Developing a System for Mapping Sensitive Marine Areas

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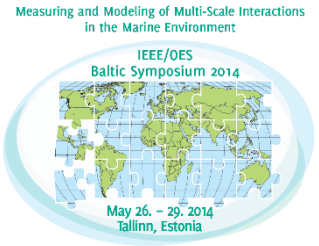
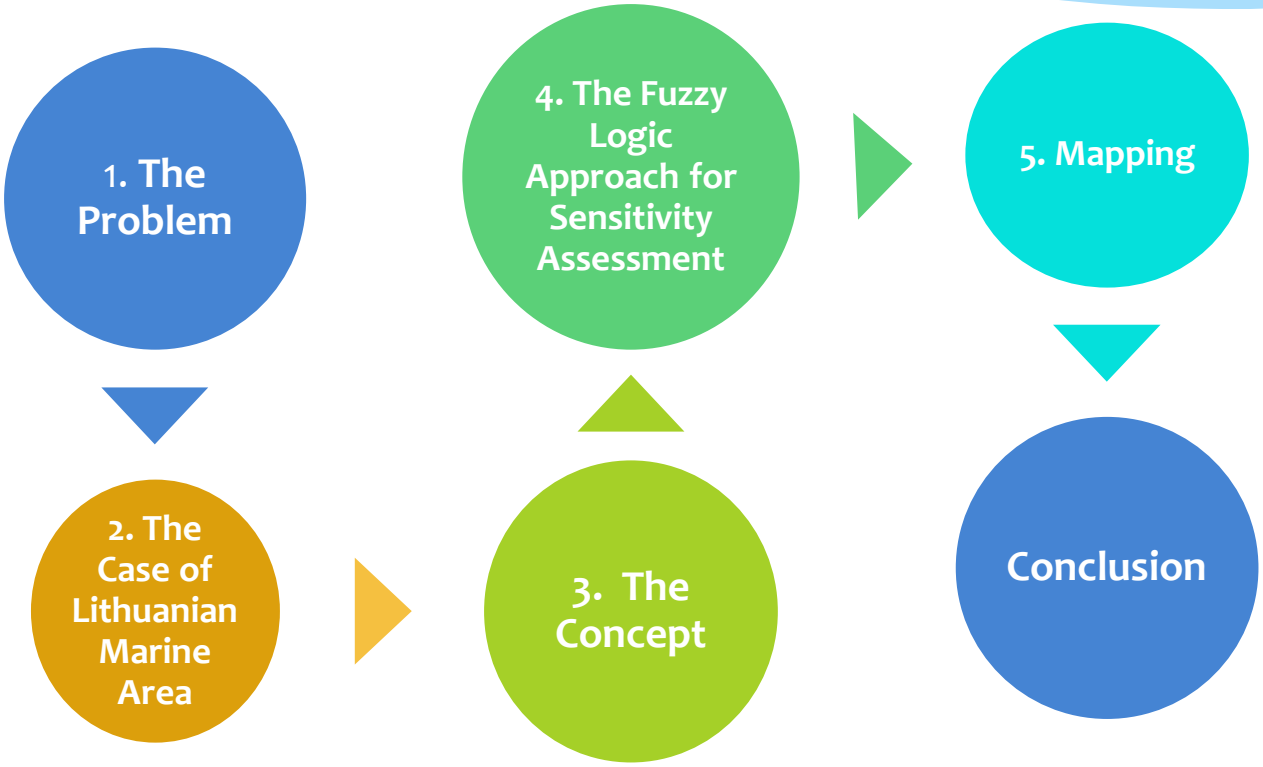
The activities are supported by Lithuanian National Science project "Technological and environmental research development in Lithuanian marine sector"



