New tools for the assessment of biodiversity developed by the European FP7 DEVOTES project

United Nations Environment Programme

The 17th Global Meeting for the Regional Seas
Conventions and Action Plans
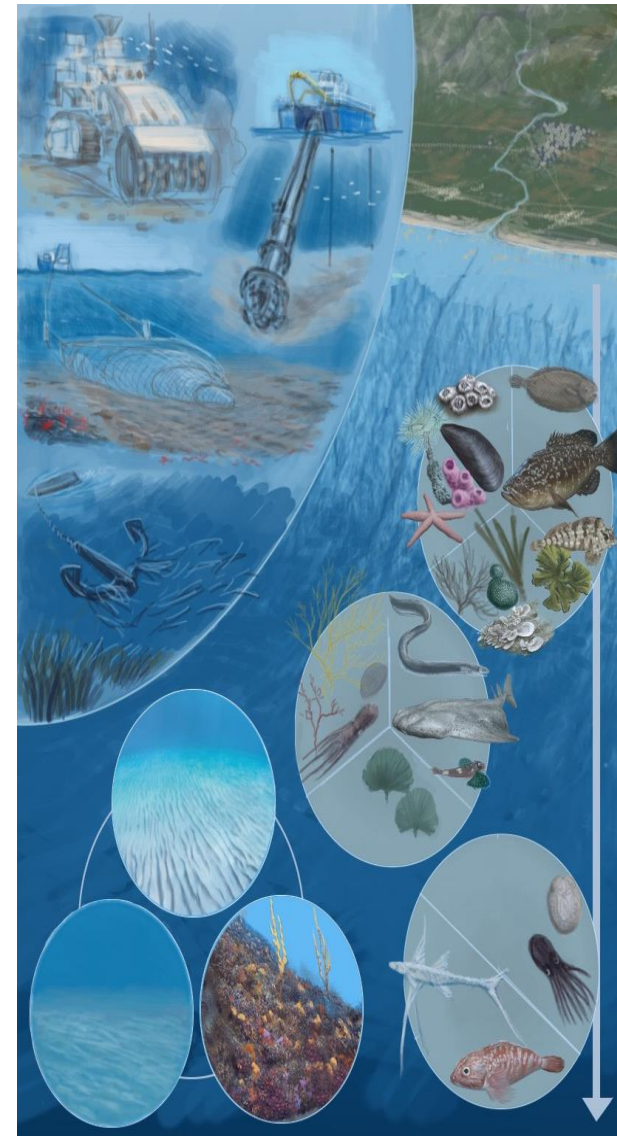Istanbul, Turkey 20 October - 22 October 2015

www.devotes-project.eu

Angel Borja

azti
tecnalia

Regional Seas Conventions, Istanbul, 20th October 2015

Descriptors and indicators

Biodiversity   **Foodwebs**   **Seafloor integrity**

Challenges and objectives

| Challenges	Objectives	Work Packages
Interaction pressure-impact-climate change	Improve our understanding of the **impact of human activities and climate change** on marine biodiversity.	**WP1: 'Human pressures and climate change'.**
Cost-benefit measures	**Identify barriers and bottlenecks** that prevent Good Environmental Status (GEnS) from being achieved	**WP2: 'Socio-economic implications of GEnS'.**
Role of indicators **GEnS meaning**	**Test indicators and develop new**, innovative ones to assess biodiversity in a harmonized way throughout the 4 regional seas.	**WP3: 'Indicator testing and development'.**
Reduce monitoring costs **New assessment tools** **Integration of data**	**Develop, test and validate innovative integrative modelling and monitoring tools** to improve our understanding of ecosystem and biodiversity changes, for integration into a unique and **holistic assessment**	**WP4: 'Innovative modelling tools'.** **WP5:'Innovative monitoring techniques** **WP6: 'Integrative assessment'**
Participation of stakeholders **Public awareness**	**Propose and disseminate strategies** and measures for ecosystems' adaptive management, including the active role of industry and relevant stakeholders	**WP7: 'Outreach, stakeholder engagement and product dissemination'.**

Test indicators and develop innovative ones

DEVOTool software: contains indicators to assess the status within the Marine Strategy Framework Directive, used by Member States and Regional Sea Conventions. Allows selecting indicators and refining them

DEVOTool software *version 0.64*
(for Mac and Windows)

Useful for:

