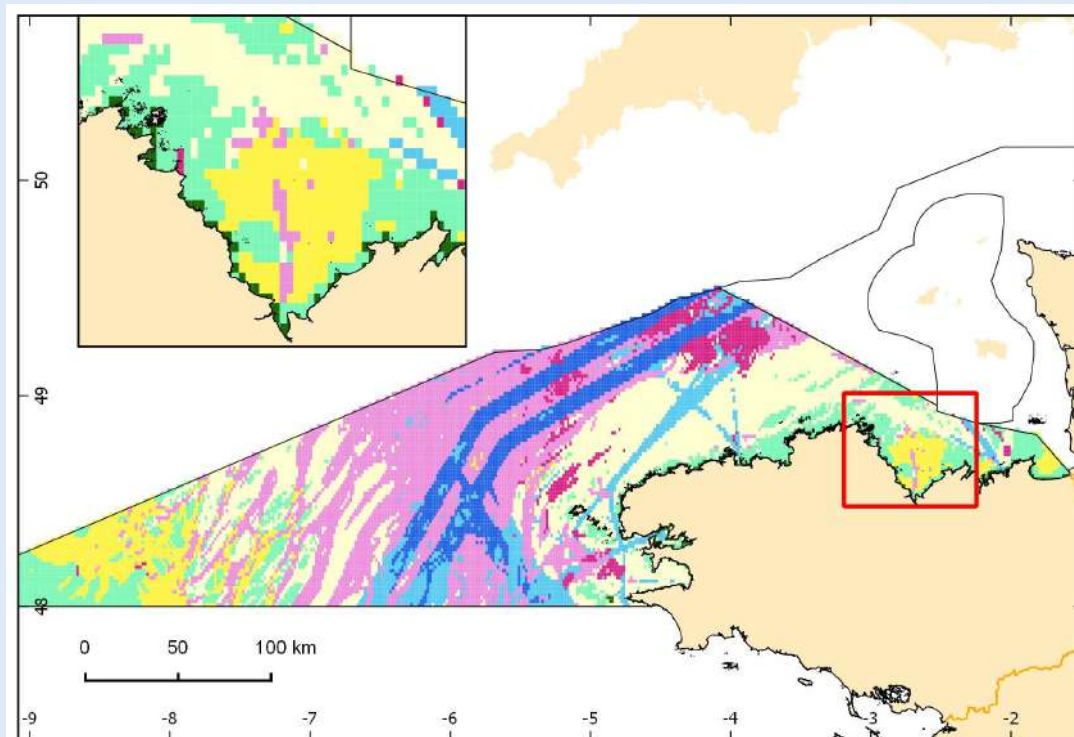
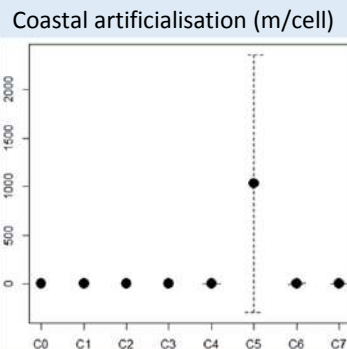
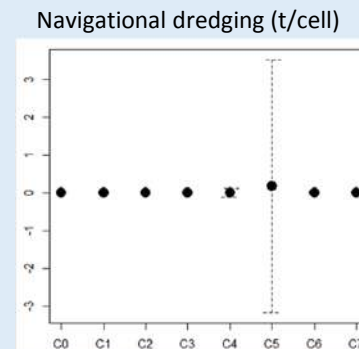
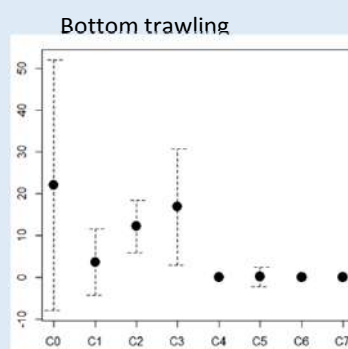
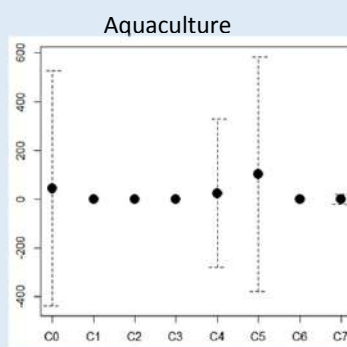
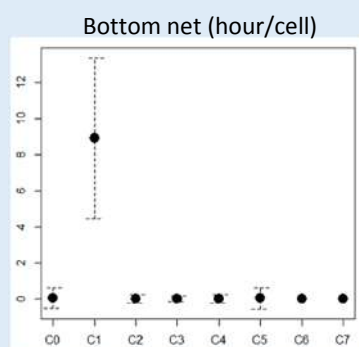
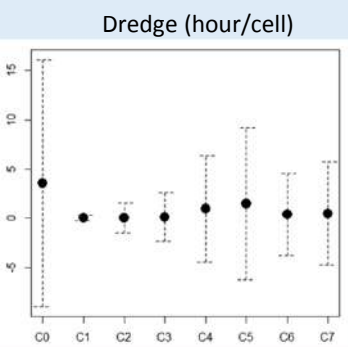
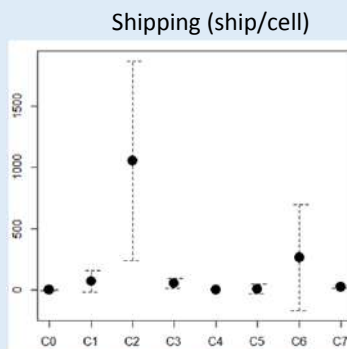
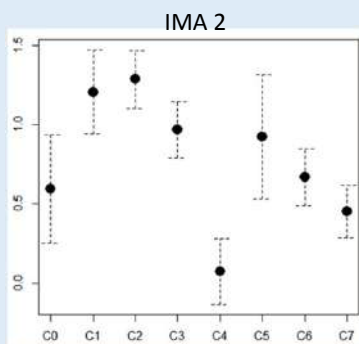
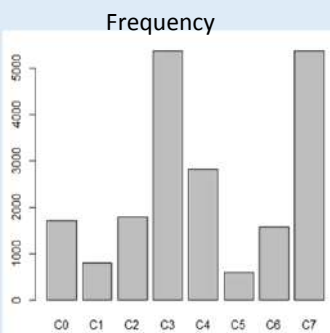
IMA 2 (Index of Marine Activities n°2 : Sum of marine activities intensity at sea)



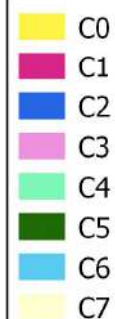
Map background : SHOM, IGN, AFB
Coordinate system : WGS 84 / Pseudo Mercator

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Map of human activities



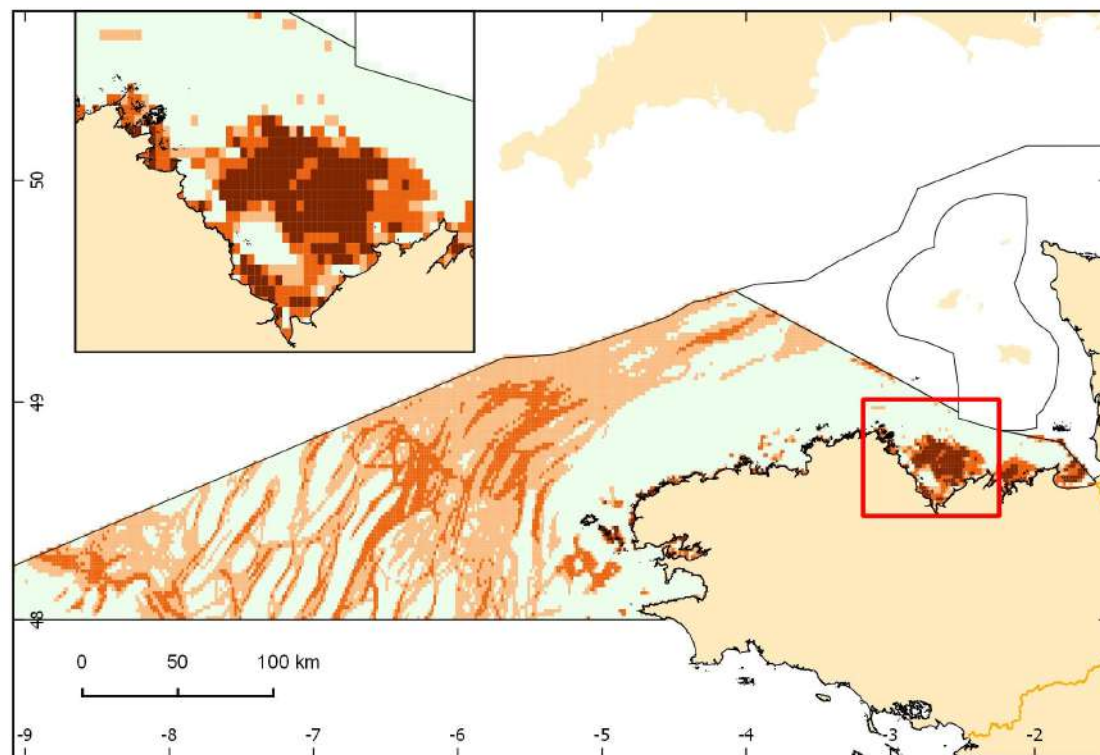
IMA 3 : Index of Marine Activities, clustering of IMA 2 with kmeans method (8 class)