Outline

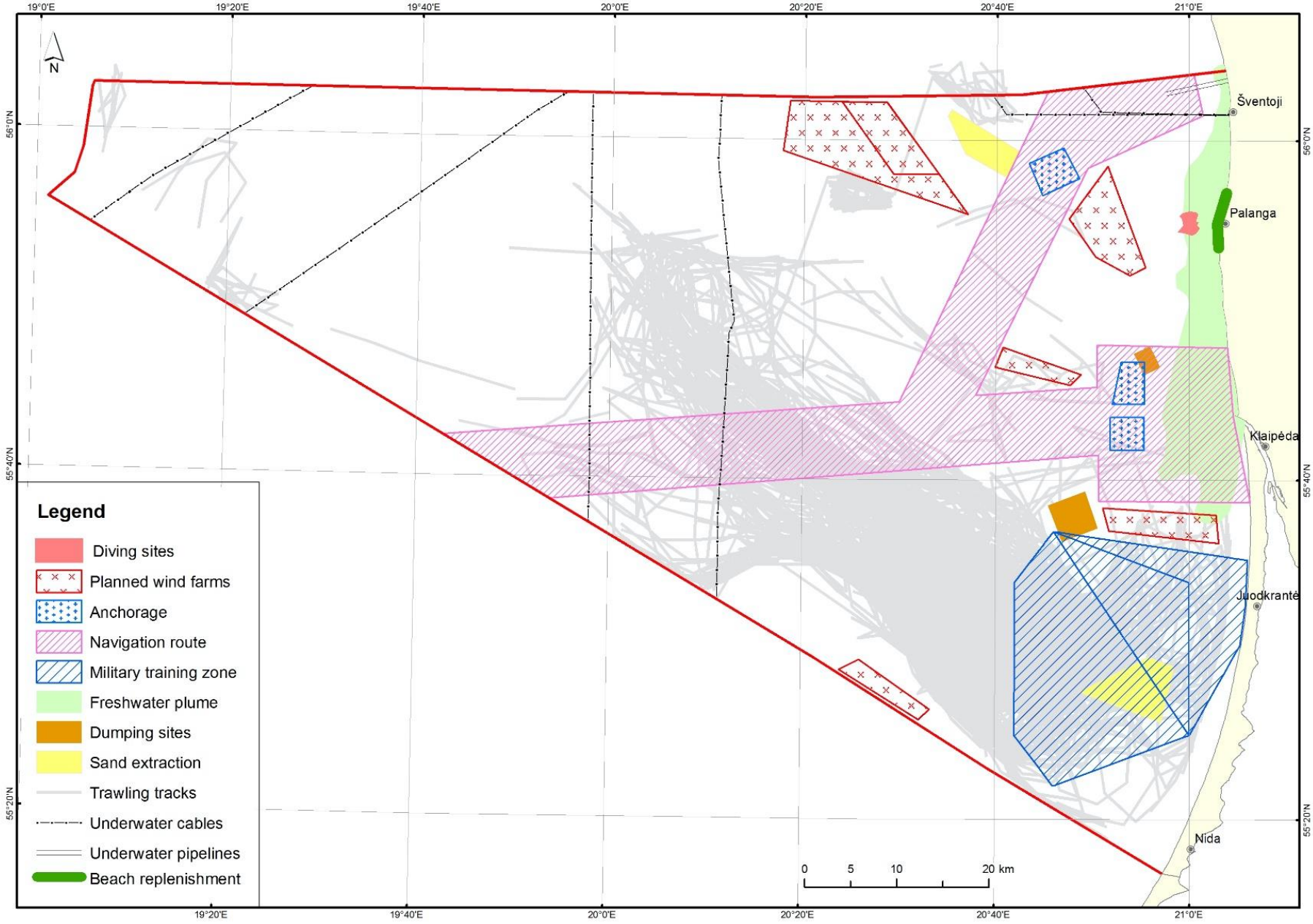

1. The Problem
2. The Case of Lithuanian Marine Area
3. The Concept
4. The Fuzzy Logic Approach for Sensitivity Assessment
5. Mapping
Conclusion