http://www.devotes-project.eu/devotool/
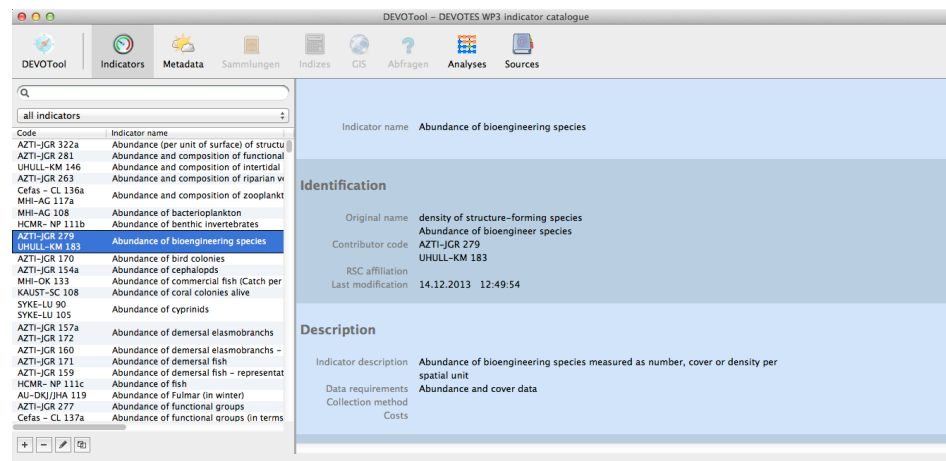
DEVOTES Biodiversity Assessment Tool

Integrated assessment of marine biodiversity status using a prototype indicator-based assessment tool

Jesper H. Andersen[1,2]*, Karsten Dahl[3], Cordula Göke[3], Martin Hartvig[4,5], Ciarán Murray[3], Anna Rindorf[4], Henrik Skov[6], Morten Vinther[4] and Samuli Korpinen[2]

Step	Action
1	Sectors
2	Habitats
3	Enter data
4	Count
5	Area
6	Quality
7	Weights
8	Status
9	Summary
	Options
	Version Info

DEVOTES

www.devotes-project.eu
Development of innovative tools for understanding marine biodiversity and assessing good environmental status

Useful for:

Introduction

- A tool to assess marine biodiversity status *sensu* the EU Marine Strategy Framework Directive (MSFD), but adaptable to any sea

- It has a modular structure, based on a conceptual view of the marine ecosystem with a hierarchical organization of biodiversity indicators

- This allows expanding with additional indicators (and Descriptors) as they become widely accepted in the scientific community

- Custom aggregation rules can be defined matching regional differences in the functioning of the ecosystem

1) Gulf of Finland
2) Kattegat
3) Southern North Sea
4) Bay of Biscay
5) Adriatic Sea
6) Eastern Aegean Sea
7) Sea of Marmara
8) Western open Black Sea

DEVOTES Pilot Study Areas, shown in a broad context, for details see text.

- The tool calculates the uncertainty associated to the result

- We have tested it in the North Sea - Baltic Sea transition area (the Kattegat) and the Bay of Biscay (Basque Coast)
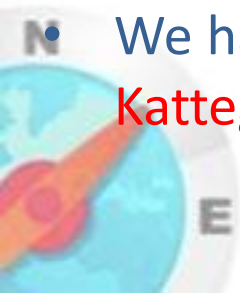
It's all about choice ...

What do you want to do?

Environmental assessment

Biodiversity assessment → What do you want to assess?

Pressure assessment

Environmental risk assessment

Environmental impact assessment

Region → Which region are you assessing?

Biodiversity components

Habitats

ecosystem processes

ecosystem services/goods

Don't know

Baltic

North-East Atlantic

Mediterranean

Black Sea

Dont't know

Which pressure do you want to assess?

Physical loss → Which habitats?

Physical damage

Underwater noise

Marine litter

...

Don't know

Seabed → Specify the habitat type:

Water column

Ice habitat

Littoral rock and biogenic reef

Littoral sediment
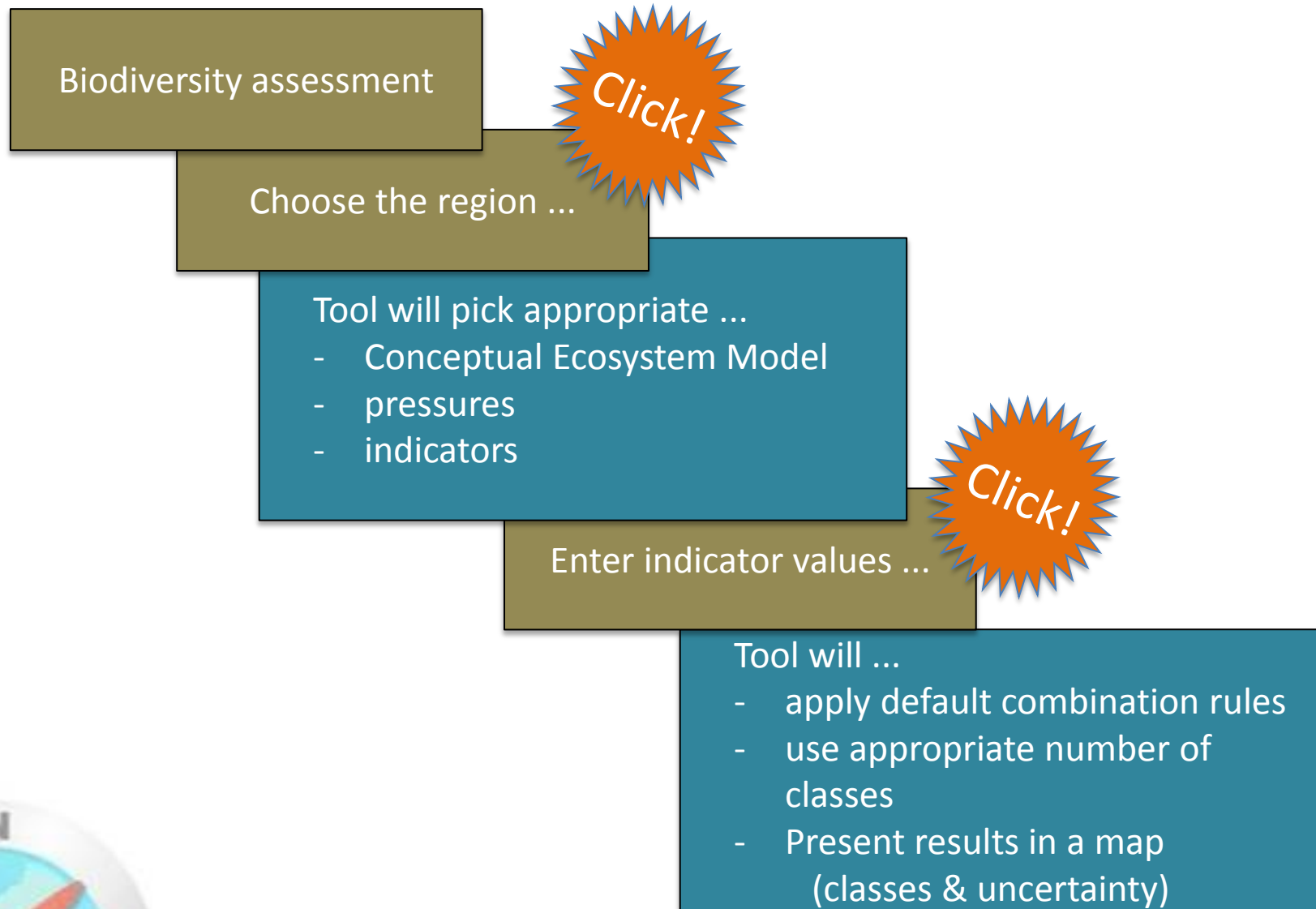
Shallow sublitoral rock and biogenic reef

Shallow sublittoral coarse sediment

...

8

Most simple case … biodiversity assessment

Biodiversity assessment

Click!

Choose the region …

Tool will pick appropriate …
- Conceptual Ecosystem Model
- pressures
- indicators

Click!

Enter indicator values …

Tool will …
- apply default combination rules
- use appropriate number of classes
- Present results in a map (classes & uncertainty)

Structure

- Geographical entities: "sectors"

- Habitat types

- Indicators
  - Boundary values
  - Observed value (+ Std Err)

- Weights for sectors/habitats
  - Area
  - Relative value ("quality")

- Results
  - 2 or 5 classes (Good/Not or Bad/Poor/Mod/Good/High)
  - Uncertainty
  - Descriptors

Contents lists available at ScienceDirect

Marine Pollution Bulletin

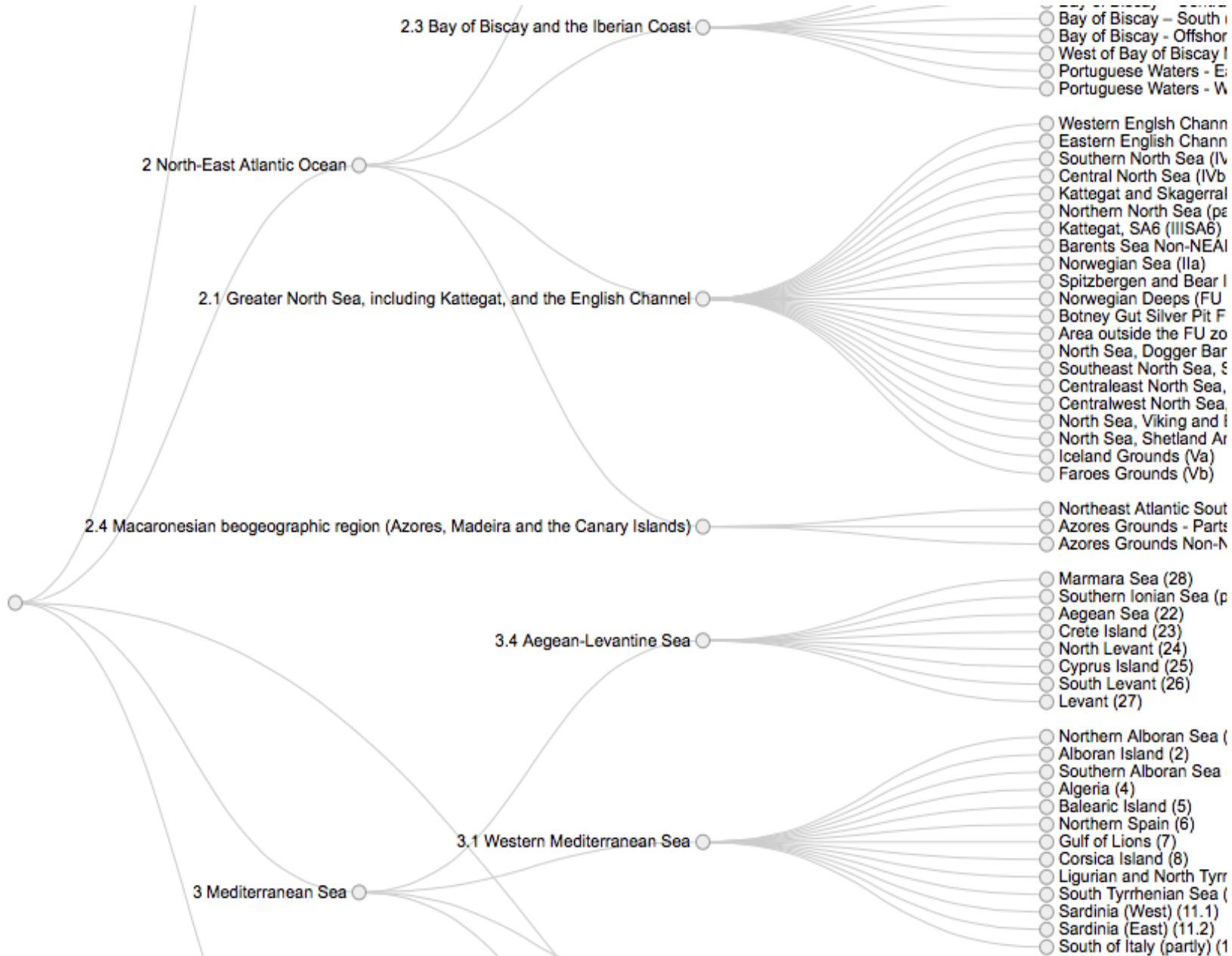journal homepage: www.elsevier.com/locate/marpolbul