Map background : SHOM, IGN, AFB
Coordinate system : WGS 84 / Pseudo Mercator

11/2017

Pressures and Multi pressures map

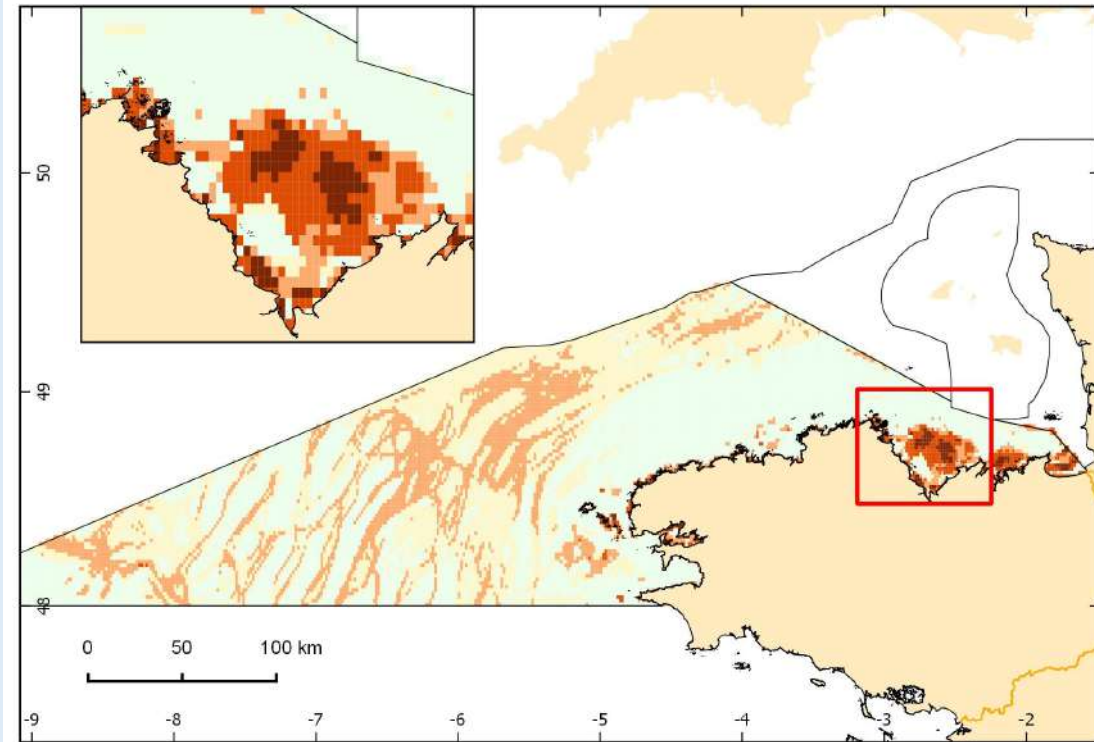


PR_P1_2: pressure penetration and/or disturbance of the substrate

- 0.000 - 0.070
- 0.070 - 0.495
- 0.495 - 0.971
- 0.971 - 3.174

Map background : SHOM, IGN, AFB
Coordinate system : WGS 84 / Pseudo Mercator

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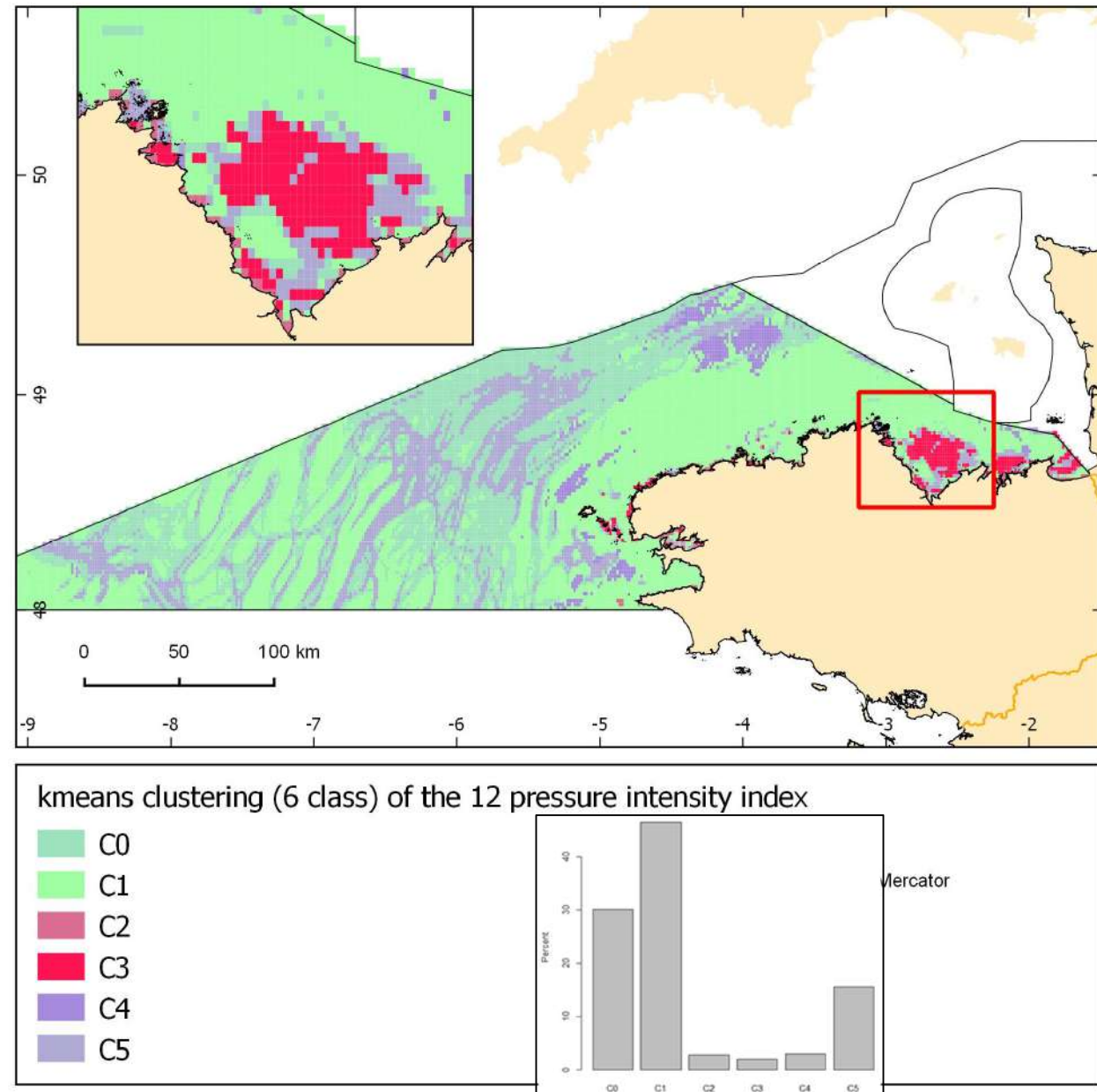
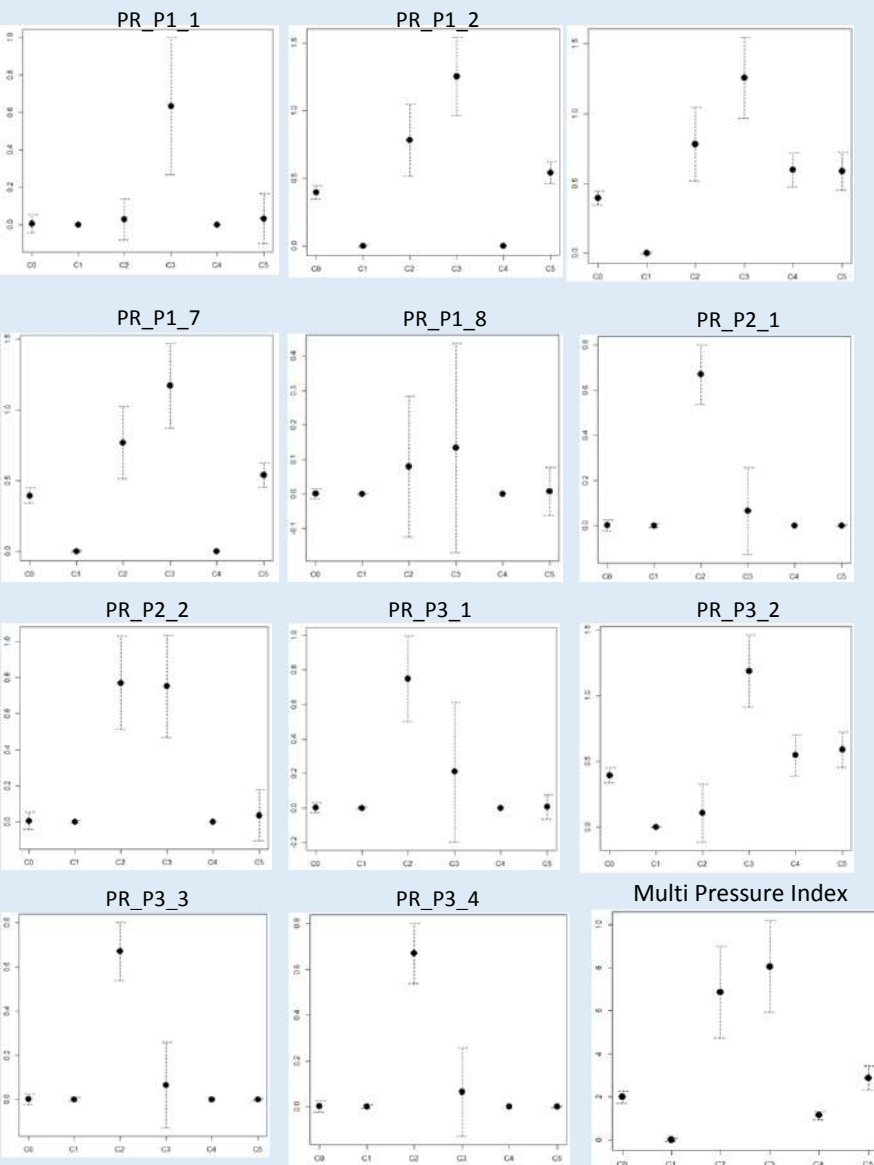
Multi Pressure Index: physical pressure