The Problem

* Overlaping natural values and human activities
  → conflicts

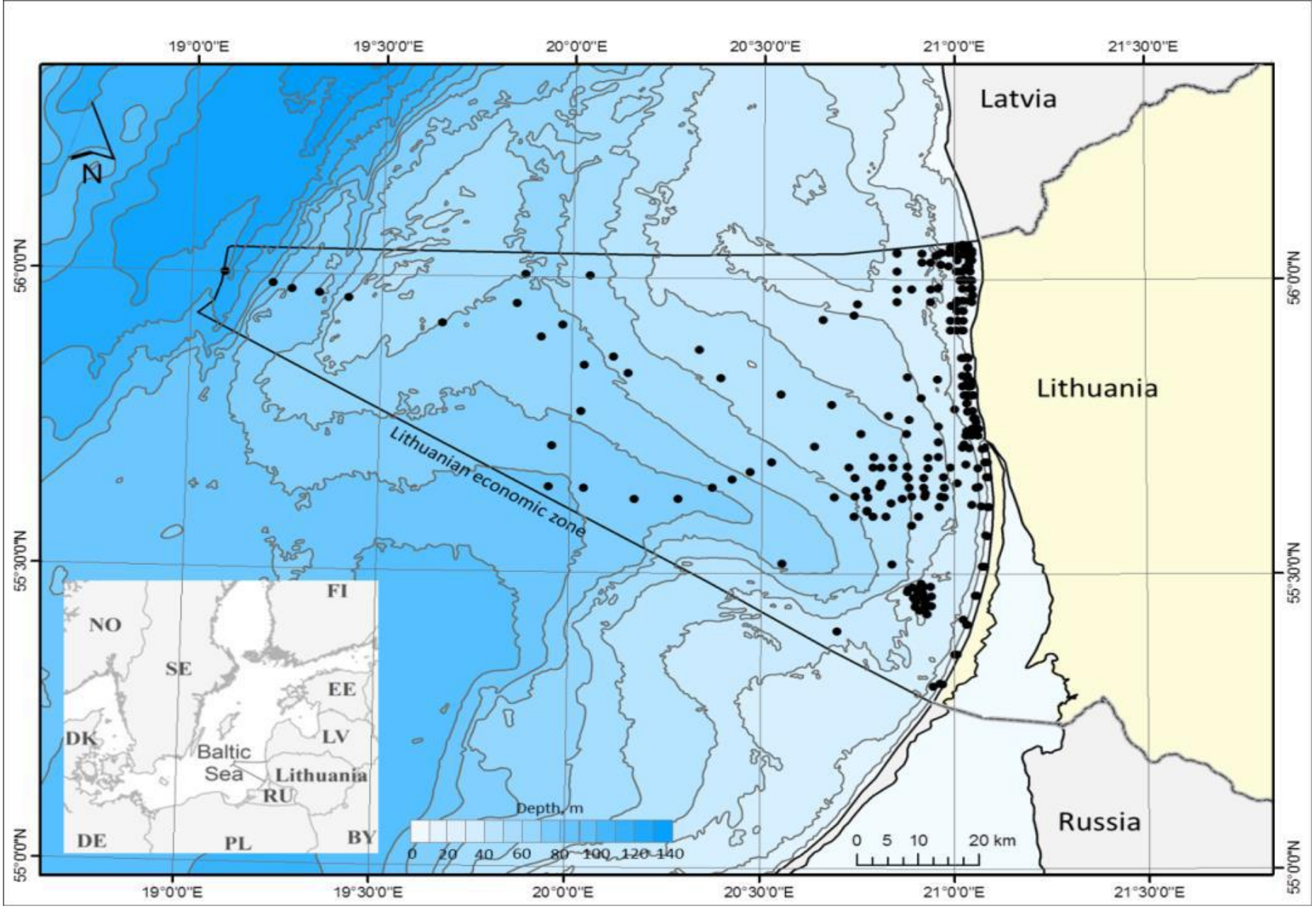
* Considerable information is needed:
  - identification of marine activities
    - their location and scale
  - also the response of environment
    - to separate pressures
    - or different sets of impacts

* The value itself can be estimated differently
  - anthropocentric
  - biocentric


19°0'E
19°20'E
19°40'E
20°0'E
20°20'E
20°40'E
21°0'E
N
56°0'N
55°40'N
55°20'N
Šventoji
Palanga
Klaipėda
Juodkrantė
Nida
Legend
Diving sites
Planned wind farms
Anchorage
Navigation route
Military training zone
Freshwater plume
Dumping sites
Sand extraction
Trawling tracks
Underwater cables
Underwater pipelines
Beach replenishment
0 5 10 20 km