ELSEVIER

Viewpoint

Good Environmental Status of marine ecosystems: What is it and how do we know when we have attained it?
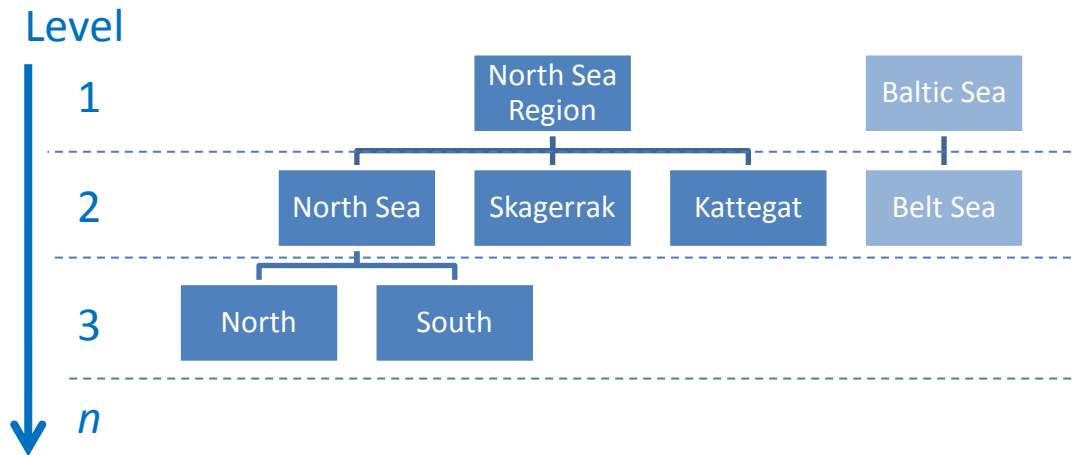
Angel Borja [a,*], Mike Elliott [b], Jesper H. Andersen [c], Ana C. Cardoso [g], Jacob Carstensen [c], João G. Ferreira [d], Anna-Stiina Heiskanen [e], João C. Marques [f], João M. Neto [f], Heliana Teixeira [g], Laura Uusitalo [e], María C. Uyarra [a], Nikolaos Zampoukas [g]

	A	B	C	D	E
1	Step	Action			
2	1	Sectors			
3	2	Habitats			
4	3	Enter data			
5	4	Count			
6	5	Area			
7	6	Quality			
8	7	Weights			
9	8	Status			
10	9	Summary			
11					
12		Options			
13		Version Info			

Choose … regions/define sectors

2.3 Bay of Biscay and the Iberian Coast
- Bay of Biscay – South (
- Bay of Biscay - Offshor
- West of Bay of Biscay I
- Portuguese Waters - E:
- Portuguese Waters - W

2 North-East Atlantic Ocean

2.1 Greater North Sea, including Kattegat, and the English Channel
- Western English Chann
- Eastern English Chann
- Southern North Sea (IV
- Central North Sea (IVb
- Kattegat and Skagerral
- Northern North Sea (pa
- Kattegat, SA6 (IIISA6)
- Barents Sea Non-NEAl
- Norwegian Sea (IIa)
- Spitzbergen and Bear I
- Norwegian Deeps (FU
- Botney Gut Silver Pit F
- Area outside the FU zo
- North Sea, Dogger Bar
- Southeast North Sea, S
- Centraleast North Sea,
- Centralwest North Sea,
- North Sea, Viking and I
- North Sea, Shetland Ar
- Iceland Grounds (Va)
- Faroes Grounds (Vb)