- 0.0000 - 0.1
- 0.1 - 2.3471
- 2.3471 - 4.4942
- 4.4942 - 8.1018
- 8.1018 - 23.2657

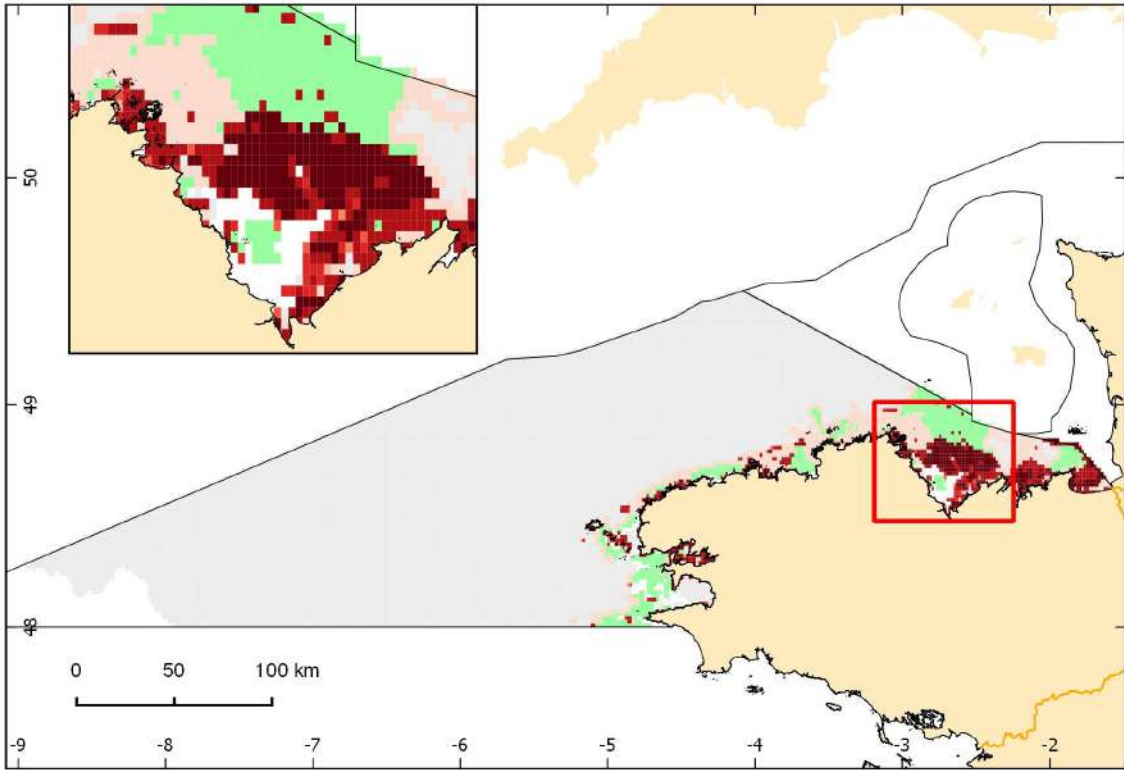
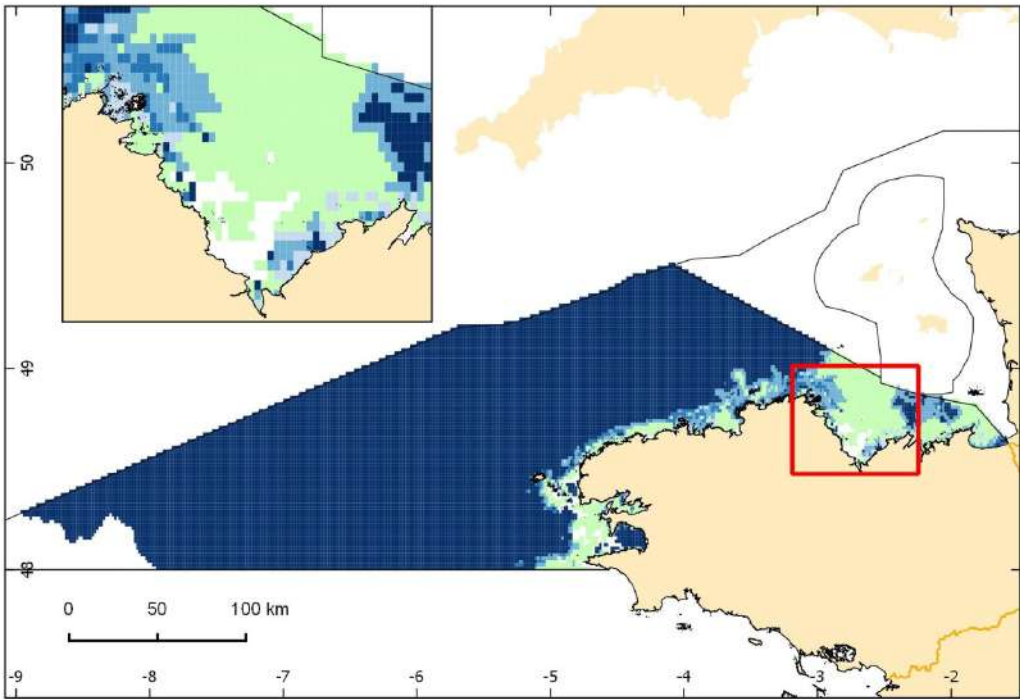
Map background : SHOM, IGN, AFB
Coordinate system : WGS 84 / Pseudo Mercator