Activity decomposition

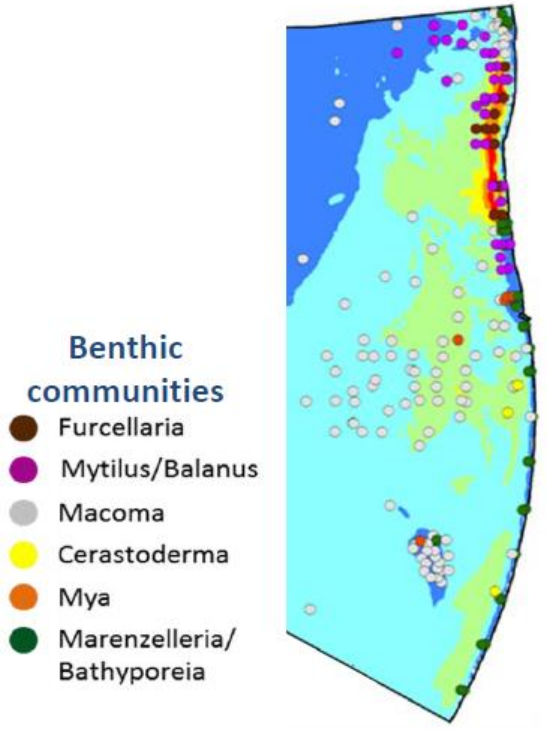
1. Substratum loss
2. Suspended sediment
3. Smothering
4. Desiccation
5. Changes in emergence regime
6. Changes in water flow rate
7. Changes in temperature
8. Changes in turbidity
9. Changes in wave exposure
10. Noise disturbance
11. Visual presence
12. Physical disturbance and abrasion
13. Displacement
14. Synthetic compound contamination
15. Heavy metals contamination
16. Hydrocarbon contamination
17. Radionuclide contamination
18. Changes in nutrient levels
19. Changes in salinity
20. Changes in oxygenation
21. Introduction of microbial pathogens/parasites
22. Introduction of non-native species
23. Selective extraction of this species
24. Selective extraction of other species


19°0'0"E
19°30'0"E
20°0'0"E
20°30'0"E
21°0'0"E
21°30'0"E
56°0'0"N
55°30'0"N
55°0'0"N
N
Latvia
Lithuania
Russia
Lithuanian economic zone
FI
NO
SE
EE
DK
LV
Baltic
Sea
Lithuania
RU
DE
PL
BY
Depth, m
0 20 40 60 80 100 120 140
0 5 10 20 km

Species of Marine Benthos

Furcellaria lumbricalis
Mytilus trossulus
Mya arenaria
Saduria entomon
Polysiphonia nigrescens
Cladophora rupestris
Macoma balthica
Cerastoderma lamarcki
Ceramium spp.
Balanus improvisus
Bathyporeia pilosa
Pontoporeia femorata
Corophium volutator
Idotea balthica

Pilayella littoralis
Ostracoda undet.
Fabricia sabella
Gammarus spp.
Halicryptus spinulosus
Hediste diversicolor
Bylgides sarsi
Jaera albifrons
Marenzelleria neglecta
Oligochaeta undet.
Pygospio elegans
Hydrobia sp.
Streblospio shrubsolii
Theodoxus fluviatilis
Monoporeia affinis



The concept for mapping the most sensitive marine areas

A

Assess

B

Map

A. Decent tool to assess sensitivity

Outline

1.1 To assess **sensitivity** of a particular species to the pressure two characteristics must be defined: **intolerance** and **recoverability**

1.2 MarLIN, The Marine Life Information Network
http://www.marlin.ac.uk

1.3 **Hiscock, K. and Tyler-Walters, H. (2003).** *Assessing the sensitivity of seabed biotopes to human activities and natural events*. Edinburgh: Scottish Natural Heritage

Intolerance	Recoverability: None	Very low (>25 yr.)	Low (>10/25 yr.)	Moderate (>5 -10 yr.)	High (1 -5 yr.)	Very high (<1 yr.)	Immediate (< 1 week)
High	Very high	Very high	High	Moderate	Moderate	Low	Very low
Intermediate	Very high	High	High	Moderate	Low	Low	Very Low
Low	High	Moderate	Moderate	Low	Low	Very Low	NS
Tolerant	NS	NS	NS	NS	NS	NS	NS