2.4 Macaronesian beogeographic region (Azores, Madeira and the Canary Islands)
- Northeast Atlantic Sout
- Azores Grounds - Parts
- Azores Grounds Non-N

3.4 Aegean-Levantine Sea
- Marmara Sea (28)
- Southern Ionian Sea (p
- Aegean Sea (22)
- Crete Island (23)
- North Levant (24)
- Cyprus Island (25)
- South Levant (26)
- Levant (27)

3.1 Western Mediterranean Sea
- Northern Alboran Sea (
- Alboran Island (2)
- Southern Alboran Sea
- Algeria (4)
- Balearic Island (5)
- Northern Spain (6)
- Gulf of Lions (7)
- Corsica Island (8)
- Ligurian and North Tyrr
- South Tyrrhenian Sea (
- Sardinia (West) (11.1)
- Sardinia (East) (11.2)
- South of Italy (partly) (1

3 Mediterranean Sea

N

Define Sectors

Level

Sector definition:

- Level
- Unique ID
- ID of parent (if level > 1)
- Area (km²)
- Weight

Choose … habitats/biotopes

Habitat definition:

- Level
- Unique ID
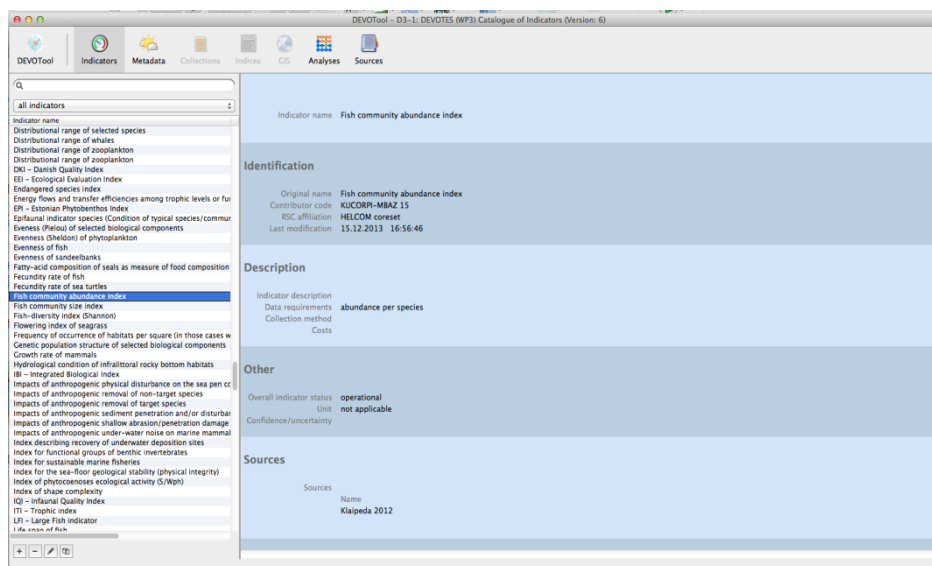- ID of parent (if level > 1)

Choose the indicators

Based on the aim, many selections are meaningful:

- MSFD: EU commission decision 2010/477/EU

- Water Framework Directive: only phytoplankton, macrophytes, zoobenthos

- CBD: Aichi biodiversity targets

- Regional Seas Conventions indicators

The tool guides through selection, using DEVOTool:

http://www.devotes-project.eu/devotool/
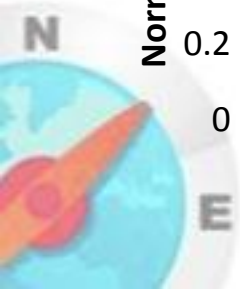
Define Indicators

- **Indicator** definition
  - Observed value
  - Target value (Boundary GEnS)
  - Range (min-max values)
- Assigned to a sector/habitat (e.g. shallow sands in the Kattegat
- **Category** (birds, fish, benthic veg, …)

Indicator Value	Normalized Value	Applies to
?	0.0	Extreme (worst)
?	0.2	Bad/Poor boundary
?	0.4	Poor/Moderate boundary
?	0.6	Good/Moderate boundary
?	0.8	Good/High boundary
?	1.0	Extreme (best)

