Ecosystem Services - Background

Miguel Inácio
miguel.inacio@io-warnemuende.de

www.baltcoast.net
Coastal areas in a global anthropogenic perspective

Coastal zones occupy around 20% of the earth’s surface

Host more than 45% of the global population

75% of the world’s largest urban agglomerations

Sale et al., 2014

Turner et al., 2014
Ecosystem Services - Context

Why are coastal zones so important?
Why are coastal zones so important?
Ecosystem Services - Context

Which conflicts occur?
Ecosystem Services - Context

What are the consequences?

EEA, 2012c
What are the consequences?

Percentage of classified water bodies in less than good ecological status or potential in coastal and transitional waters:
- < 10%
- 10–30%
- 30–50%
- 50–70%
- 70–90%
- ≥ 90%

EEA member countries not reporting under Water Framework Directive
- No data
- Outside coverage

EEA, 2012c
Ecosystem Services - Concept

*What are the benefits for humans?*

**Ecosystem Goods and Services**
Ecosystem Services - Concept

Ecosystem Service

Ecosystem

Service

www.ansi.org
Ecosystem services:

“benefits that people take from the ecosystem” (MEA, 2005)
Ecosystem Services - Concept

Biogeochemical cycles

Air and climate regulation

Science and education
Legacy of the sea

Inedible goods
Regulation of environmental toxins

Sediment retention
Chemical resources

Food webs
Habitat
Cultural heritage

Biological diversity

Nutrient buffering
Primary production

Inedible goods
Biologic regulation

Food
Inspiration

Space and waterways
Resilience

Energy

O² CO₂

H₂O

www.ieep.eu
Different definitions of ES but all most similar:

- “Ecosystem services are the outputs of ecosystem from which people derive benefits” (National Ecosystem Services assessment, 2011 and Millennium Ecosystem Services Assessment, 2005)

- “the aspects of ecosystems utilized (actively or passively) to produce human well-being” (Fisher et al. 2009)

- “The direct and indirect contributions of ecosystems to human well-being. The concept of ecosystem goods and services is synonymous with ecosystem services (The Economics of Ecosystems and Biodiversity: TEEB, 2010)

- Ecosystem services are made up of tangible goods (e.g. food and raw materials) and intangible services (e.g. the regulation of our climate and the remediation of waste). (Hattam et al 2016)
Ecosystem services:

“contributions of ecosystem structure and function – in combination with other inputs – to human well-being” (Burkhard et al., 2012)
According to Nahlik (2012) the concept of ES should be:

1. **definition and classification of ecosystem services classes** including those issues such as **double-counting** are added;

2. **trans-disciplinary** – providing for the integration of collaboration between disciplines, including them in the development of the framework and ensuring that the **terminology used** is appropriate for all;

3. **community engagement** – dialog with local stakeholders and scientist;

4. **resilient** – adaptable and responsive to changing conditions, experience and improved knowledge, to **ensure that they are operational over the long-term**;

5. **cohesive and coherent** – conceptually sound and organized logically, realistically and its use demonstrated

6. **policy-relevant** – the framework should include **policy objectives** as a major component of the framework
Ecosystem Services - Concept

Environmental

Social

Economic
Ecosystem Services - Concept

ECOLOGICAL
- Photosynthesis
- Soil Creation
- Pollination
- Water Cycle
- Tourism
- Health & Well-being
- Aesthetic
- Recreation
- Water
- Food
- Wood
- Fiber
- Clean Air
- Flood Control
- Purify Water
- Carbon Storage

CULTURAL
- Education
- Recreation
- Health & Well-being
- Aesthetic
- Tourism
- Agriculture
- Art
- Heritage
- Education

ECONOMIC
- Food
- Wood
- Fiber
- Clean Air
- Flood Control
- Purify Water
- Carbon Storage
- Education

REGULATING
- Water
- Soil
- Climate
- Erosion
- Insect Control
- Disease Control

Ecosystem Services
Indispensable
Irreplaceable
Invaluable
How this all work?
The need to access Nature’s “capital value” lead to the need of performing assessment of ecosystem services

But...

There was no name for the services neither how to classify them in categories or so

Then...