A. Fuzzy Logic Approach

Fuzzy sets

Classical set

* Classical set *A* might be expressed as

$$A = \{x \mid x \in X\}$$

* For example

$$A = \{x \mid x > 6\}$$

Fuzzy set

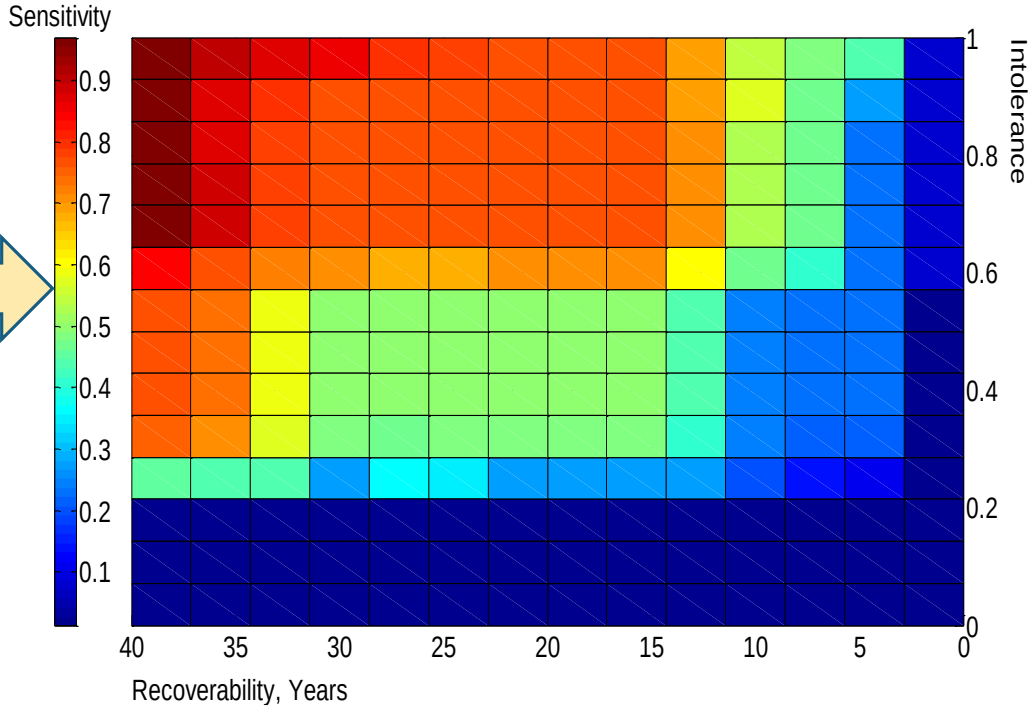
* If *X* is the universe of discourse and its elements are denoted by *x*, then a fuzzy set *A* in *X* is defined as a set of ordered pairs

$$A = \{x, \mu A(x) \mid x \in X\}$$

* $\mu A(x)$ is called the membership function (or MF) of *x* in A.
* The membership function maps each element of X to a membership value between *0* and *1*