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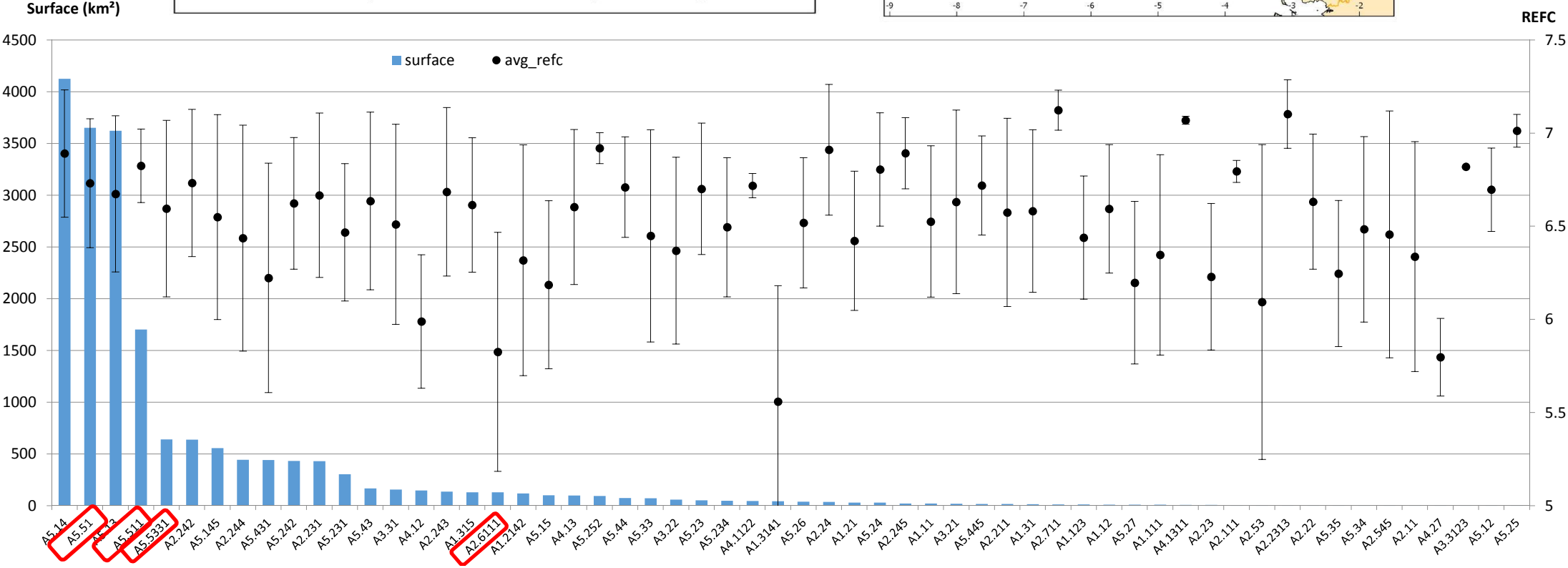
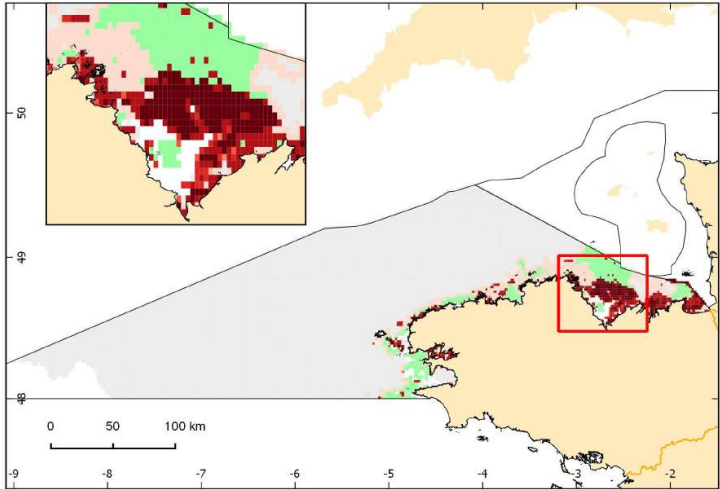
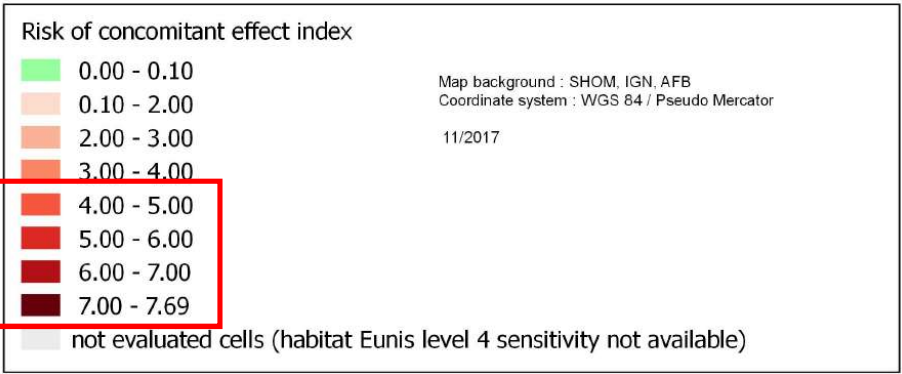
Multi Pressures Map