Some classifications started to be developed and in 2005 the Ecosystem Services concept started to be better developed with the Millennium Ecosystem Assessment (MEA) which is still one of the most widely used classifications of ecosystem services
Ecosystem Services - Classification

**MEA**
- 4 Categories
- 21 Sections
- Classification accepted and used in global sub global assessments

**TEEB**
- 4 Categories
- 22 Sections
- Updated classification based on MA, used in ongoing national TEEB studies across Europe

**CICES**
- 3 Categories
- 30 Sections
- Build on MA and TEEB, hierarchical system tailored to accounting
Common International Classification for Ecosystem Services (CICES)

- Build on the need of standardization for the development of accounting methods and at the same time with the objective of allowing comparisons.

- CICES has been evolving following the idea that besides the standardization this classification should work on mapping and valuing ES and ecosystem.

- CICES does this in a more hierarchical and systematic approach of assessing ES.

- This classification is the “officially” accepted by EU, mainly connected with “Mapping and assessment of ecosystems and their services”, which forms part of EU Biodiversity 2020 Strategy.
CICES Classification divides the Ecosystem in 3 major categories (sections):

- **Provisioning**
- **Regulation & Maintenance**
- **Cultural**

This classification is further divided into:

- **Division**
- **Group**
- **Class**
- **Class type**

### CICES for ecosystem accounting

<table>
<thead>
<tr>
<th>Section</th>
<th>Division</th>
<th>Group</th>
<th>Class</th>
<th>Class type</th>
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<tr>
<td>Provisioning</td>
<td>Nutrition</td>
<td>Biomass</td>
<td>Cultivated crops</td>
<td>Crops by amount, type</td>
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<td></td>
<td>Reared animals and their products</td>
<td>Animals, products by amount, type</td>
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<td>Wild plants, algae and their outputs</td>
<td>Plants, algae by amount, type</td>
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<td>Wild animals and their outputs</td>
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<td>Plants and algae from in-situ aquaculture</td>
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<td>Water</td>
<td>By amount, type</td>
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<td>Surface water for drinking</td>
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<td>Ground water for drinking</td>
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</table>

Note this section is open in that many class types can...
3 Categories

Provisioning services

Regulating & Maintenance services

Cultural services
Provisioning services:

- All material and biota-dependent energy outputs from ecosystems
- Tangible things that can be directly exchanged or traded

3 Major divisions:

- **Nutrition** – all ecosystem outputs use directly or indirectly as food
- **Material (biotic)** – used directly or employed in the manufacture of goods
- **Energy (biomass)** – biotic renewable energy sources and mechanical energy provided by animals
Regulating and maintenance services:

- All ways in which ecosystems control or modify biotic or abiotic parameters that define the environment of people
- These services are not consumed directly but affect the performance of individuals communities and populations and their activities

3 Major divisions:

- **Mediation of waste, toxics and other nuisances** – the services biota ecosystems provide to detoxify or simply dilute substances mainly as result of human action

- **Mediation of flows** – services such as regulation and maintenance of land and snow masses, flood and storm protection

- **Maintenance of physical, chemical, biological conditions** – ecosystem provide for sustainable living conditions (climate regulation, soil formation, nursery functions) supporting the provisioning services
Cultural Services:

➢ All non-material ecosystem outputs that have symbolic, cultural or intellectual significance

2 Major divisions:

– Physical and intellectual interactions with biota, ecosystems and land-/seascapes

– Spiritual, symbolic and other interactions with biota, ecosystems and land-/seascapes
Intermediate Services

Regulate the provisioning of final services

Final Services

Direct use by humans
Concept definition ✓
Classification and categorization ✓

But...

How to access or measure them?

well...

To access ecosystem services the best way is to define **indicators** that can represent and somehow measure the service.
The best way of assessing ES is through the use of **Indicators**, but since the concept was in general focus on terrestrial assessments there are few indicator lists available for the marine environment!

...but, some efforts have been done and the **EU Project MAES**, developed an indicator set for application of ES concept in marine realm!