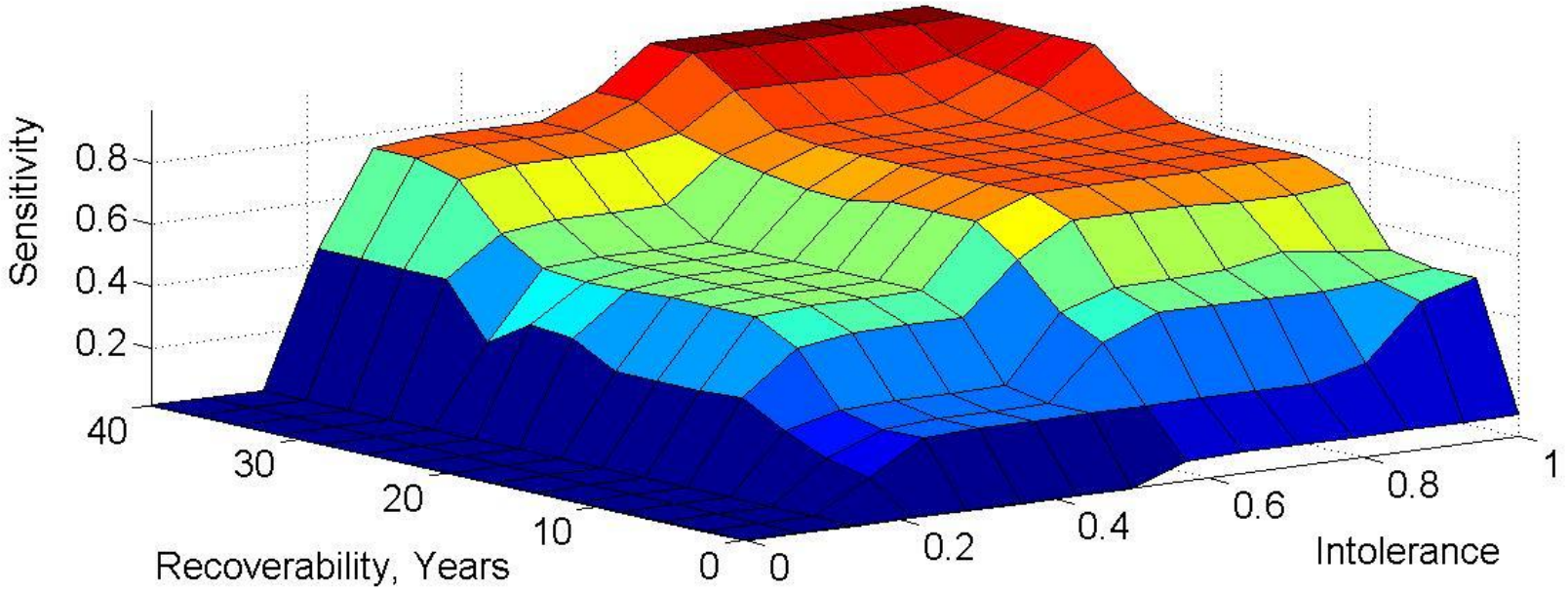
A. Improved 2D Marlin matrix

Intolerance	Recoverability: None	Very low (>25 yr.)	Low (>10/25 yr.)	Moderate (>5 -10 yr.)	High (1 -5 yr.)	Very high (<1 yr.)	Immediate (< 1 week)
High	Very high	Very high	High	Moderate	Moderate	Low	Very low
Intermediate	Very high	High	High	Moderate	Low	Low	Very Low
Low	High	Moderate	Moderate	Low	Low	Very Low	NS
Tolerant	NS	NS	NS	NS	NS	NS	NS



A. Sensitivity surface

Outline



Ocean & Coastal Management xxx (2014) 1–7

Contents lists available at ScienceDirect

Ocean & Coastal Management

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

Switching to numerical scale in marine environmental decision support systems: fuzzy logic approach

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ARTICLE INFO

Article history:
Available online xxx

ABSTRACT

Environmental decision support systems (EDSS) are usually based on environmental models, databases and assessment tools. However, EDSS requires lots of reliable data, which are not readily available, especially information on the distribution of species in marine environments and their dependencies on natural or human pressures. In these cases information is distributed among nominal categories (ranks) which are later used for the decision support. Rules used for assignment into the ranks usually are rough; some of them could be overlapping. But during the decision process the exact rank values are used ignoring the fact that they are derived from the incomplete knowledge. That complicates the comparison of results provided by different cases. In this study a fuzzy logic approach for merging rank and quantitative data with respect to initial accuracy is presented using the example of sensitivity assessment methodology provided by Marine Life Information Network. The proposed approach combines expert knowledge and fuzzy logic methods and provides a possibility to use numerical scales in marine environmental decision support systems, and is a flexible tool for explicit (numerically expressed) sensitivity assessment. This approach can be also applied to other environmental indicators and assessments.