Indicator value **_increasing_** with improved biodiversity
e.g. Secchi depth, number of species
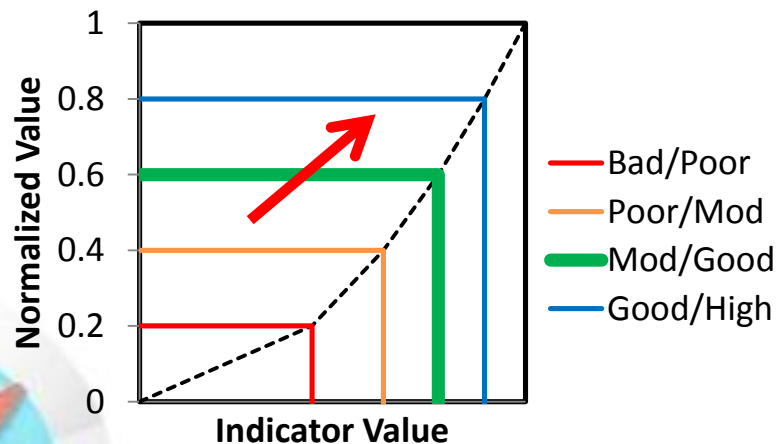
Indicator value **_decreasing_** with improved biodiversity
e.g. Chl-a concentration, fish mortality rates
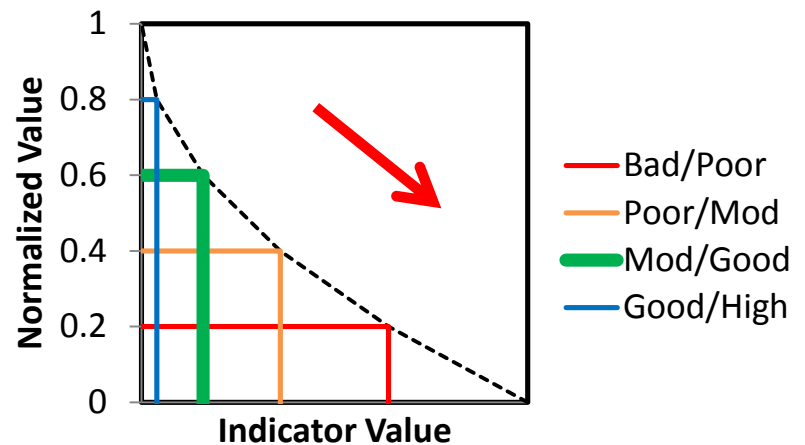
Indicators

|	Sector Level	Sector ID	Habitat	Habitat ID	Indicator Type	Indicator	Unit	Bad 0	Bad/Poor 0.2	Poor/Mod 0.4	**Mod/Good 0.6**	Good/High 0.8	High 1	Obs value	StdErr
BORNHOLM BASIN	2	31	elagic	1	Pelagic	Chl-a, annual mean	ug/l	2.7	2.4	2.1	**1.8**	1.5	1.2	2.17	0.97265
BORNHOLM BASIN	2	31	hallow muds	5	Benthic Fauna	Zoobenthos (average number of taxa)	no of taxa	-1.8E-15	2.48	4.96	**7.44**	9.92	12.4	2.96	1.976
BORNHOLM BASIN	2	31	elagic	1	Fish	Herring spawning stock biomass (22-2	1000 tons	108.75	145	181.25	**217.5**	253.75	290	175	68.6875
BORNHOLM BASIN	2	31	elagic	1	Fish	Cod spawning stock biomass	1000 tons	0	9.2	18.4	**27.6**	36.8	46	27	11.193
BORNHOLM BASIN	2	31	elagic	1	Fish	Sprat spawning stock biomass (whole	1000 tons	633.675	578.34	523.005	**467.67**	412.335	357	886	291.0391
BORNHOLM BASIN	2	31	elagic	1	Pelagic	NO2+NO3, winter mean (BY39)	uM	4.5	4	3.5	**3**	2.5	2	2.88	1.2054
BORNHOLM BASIN	2	31	elagic	1	Pelagic	DIP, winter mean (BY39)	uM	0.5625	0.5	0.4375	**0.375**	0.3125	0.25	0.75	0.196875
BORNHOLM BASIN	2	31	elagic	1	Pelagic	Secchi depth, summer mean, offshore	m	3.375	4.5	5.625	**6.75**	7.875	9	7	2.40625
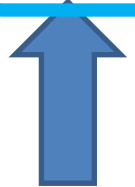
Sector | Habitat | Indicator Category, Name, Units | Boundary values | Observed values

<<back next>> Boundaries Check
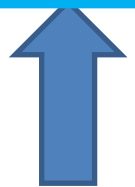
Habitat areas and weights

- Final **weighting** is a product of
  - Sector area
  - Sector weight
  - Habitat area
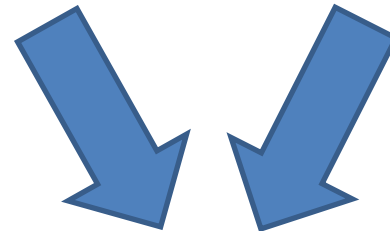 - Habitat quality (*subjective* relative value)

- $Weight = Area \times Quality$

- $\sum weights = 1$

Area

Quality

Habitats

Weight

Sectors

Sector Name	Sector Level	Sector ID	Parent ID	Area (km2)	Pelagic	Benthic	Mud	Sand	Reef	
Habitat Level -->					1	1	2	2	2	
Habitat ID -->					1	2	3	4	5	
Parent ID -->							2	2	2	
NORTHERN SEA	1	1		9611						0
Big Fjord	2	2	1	325	0.15955			0.15955		0.31909
Big Fjord, Inner	3	3	2	147			0.14433			0.14433
Big Fjord, Outer	3	4	2	178			0.17476			0.17476
WESTERN SEA	1	5		5449						0
South Bay	2	6	5	247				0.01802		0.01802
South Bay, Inner	3	7	6	96	0.0035	0.0035				0.00701
South Bay, Outer	3	8	6	151	0.00551	0.00551				0.01102
Southern straits	2	9	5	673	0.04912	0.04912				0.09823
Little Archipelago	2	10	5	1559			0.11377	0.11377		0.22754
					0.21767	0.05813	0.43286	0.29134	0	