### Indicators for ecosystem services delivered by marine ecosystems

<table>
<thead>
<tr>
<th>Division</th>
<th>Group</th>
<th>Class</th>
<th>Marine Inlets and Transitional waters</th>
<th>Coastal waters</th>
<th>Shelf waters</th>
<th>Open Ocean</th>
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<td>Wild plants, algae and their outputs</td>
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<td></td>
<td>Wild animals and their outputs</td>
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<td>Plants and algae from in-situ aquaculture</td>
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</table>
Marine ecosystem services: Linking indicators to their classification

Caroline Hattam a,*, Jonathan P. Atkins b, Nicola Beaumont a, Tobias Börger a, Anne Böhnke-Henrichs c, Daryl Burdon d, Rudolf de Groot c, Ellen Hoefnagel e, Paulo A.L.D. Nunes f, Joanna Piwowarczyk g, Sergio Sastre h, Melanie C. Austen a

Typology and indicators of ecosystem services for marine spatial planning and management

Anne Böhnke-Henrichs a,*, Corinne Baulcomb b, Rebecca Koss c, S. Salman Hussain b, Rudolf S. de Groot a

The UK National Ecosystem Assessment

Synthesis of the Key Findings
Ecosystem Services - Methodology

Concept definition
Classification and categorization
Indicators

Now ...
...is all about choosing the methodology
There are different approaches and methodologies for ES assessment, although there is no standard one to follow!

**different kinds of approaches**

**Qualitative**  
**Semi-Quantitative**  
**Quantitative**

Which approach to take depends on the scope of the assessment
Decide on the number of services to be assessed
Ecosystem Services - Methodology

Assessing the functions and parameters that define the ecosystem

Understand how they work and how they can be quantified

Market Values:
- **travel cost method** (how much do you pay to go to the beach)
- **hedonic price** (value of house when close to the beach)
- **replacement costs** (how much cost to simulate the service mechanically)
- **market prices**

Non-market Values:
- **Willingness to pay**
- **Choice modelling**
Ecosystem services provided by a complex coastal region: challenges of classification and mapping

Lisa P. Sousa¹, Ana I. Sousa¹, Fátima L. Alves¹ & Ana I. Lillebø²
Ecosystem Services - Methodology

The “Matrix” Approach!

Developed by
Benjamin Burkhard
& colleagues from Kiel University

Many applications not only in Europe but also already applied in Indonesia!

Mapping ecosystem service supply, demand and budgets
Benjamin Burkhard\textsuperscript{a,}\textsuperscript{*}, Franziska Kroll\textsuperscript{a}, Stoyan Nedkov\textsuperscript{b}, Felix Müller\textsuperscript{a}

Contents lists available at ScienceDirect
Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind
Ecosystem Services - Methodology

The “Matrix” Approach

Space for improvement through Modeling

- Hydrographical modeling
- Bio/Physical/Chemical modeling

Quantitative Approach!

- Past and Future Scenarios
- Relative change of ES provision
- Sustainability regarding ES
Ecosystem Services Assessment Tool (ESAT)

easy to apply tool for ecosystem services assessment in the marine environment
Loss of ecosystem integrity, resilience and overall ecological status

Impact on the ecosystem’s ability to provide ecosystem services
Ecosystem Services - Methodology

31 Ecosystem Services (Provisioning, Regulating & Maintenance, Cultural Services)

54 Indicators

representing the good ecological status following Water Framework Directive

Initial Status

Present Status

representing the present ecological conditions

Decrease in the provision

No Change

Increase in the provision
Incorporate different types of Data

<table>
<thead>
<tr>
<th>Observational Data</th>
<th>Literature and Reports</th>
<th>Other Sources (Modelling)</th>
<th>Expert Knowledge</th>
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For each source it is given criteria about Quality / Reliability of data

1. Very High
2. High
3. Moderate
4. Low
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<tr>
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<td>Wild plants, algae and their outputs</td>
<td>Harvest</td>
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<td>Nº of Species</td>
<td>nº/km²</td>
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<td>Wild animals and their outputs</td>
<td>Landings</td>
<td>Ton/yr./km²</td>
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<td></td>
<td>Landing of key market species</td>
<td>Ton/yr./km²</td>
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<td>Biomass</td>
<td>Animals from in situ aquaculture</td>
<td>Harvest</td>
<td>Ton/a</td>
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<td>Nº of Species</td>
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<tr>
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<td>Water</td>
<td>Surface water for drinking purposes</td>
<td>Harvest</td>
<td>Ton/yr./km²</td>
</tr>
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<td>Nº of Species</td>
<td>nº/km²</td>
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<td>Materials</td>
<td>Biomass</td>
<td>Fibres and other materials from plants, algae and animals for direct use or processing</td>
<td>Harvest</td>
<td>Ton/yr./km²</td>
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<td>Materials from plants, algae and animals for agriculture</td>
<td>Harvest</td>
<td>Ton/yr./km²</td>
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Assessment
## Ecosystem Services - Methodology