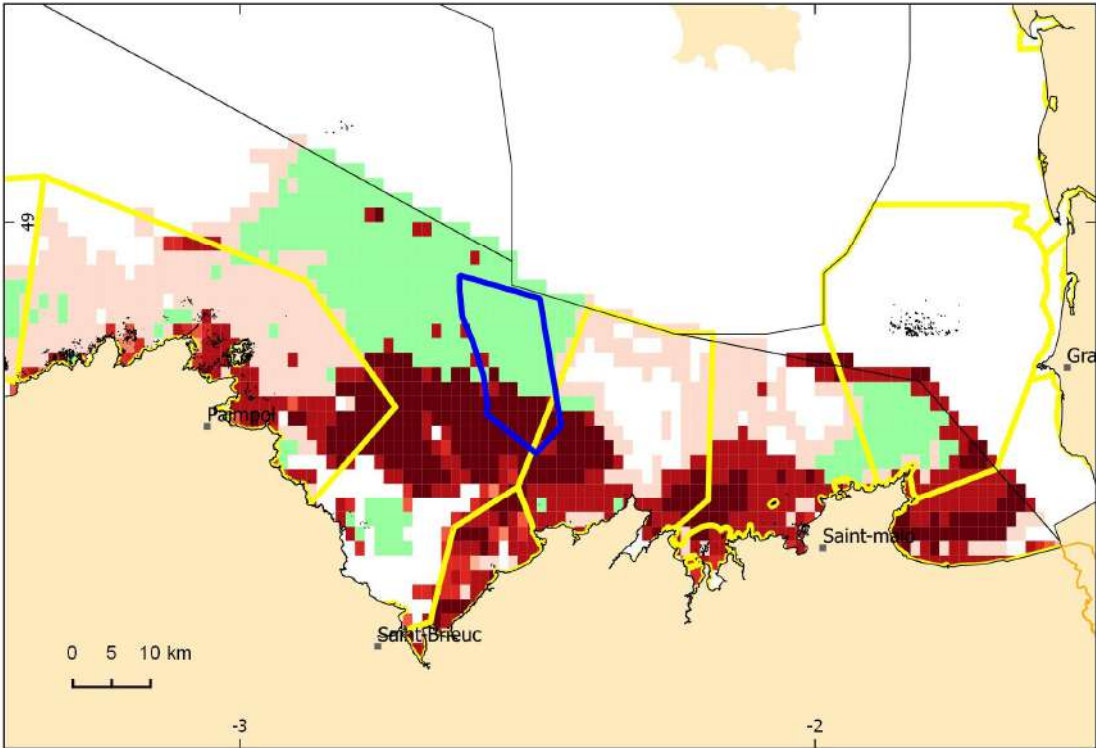
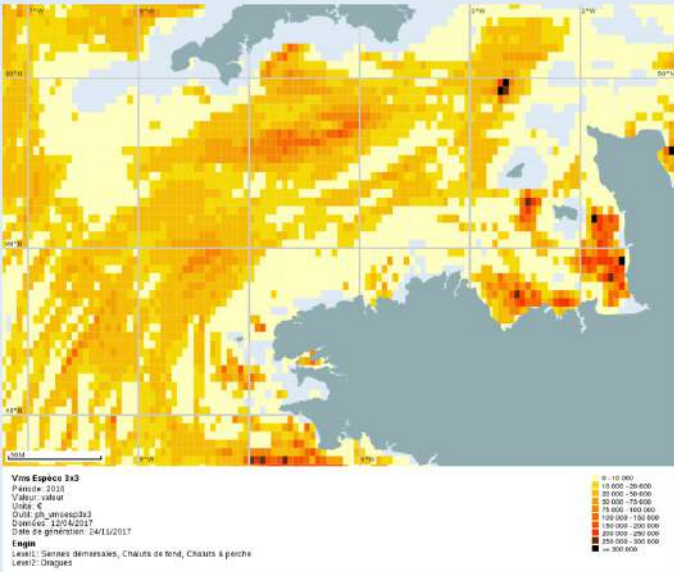
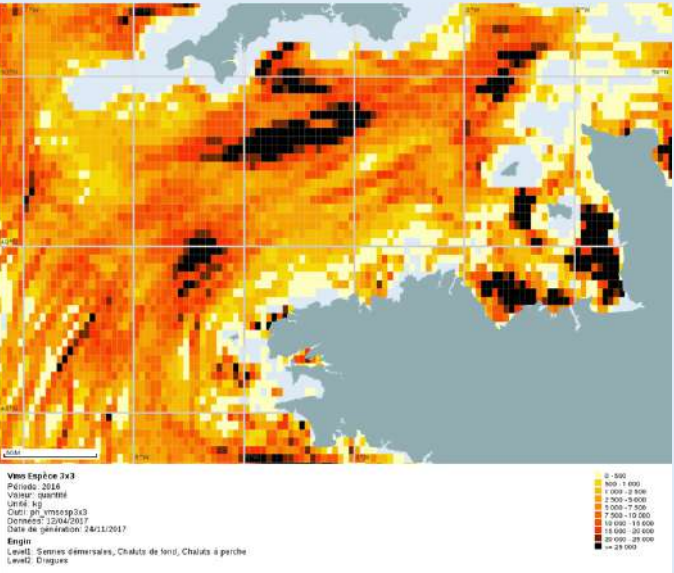
Risk of concomitant effects



Discussion : CEA & MSP



Discussion : CEA & MSP



wind farm 2011 planification project

Natura 2000 sites

Risk of concomitant effects

- 0.00 - 0.10
- 0.10 - 2.00
- 2.00 - 3.00
- 3.00 - 4.00
- 4.00 - 5.00
- 5.00 - 6.00
- 6.00 - 7.00
- 7.00 - 7.69

Map background : SHOM, IGN, AFB
Coordinate system : WGS 84 / Pseudo Mercator

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Thank You !



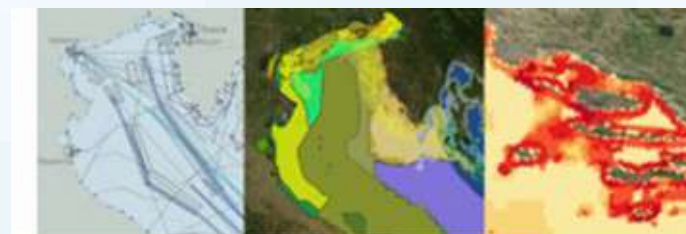
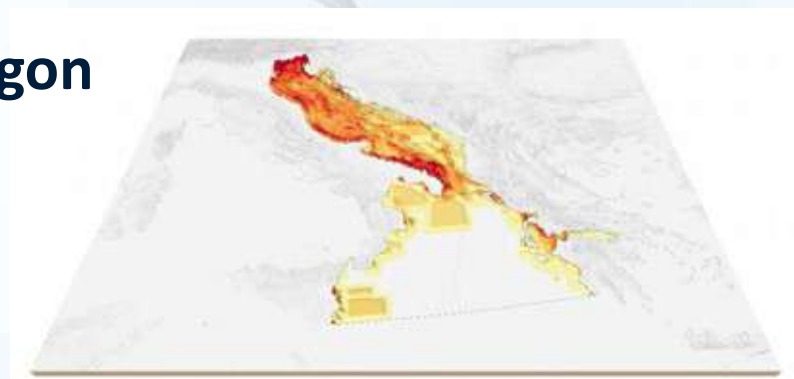
frederic.quemmerais-amice@afbiobiodiversite.fr

Advancing Cumulative Effects Assessment in the Adriatic Sea: challenges and solutions

Stefano Menegon

CNR-ISMAR Venice, Italy

University IUAV of Venice



Tools4MSP



A work in progress



EU Project **ADRIPLAN**

ADRIatic Ionian maritime spatial
PLANning, (DG-MARE 2013-2015)
Scale: Adriatic-Ionian macroregion



Italian National Flagship Project **RITMARE**

Ricerca Italiana per il Mare
(2012 – **2016** – **2017**)
Scale: local/regional high resolution



EU Project **SUPREME**

Supporting maritime spatial
Planning in the Eastern
Mediterranean
(DG-MARE EASME 2017-2018)
Scale: regional / transboundary



Portodimare

EU Project **Portodimare**
geoPORTal of TOols & Data for
sustainable Management of coAstal
and maRine Environment
(ADRION 2018-2019)

Development Streams

CEA model

MSP-driven

Tools4MSP



Source-pressure-pathway-receptor linkage

Linear and non-linear behaviour

Additive, dominant and antagonist effects,

Transboundary effects

Scenario analysis

Uncertainty assessment

Visualization tools
(e.g. Sankey diagrams)

CEA Backsourcing (CEA-B)

Community-based collaborative platform

Integrated tools: Information Sharing and retrieval, Geovisualization, Multi-objective tools for MSP

SDI functionalities

CEA Model Advancements

- 1) Mecf = Multi effect combination factor
(additive, dominant and antagonist stressor effects)

$$CEA = \sum_{k=1}^n d(E_k) \left(\overbrace{\sum_{j=1}^m s_{j,k} (1 - mec f_k) eff(P_j, E_k)}^{\text{Additive model}} + \overbrace{\max_{j=1}^m s_{j,k} mec f_k eff(P_j, E_k)}^{\text{Dominant model}} \right)$$