<<back next>> Calculate

Weighting principles

- ## Choice of subdivisions should not affect weighting
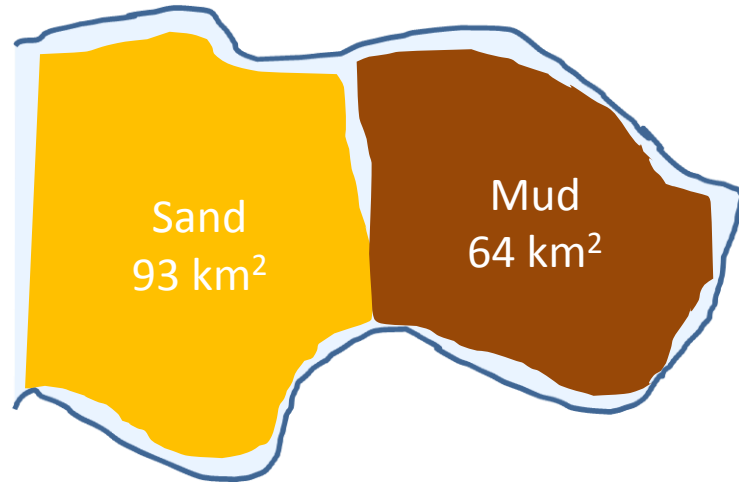
Sand 93 km²

Mud 64 km²

1 sector

Sector Name	Sector Level	Sector ID	Parent ID	Area (km2)	Pelagic	Benthic	Sand	Mud	
Imaginary Bay	1	1		157	0.5		0.296178	0.203822	1
					0.5	0	0.296178	0.203822	

Calculate

1 sector with 2 sub-sectors

Sector Name	Sector Level	Sector ID	Parent ID	Area (km2)	Pelagic	Benthic	Sand	Mud	
Imaginary Bay	1	1		157	0.5				0.5
Imaginary Bay Inner	2	2	1	64				0.203822	0.203822
Imaginary Bay Outer	2	3	1	93			0.296178		0.296178
					0.5	0	0.296178	0.203822	

Calculate

DEVOTES

<<back

Calculate

Sector Name	Sector Level	Sector ID	Fish	Birds	Mammals	Pelagic	Benthic Veg	Benthic Fauna	Benthic		AVERAGE	STATUS	Bad	Poor	Mod	Good	High
NORTH SEA	1	1	0.6145	0.4225	0.6144	0.5911	0.4610	0.5079			○ 0.5710	Mod	28.9%	10.7%	11.9%	8.4%	40.2%
NORTH SEA, east+south	2	2	0.6140	0.5201	1.0000						● 0.6353	Good	29.3%	6.2%	6.4%	5.3%	52.8%
NORTH SEA, northern part	2	3	0.6222	0.3420	0.4232	0.6571					○ 0.5661	Mod	30.8%	12.5%	9.9%	5.0%	41.8%
Ringkøbing Fjord	2	4					0.2371	0.7600			● 0.3678	Poor	47.6%	12.8%	11.8%	9.9%	18.0%
SKAGERRAK, offshore	2	5	0.5875	0.3420	0.2000	0.8720					○ 0.5290	Mod	33.2%	12.9%	5.9%	8.1%	39.8%
KATTEGAT	2	6	0.6532	0.2487	0.4483	0.2778	0.4709	0.5181			○ 0.5063	Mod	19.7%	14.9%	29.1%	20.9%	15.4%
Limfjorden	2	10				0.4484	0.3219	0.2360			● 0.3790	Poor	35.4%	13.2%	20.6%	15.8%	15.0%
Mariager Fjord	2	11				0.2573		0.2364			● 0.2468	Poor	47.4%	23.8%	14.2%	7.7%	6.9%
Randers Fjord	2	12				0.0886	0.1730	0.5943			● 0.1781	Bad	62.1%	9.8%	10.9%	11.1%	6.1%
Isefjorden - Roskilde Fjor	2	15				0.1733	0.7865	0.0000			○ 0.5895	Mod	28.8%	7.5%	21.4%	10.4%	31.9%
Øresund, centrale del	2	16				0.4635	0.6603				○ 0.5619	Mod	21.6%	13.3%	16.4%	18.1%	30.6%
BALTIC	1	17	0.3175			0.3609	0.3148	0.3816	0.0291		● 0.3460	Poor	39.9%	18.4%	15.6%	11.9%	14.2%
Fakse Bugt - Stevns	2	18				0.2838	0.7059	0.5000			○ 0.4434	Mod	34.3%	11.8%	14.5%	14.3%	25.0%
Aarhus Bay	2	19				0.4181						Mod	27.3%	13.2%	17.1%	20.0%	22.4%
North of Funen	2	20				0.2994							43.9%	13.6%	13.6%	12.0%	16.9%
Odense Fjord	2	21				0.0379	0.3993	0.5459	0.3453		● 0.2980	Poor	38.6%	21.4%	16.5%	19.6%	3.9%
Sejerø Bugt	2	24					0.1425				● 0.1425	Bad	59.2%	22.1%	10.2%	6.3%	2.2%
Kalundborg Fjord	2	25					0.0110					Bad	16.6%	7.7%	2.2%	0.8%	
Little Belt, southern parts	2	26				0.2662	0.5185						12.8%	22.1%	13.7%	7.8%	
Smålandsfarvandet	2	27					0.1958	0.3152			○ 0.2555	Poor	47.1%	18.7%	15.7%	10.1%	8.4%
Rødsand - Femer Bælt	2	28					0.4505	0.2880			● 0.3693	Poor	33.2%	20.9%	19.4%	12.6%	
Hjelm Bugt	2	29				0.4087	0.5417									20.5%	
ARKONA BASIN	2	30	0.3175			0.4839					○ 0.5553					31.4%	
BORNHOLM BASIN	2	31	0.3175			0.4114		0.2387			○ 0.3049	Poor	41.7%	27.9%	13.7%	7.1%	9.5%