### Initial Status

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### Classes of ES

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<th>2.5 to 4.1</th>
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</table>
## Provisioning Services - Methodology

### Present Status

**ES classification**
- **Section**: Provisioning Services
- **Division**: Nutrition
- **Group**: Biomass
- **Class**: Wild animals and their outputs

<table>
<thead>
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### Data Sources

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</table>

| 0.317  | 0.317 | 0.520 | 0.765 | 0.765 | 1.000 | 1.000  | 1.182  | 1.182 | 1.430 | 1.430 | 1.690  | 1.690  | 2.210  | 2.210  | 3.250  | 3.250  | 5.330  | 5.330  |
## Ecosystem Services - Methodology

### Ecosystem Services Classification

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Visualization
## Ecosystem Services - Methodology

### Provisioning Services
- Wild animals and their outputs
- Filtration/sequestration/storage/accumulation by ecosystems
- Dilution by atmosphere, freshwater and marine ecosystems
- Mass stabilisation and control of erosion rates
- Buffering and attenuation of mass flows

### Regulating & Maintenance Services
- Flood Protection
- Maintaining nursery populations and habitats
- Pest and Disease control
- Decomposition and fixing processes
- Chemical condition of salt waters
- Global climate regulation by reduction of greenhouse gas concentrations
- Micro and regional climate regulation

### Cultural Services
- Experiential use of plants, animals and land-seascapes in different...
- Physical use of land-seascapes in different environmental settings
- Scientific and Educational
- Heritage, cultural
- Entertainment
- Aesthetic
- Symbolic
- Sacred and/or religious
- Existence
- Bequest
Ecosystem Services - Methodology

Sections
1. Provisioning Services
2. Regulating & Maintenance Services
3. Cultural Services

Divisions
1. Nutrition
2. Materials
3. Energy
4. Regulation of waste, toxins and other substances
5. Mediation of flow
6. Maintenance of physical, chemical, biological conditions
7. Physical and intellectual interactions with biota, ecosystems, and land/naturalcaps (environmental settings)
8. Spiritual, symbolic and other interactions with biota, ecosystems, and land/naturalcaps
9. Lifecycle maintenance, habitat and gene pool protection
10. Pest and disease control
11. Soil formation and composition
12. Water conditions
13. Atmospheric composition and climate regulation
14. Physical and experiential interactions
15. Intellectual and subjective interactions
16. Spiritual and/or emblematic
17. Other cultural outputs

Classes
1. Wild plants, algae and their outputs
2. Wild animals and their outputs
3. Animals from in situ aquaculture
4. Plants and algae from in situ aquaculture
5. Surface water for drinking purposes
6. Fibers and other materials from plants, algae and animals for direct use or processing
7. Materials from plants, algae and animals for agriculture
8. Surface water for non-drinking purposes
9. Plant-based resources
10. Animal-based resources
11. Filtration/reclamation/management of ecosystems
12. Dilation by atmosphere, freshwater and marine ecosystems
13. Mass stabilisation and control of erosion rates
14. Buffering and attenuation of mass flows
15. Flood Protection
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Indicators
1. Hoverfly
2. Biotic index
3. Land use
4. Landing of key market species
5. Harvester
6. NHP of species
7. Harvest
8. NHP of species
9. Use of water
10. Harvest
11. Harvest
12. Use of water
13. Use
14. Use
15. Afforestation
16. Forest
17. Decontamination
18. Averaged annual emission per year
19. Extent of selected emergent, submerged and intertidal habitats
20. Sediment accumulation rate
21. Shoreline erosion rate
22. Maximum depth (to calculate maximum wave height)
23. Oxygen concentration < 4 mg/L
24. Oxygen concentration < 8 mg/L
25. Species distribution
26. No data

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Ecosystem Services - Methodology

Provisioning Services

Cultural Services

Regulating & Maintenance Services

-present status
- initial status

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## Ecosystem Services - Methodology