- 2) effect = Effect exerted by a Pressure

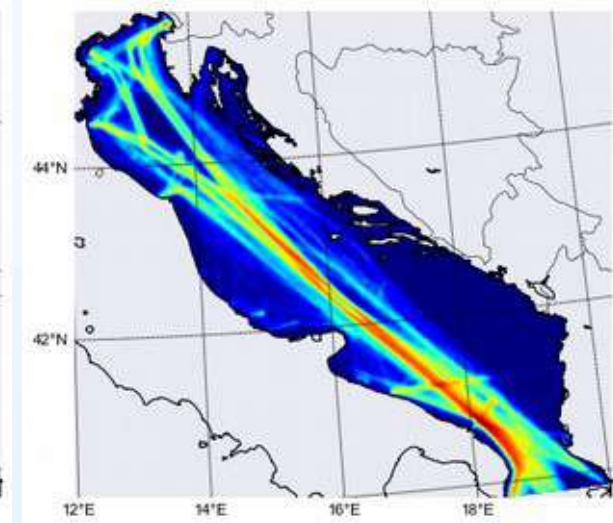
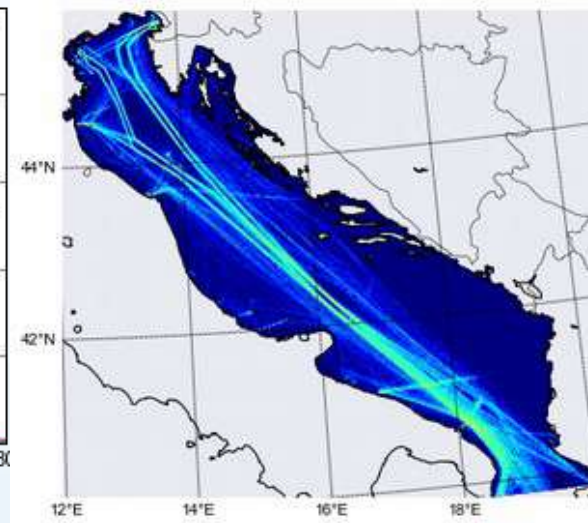
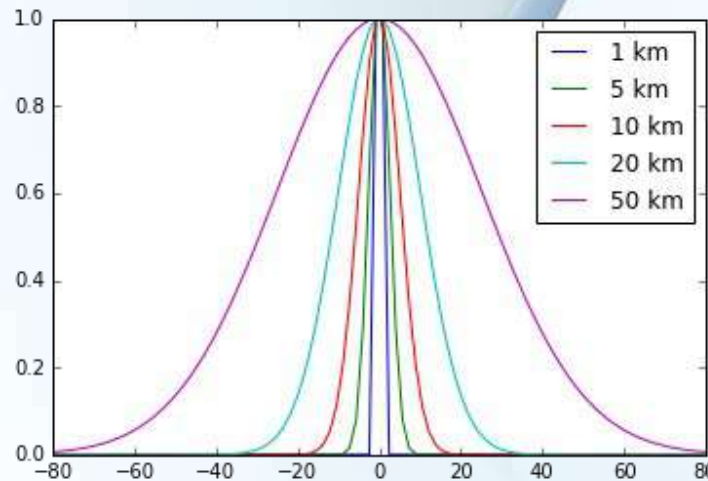
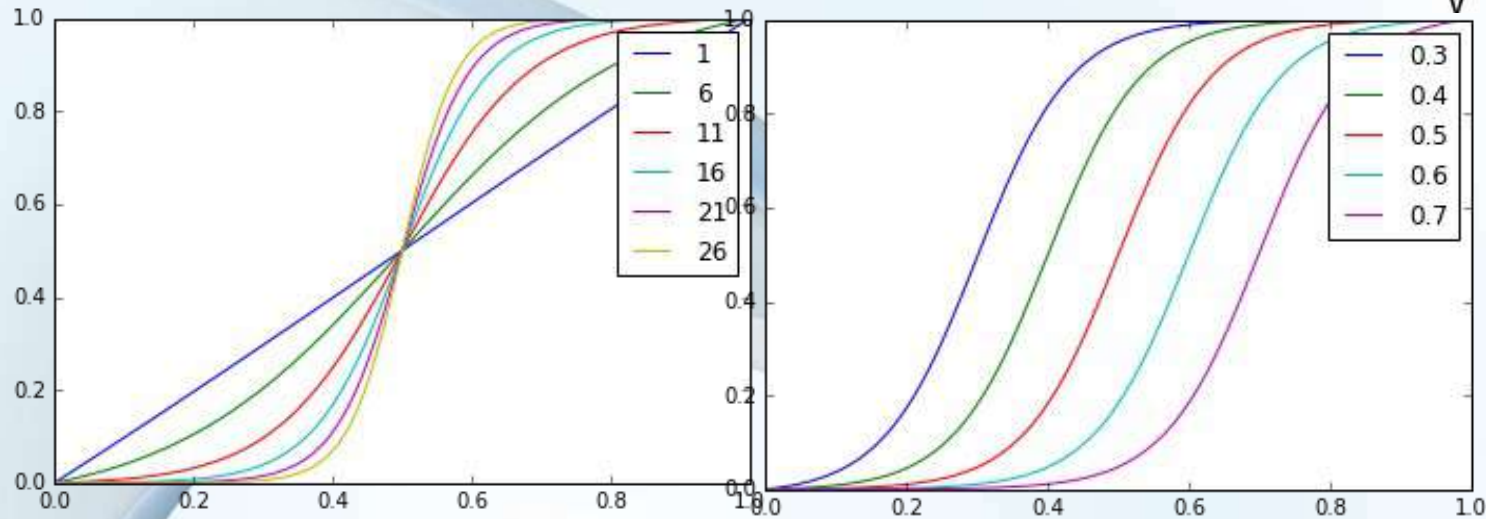
$$eff(P_j, E_k) = rfunc_{j,k} \left(\left(\sum_{i=1}^l w_{i,j,k} i(U_i, M_{i,j,k}) \right)' \right)$$

- 3) Rfunc = Response function
(e.g. Linear, non-Linear, Threshold function)

- 4) i = Distance Model
(e.g. gaussian convolution)

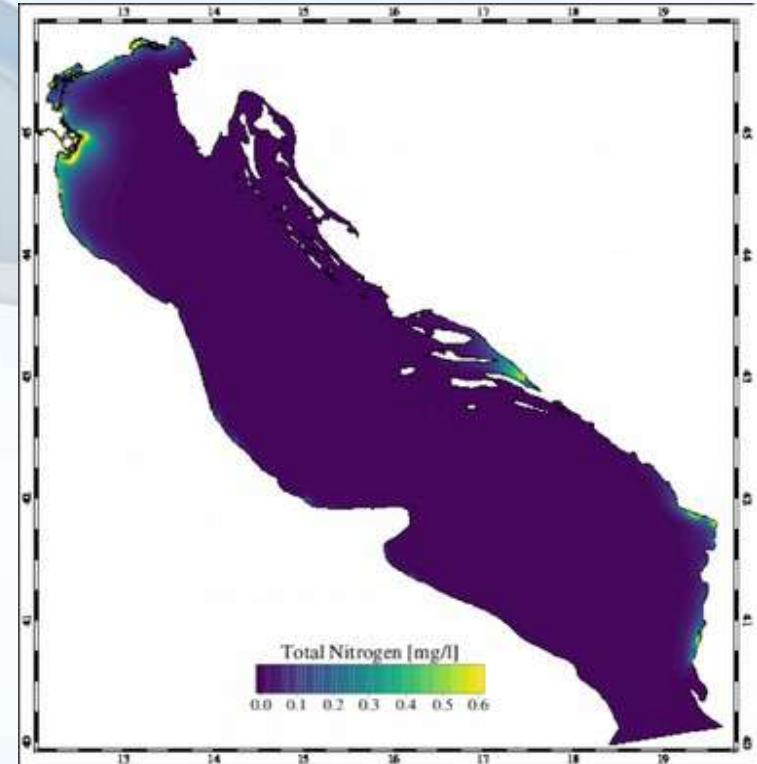
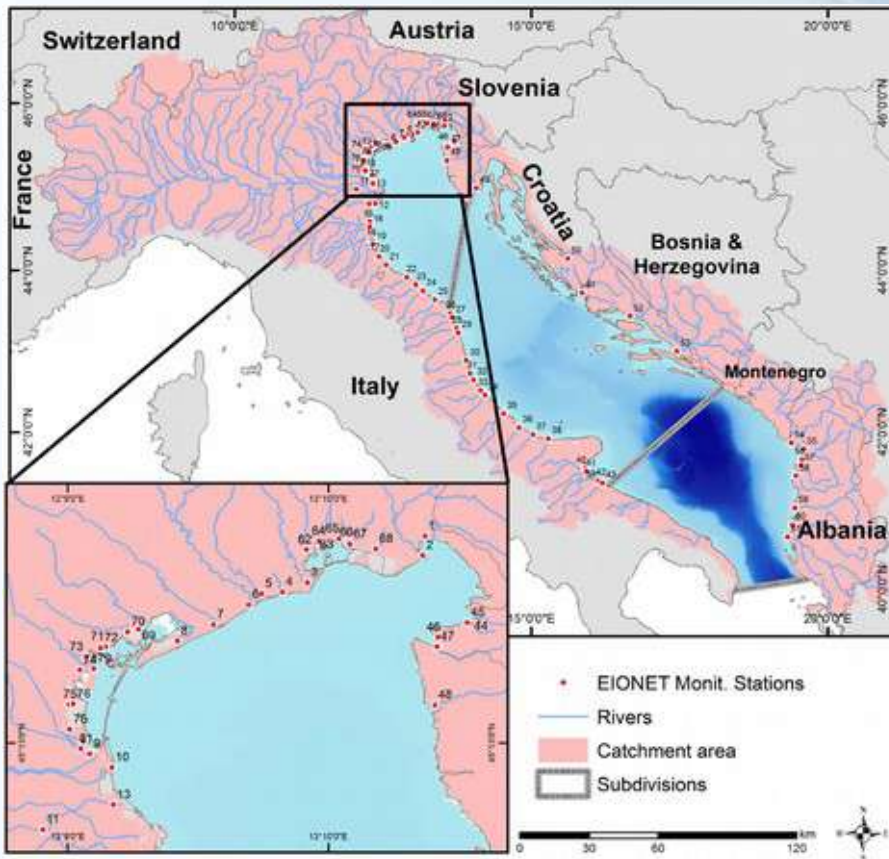
CEA Model Advancements