			● 0.6102	○ 0.4225	● 0.6144	○ 0.4755	○ 0.4026	○ 0.4769	● 0.0291						
		Bad	36.7%	14.7%	8.0%	35.4%	42.3%	16.5%	92.6%						
		Poor	2.6%	39.1%	26.1%	10.8%	13.2%	19.3%	4.6%						
		Mod	3.1%	24.7%	22.5%	12.5%	14.8%	31.0%	2.6%						
		Good	3.8%	14.0%	6.0%	13.3%	10.4%	21.0%	0.2%						

START / Sectors / Habitats / Data / Count / Area / Quality / Weights / Calculation / Status / **Summary**
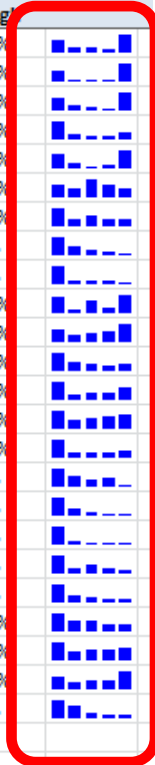
- 2 result sheets
  - Status per sector
  - Summary (incl. children)

Uncertainty assessment

- Normally distributed random variable (μ,σ)

- N simulations per indicator (e.g. 10 000)

- Each simulated value is classified

- Gives each indicator a probability distribution for 5 classes.

- Probabilities aggregated using same weights as status values
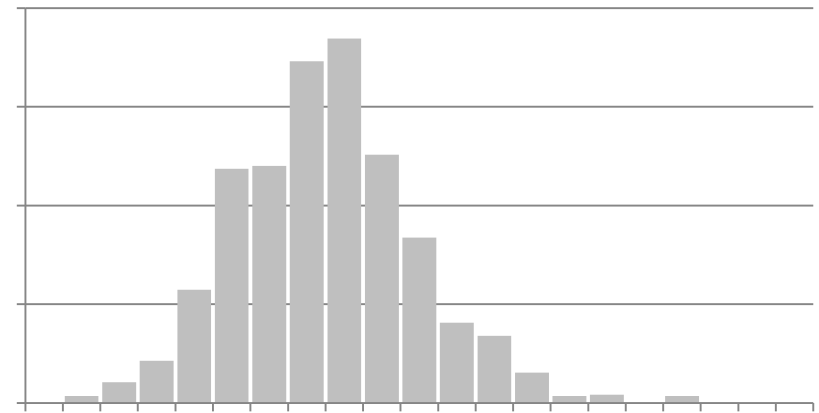
Bad	Poor	Mod	Good	High	
10.9%	39.5%	42.4%	7.1%	0.1%	

Conclusions

- **DEVOTES has created a flexible tool to assess the environmental status of marine systems**

- **It can be used either for the MSFD or by the Regional Seas Conventions assessments**

- **You can include your own indicators or those recommended by the European Commission**

- **You can select your weightings**

- **You have the possibility of assessing a single descriptor (e.g. biodiversity) or multiple ones**

- **The tool provides you the uncertainty associated to the result**

- **By the end of the year a free software will be available**

- **Your feedback is more than welcome!!!**

http://www.devotes-project.eu/deliverables-and-milestones/

Papers downloadable from:

https://zenodo.org/collection/user-devotes-project

DEVOTES
www.devotes-project.eu
Development of innovative tools for understanding
marine biodiversity and assessing good environmental status

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www.devotes-project.eu

Dr Ángel Borja (aborja@azti.es)
Twitter: @AngelBorjaYerro
ResearchGate Profile: https://www.researchgate.net/profile/Angel_Borja/
Linkedin: www.linkedin.com/profile/view?id=245091062&trk=tab_pro

Regional Seas Conventions, Istanbul, 20th October 2015