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<td>Animal and algae from in situ aquaculture</td>
<td>0</td>
</tr>
<tr>
<td>Surface Water for drinking purposes</td>
<td>3</td>
</tr>
<tr>
<td>Fibres and other materials from plants, algae and animals (for direct use or processing)</td>
<td>3</td>
</tr>
<tr>
<td>Materials from plants, algae and animals for agriculture</td>
<td>3</td>
</tr>
<tr>
<td>Surface Water for non-drinking purposes</td>
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</tr>
<tr>
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<td>3</td>
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</tr>
<tr>
<td>Filtration/sequestration/transport/acclimation by ecosystems</td>
<td>3</td>
</tr>
<tr>
<td>Diffusion by atmosphere, freshwater and marine ecosystems</td>
<td>3</td>
</tr>
<tr>
<td>Mass stabilization and control of erosion rates</td>
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<tr>
<td>Buffering and attenuation of large flows</td>
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<td>Flood protection</td>
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<tr>
<td>Maintaining nursery populations and habitats</td>
<td>3</td>
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<tr>
<td>Decomposition and dying processes</td>
<td>3</td>
</tr>
<tr>
<td>Chemical condition of salt waters</td>
<td>3</td>
</tr>
<tr>
<td>Global climate regulation by reduction of greenhouse gas concentrations</td>
<td>3</td>
</tr>
<tr>
<td>Micro- and regional climate regulation</td>
<td>3</td>
</tr>
<tr>
<td>Experimental use of plants, animals and land (easements) in different environmental settings</td>
<td>3</td>
</tr>
<tr>
<td>Physical use of land/easements in different environmental settings</td>
<td>3</td>
</tr>
<tr>
<td>Scientific and Educational</td>
<td>3</td>
</tr>
<tr>
<td>Heritage, cultural</td>
<td>3</td>
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<tr>
<td>Entertaiment</td>
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<tr>
<td>Aesthetics</td>
<td>3</td>
</tr>
<tr>
<td>Symbolic</td>
<td>3</td>
</tr>
<tr>
<td>Sacred and/or religious</td>
<td>3</td>
</tr>
<tr>
<td>Esoteric</td>
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<tr>
<td>Bequest</td>
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#### Scenario 4

<table>
<thead>
<tr>
<th>Class</th>
<th>Average</th>
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<tr>
<td>Wild plants, algae and their outputs</td>
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<tr>
<td>Wild animals and their outputs</td>
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➢ To whom this concept can be relevant?

– Governments
– Managers and Policy makers
– Stakeholders
– Scientists
– NGO’s
– General Public

TARGET 2 Maintain and restore ecosystems and their services
Ecosystem Services - Importance

Policy & stakeholder mapping, stakeholder dialogue, dysfunction diagnosis, policy & management options, definition of indicators

Cause & effect chain, definition of ‘virtual system’, identification of social & economic components, institutional mapping, external hazard analysis

Data and tool analysis, creation of conceptual & simulation models, development of alternative management solutions (scenarios)

Model calibration & validation, simulations of the scenarios simulations & interpretive analysis

Preparation of decision taking process, evaluation of scenarios stakeholders & managers dialogues and meetings

Plan & measure execution including institutional, legal and financial arrangements

Social, economic & ecological data collection, indicator based evaluation of process and state

External framework conditions

Issue Identification

System Design

System Formulation

System Assessment

Implementation

Monitoring & Evaluation

Stakeholder engagement
Ecosystem Services - Importance

Following the services of the Ecosystem Services Assessment Tool

Identify which services are relevant for the study area

Policy & stakeholder mapping, stakeholder dialogue, dysfunction diagnosis, policy & management options, definition of indicators
Social, economic & ecological data collection, indicator based evaluation of process and state

Application of the Ecosystem Services Assessment Tool

Comparing Initial and Present Status

Comparing Present Status and Future Scenarios

External framework conditions

Issue Identification

System Design

System Formulation

System Assessment

Implementation

Monitoring & Evaluation

Stakeholder engagement

Ecosystem Services - Importance

Application of the Ecosystem Services Assessment Tool

Social, economic & ecological data collection, indicator based evaluation of process and state
Ecosystem Services - Importance

State → Function → Service

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Final remarks

➢ Good concept to help raise awareness on the **value of Nature and its contribution to human wellbeing**;

➢ The increase of assessments and mapping of ES in the oceans will develop our **knowledge about the interaction of economic and social with the ecologic part of the system**

➢ Development of a **standard methodology and indicators** that fits both land and sea and incorporates land-sea interface;

➢ **Raise awareness of the Public about the concept!**
Thank You

Any question send email to: miguel.inacio@io-warnemuende.de / miguel.inacio@jmtc.ku.lt