http://dx.doi.org/10.1016/j.ocecoaman.2014.02.002

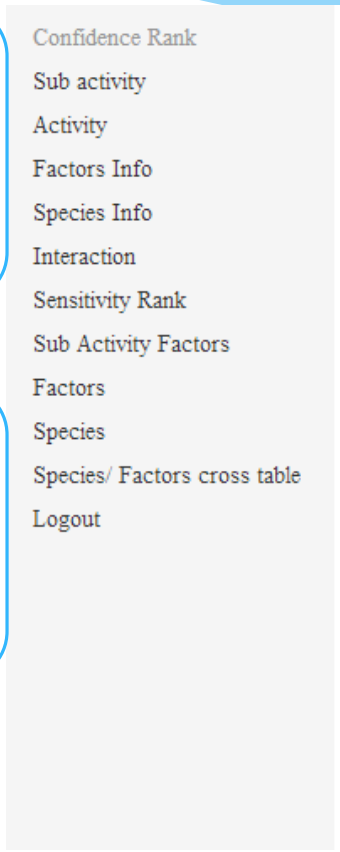
B. Map

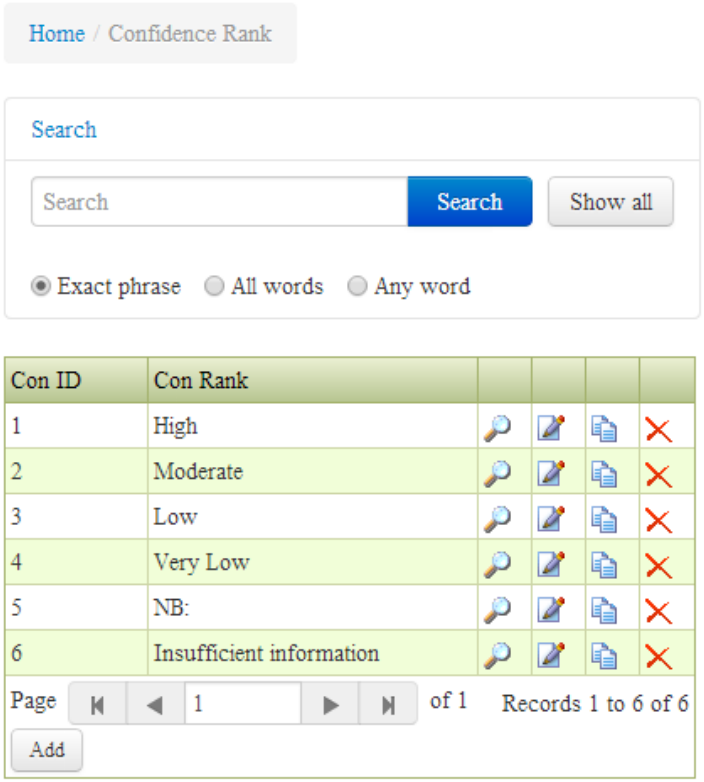
Geo-spatial database

- Activities
- Sub-activities
- Factors
- Species
- Species/factor sensitivity value

WEB application

- Human activities mapping
- Species and habitants mapping
- Map of the most threatened to anthropogenic pressures marine areas





B. The Purpose

What marine areas are the most threatened to anthropogenic pressures?

B. Multi-criteria evaluation

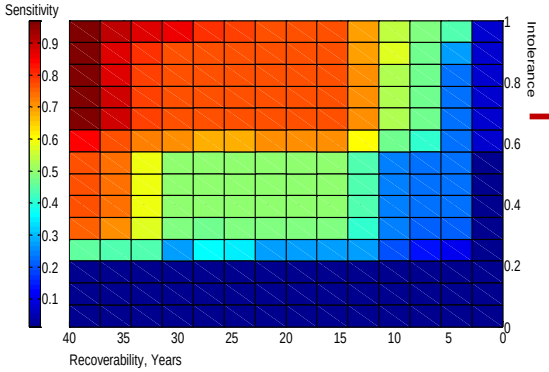
Also known as

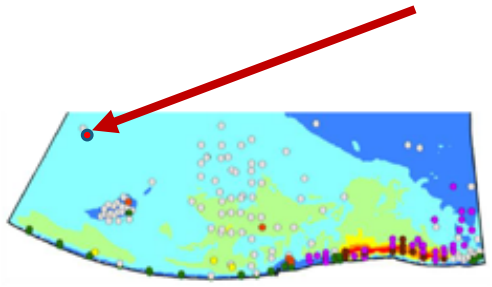
- Multi Criteria Analysis
- Multi Criteria Evaluation (MCE)
- Multi Criteria Preference Analysis
- Multi Criteria Decision Making
- Multi Objective Evaluation

Multi-criteria Evaluation (MCE)

- is primarily concerned with how to combine the information from several criteria to form a single index of evaluation

B. Aggregation of sensitivity values





Total location sensitivity

MCE function

Integral location sensitivity for factor 1

...

Integral location sensitivity for factor 24

MCE function

Sensitivity of species 1 for factor 1

...

Sensitivity of species 29 for factor 1

Sensitivity of species 1 for factor 24

...

Sensitivity of species 29 for factor 24

Available MCE methods

Scaling methods	*Frequency methods*	*Ratio-scaling methods*
• *ordinal geometric evaluation*	• *qualitative concordance analysis* • *permutation method* • *numerical interpretation method*	• *generalized concordance analysis* • *rescoring method*

Conclusion/Further Research

Outline

* The system could serve as a tool for marine spatial planning, providing good background for decision making, i. e. the placement of activities in the least sensitive areas
* Implementation of the sensitivity assessment method in fuzzy logic domain allows to compute continuous sensitivity values and escape from pure categorical judgment
* In current development stage we face difficulty while selecting a proper MCE method, for eaxample *ordinal geometric evaluation, qualitative concordance analysis, permutation method, numerical interpretation method, generalized concordance analysis or rescoring method?*

Aitäh!
Thank you!
Ačiū!