Examples of
response
functions



Distance model applied to model of maritime transport
Original traffic density layer (middle), 10km of influence (right)

Integration of Land Based Activities



3-D hydrodynamic modelling of nutrient dispersion (organic matter, nitrogen and phosphorus) and salinity in the Adriatic Sea Basin

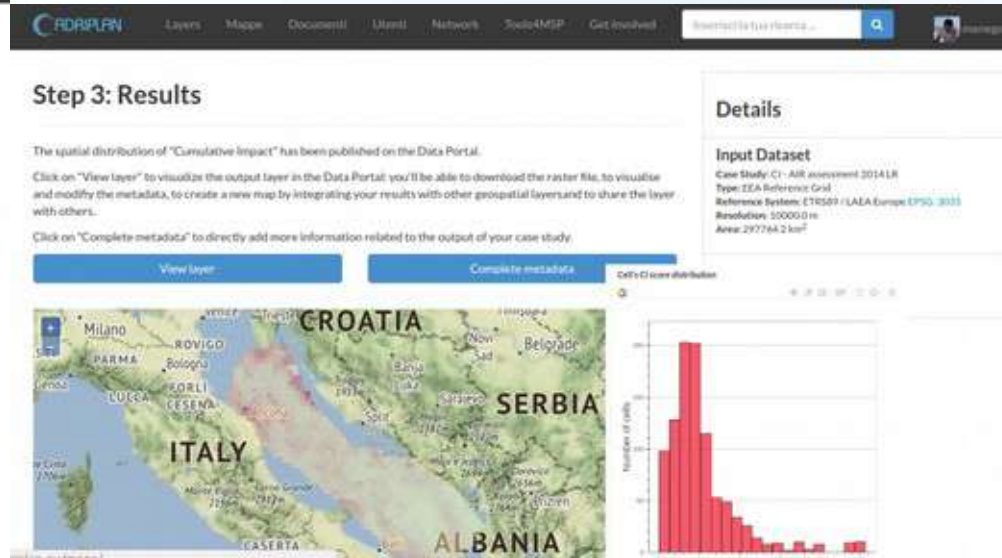
SHYFEM - Shallow water Hydrodynamic Finite Model

Urban areas, coastal tourism, catchment areas: 78 rivers, 40 coastal cities

**Geopython standalone library
for rapid prototyping**
<https://github.com/CNR-ISMAR/tools4msp>

- Community – based collaborative **platform**
- Integrated tools: Information, Sharing and retrieval, Geovisualization
- Multi-objective tools for MSP
- SDI functionalities
- Conflict score analysis (COEXIST methodology), Cumulative Effects Assessment

ADRIPLAN Portal
<http://data.adriplan.eu>

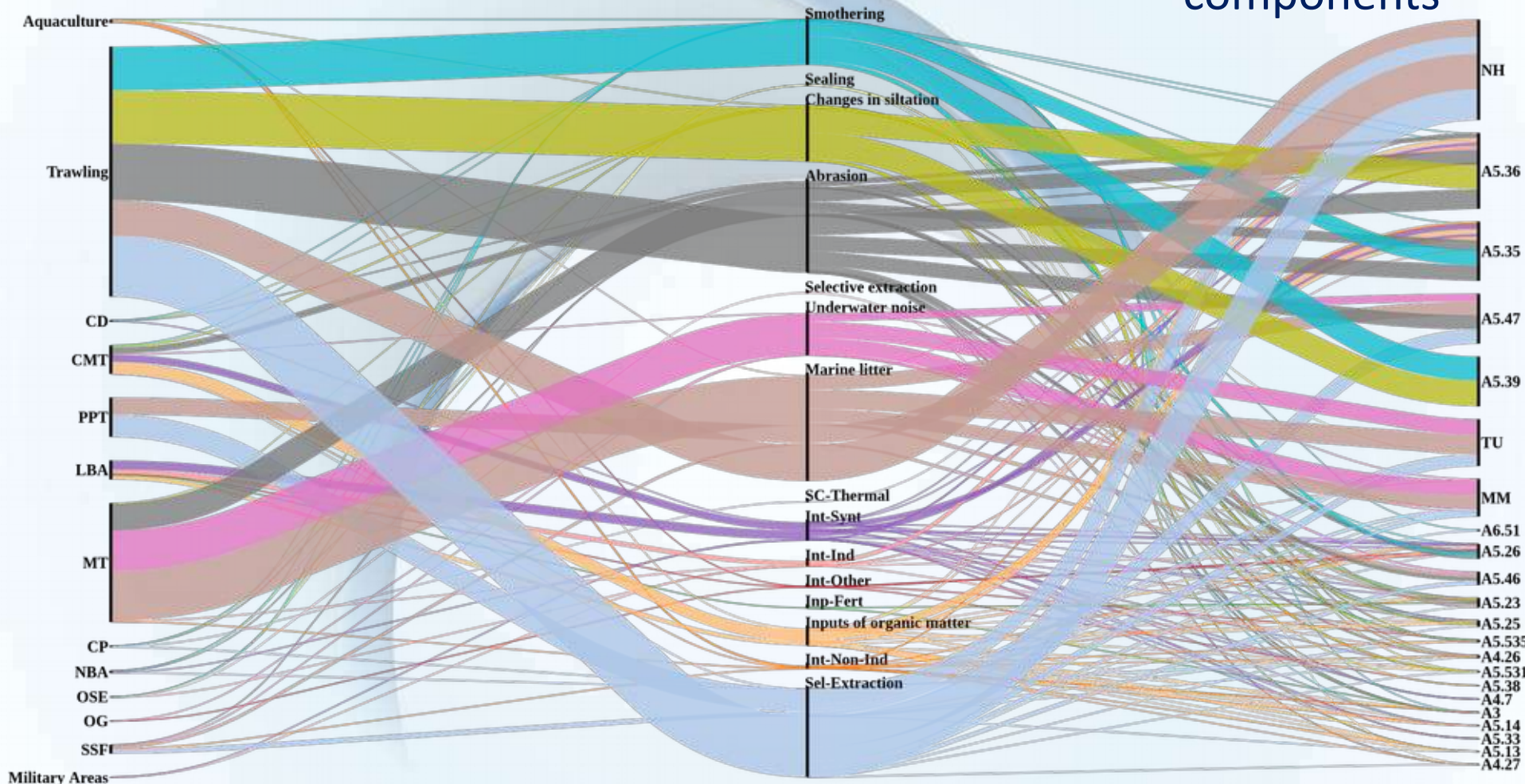


CEA impact chain

Human uses

Pressures

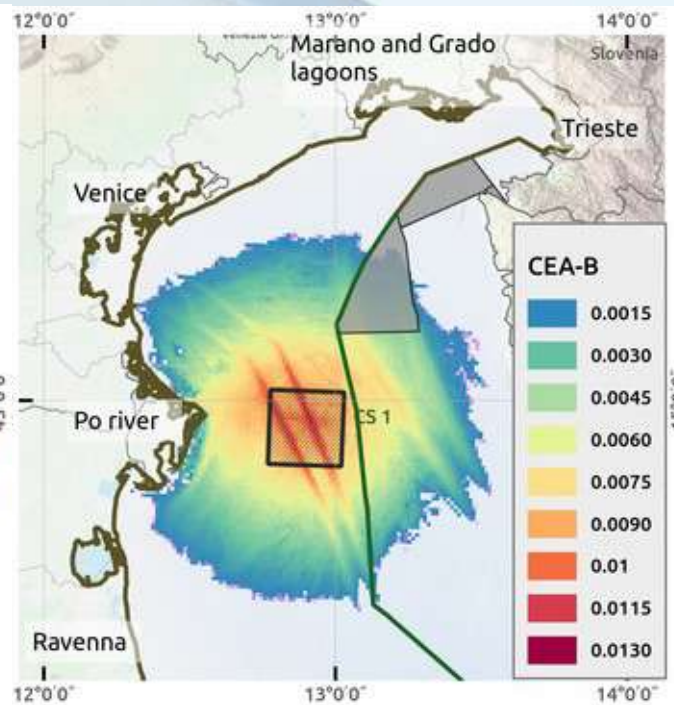
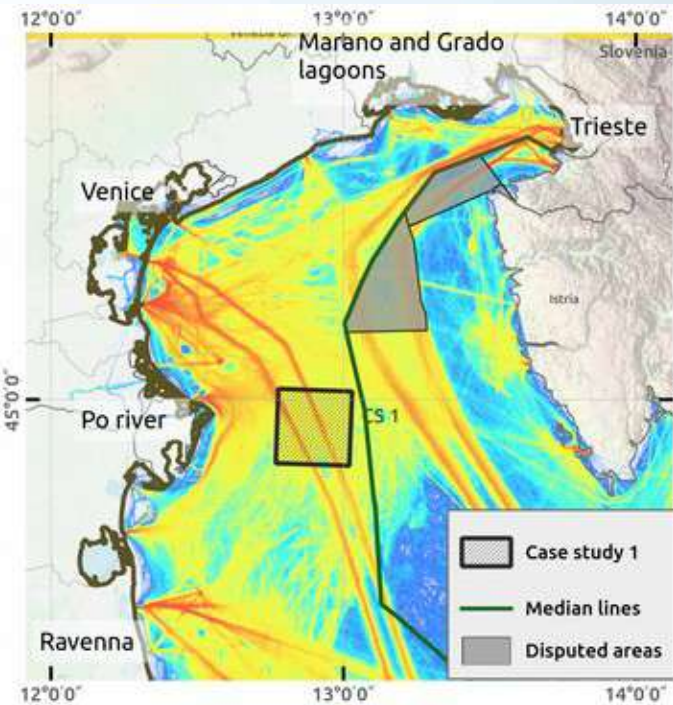
Environmental
components



CEA impact chain visualization tool (Sankey diagrams)

CEA Backsourcing (CEA-B)

CEA-B is an inverse CEA model

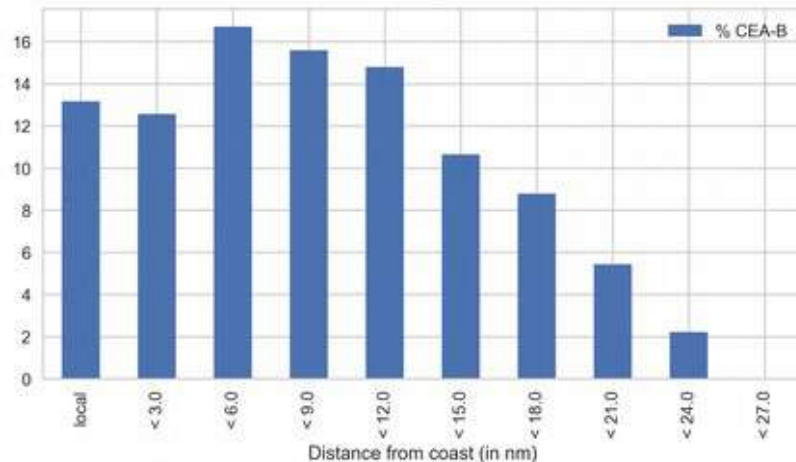


Case Study:

U: Marine traffic

P: Underwater noise

E: Loggerhead
Turtles



To **identify and quantify** sources of anthropogenic pressures affecting receptors/environmental components

Transboundary effects
spatialization

- **Knowledge gap**

- ➔ Three-dimensional and multi-temporal (e.g. seasonality) aspects for source data and pressures

- **Methodological**

- ➔ Standardized terminology, procedures
- ➔ Embedding CEAs in a risk management process
- ➔ Direct incorporation of uncertainty and sensitivity assessments
- ➔ Baseline conditions (GES)
- ➔ Model dynamic process

- **Ecological**

- ➔ Deeper integration of spatio-temporal models (e.g. ecological, hydrodynamic) to address MSFD descriptors
- ➔ Integrating the socio-ecological dimension (Ecosystem Services)

- **Related to MSP process**

- ➔ From multi-objective to multi-functional (MSP process – driven)
- ➔ Acceptability and usability of decision support systems in the science-policy interface

- **IT Infrastructure**

- ➔ Implement a full operational Infrastructure
- ➔ Address EMODNET, Copernicus, INSPIRE operational linkages

Developing a modelling framework for MSP-oriented cumulative effects assessment: A case study for the Italian Adriatic Sea

Stefano Menegon^{a,1,*}, Daniel Depellegrin^{a,1}, Giulio Farella^a, Elena Gissi^b, Alessandro Sarretta^a, Chiara Venier^a,
Andrea Barbanti^a

^a CNR - National Research Council of Italy, ISMAR - Institute of Marine Sciences, Venice, Italy
^b Department of Design and Planning in Complex Environments, Università Iuav di Venezia, Venice, Italy

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Multi-objective spatial tools to inform maritime spatial planning in the Adriatic Sea

Daniel Depellegrin^{a,*}, Stefano Menegon^{a,1}, Giulio Farella^a, Michol Ghezzi^a, Elena Gissi^b,
Alessandro Sarretta^a, Chiara Venier^a, Andrea Barbanti^a

^a CNR - National Research Council of Italy, ISMAR - Institute of Marine Sciences, Venice, Italy
^b Department of Design and Planning in Complex Environments, Università Iuav di Venezia, Venice, Italy



RESEARCH ARTICLE

Addressing uncertainty in modelling cumulative impacts within maritime spatial planning in the Adriatic and Ionian region

Elena Gissi^{1,*}, Stefano Menegon², Alessandro Sarretta², Federica Appiotti^{1†},
Denis Maragno^{1†}, Andrea Vianello^{2†}, Daniel Depellegrin^{2†}, Chiara Venier²,
Andrea Barbanti²

¹ Department of Design and Planning in Complex Environments, Università Iuav di Venezia, Venice, Italy,
² Institute of Marine Sciences, National Research Council, Venice, Italy

PeerJ Preprints

Open source tools to support Integrated Coastal Management and Maritime Spatial Planning

Stefano Menegon¹, Alessandro Sarretta¹, Andrea Barbanti¹, Elena Gissi², and Chiara
Venier¹

¹ Consiglio Nazionale delle Ricerche, Istituto di Scienze Marine (CNR-ISMAR), Arsenale - Tesa 104, Castello
2737/F, 30122 Venezia, Italy

² Department of Design and Planning in Complex Environments, Università IUAV di Venezia, S. Croce 1957 -
30135 Venezia Italy

Working group

Tools4MSP

CNR-ISMAR Venice, Italy

Andrea Barbanti

Daniel Depellegrin

Giulio Farella

Michol Ghezze

Stefano Menegon

Alessandro Sarretta

Chiara Venier

tools4msp@ismar.cnr.it

Planning in Complex Environments

University IUAV of Venice

Federica Appiotti

Elena Gissi

Elisabetta Manea

Denis Maragno

msp@iuav.it

***Modelers, Data Scientists, Environmental
Engineers, Planners, Marine Ecologists ...***