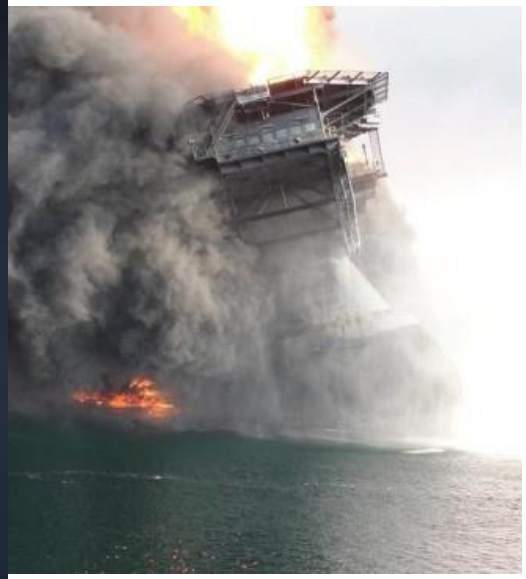
Challenges in assessing the status of marine waters: assisting policy-makers and stakeholders in such complex task from the EU project DEVOTES

Angel Borja

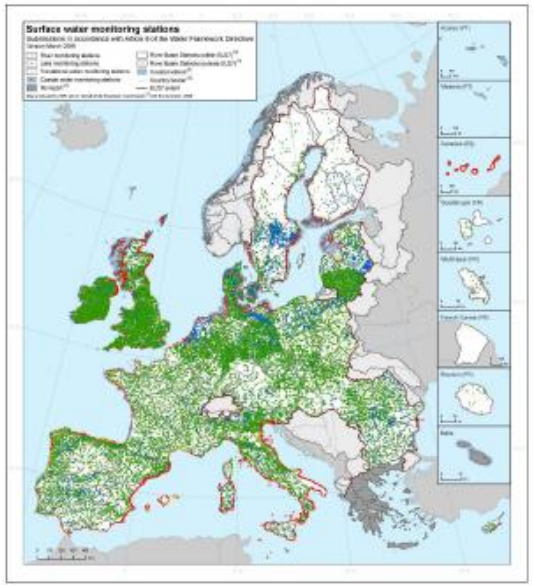
17th -20th September 2013, Varna (Bulgaria)

Introduction

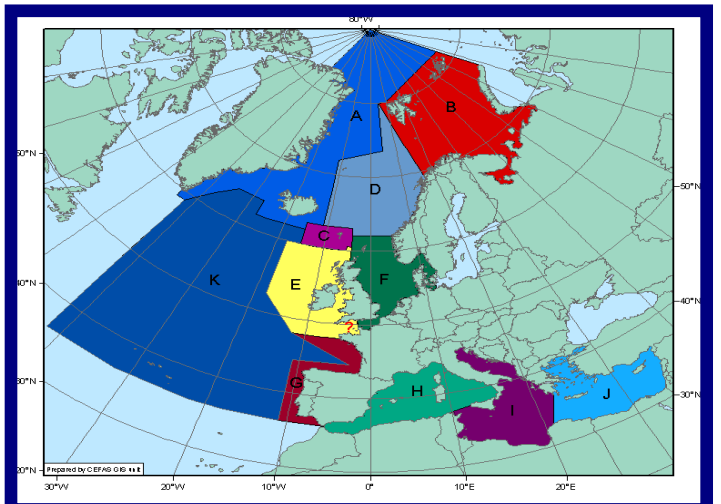


Introduction

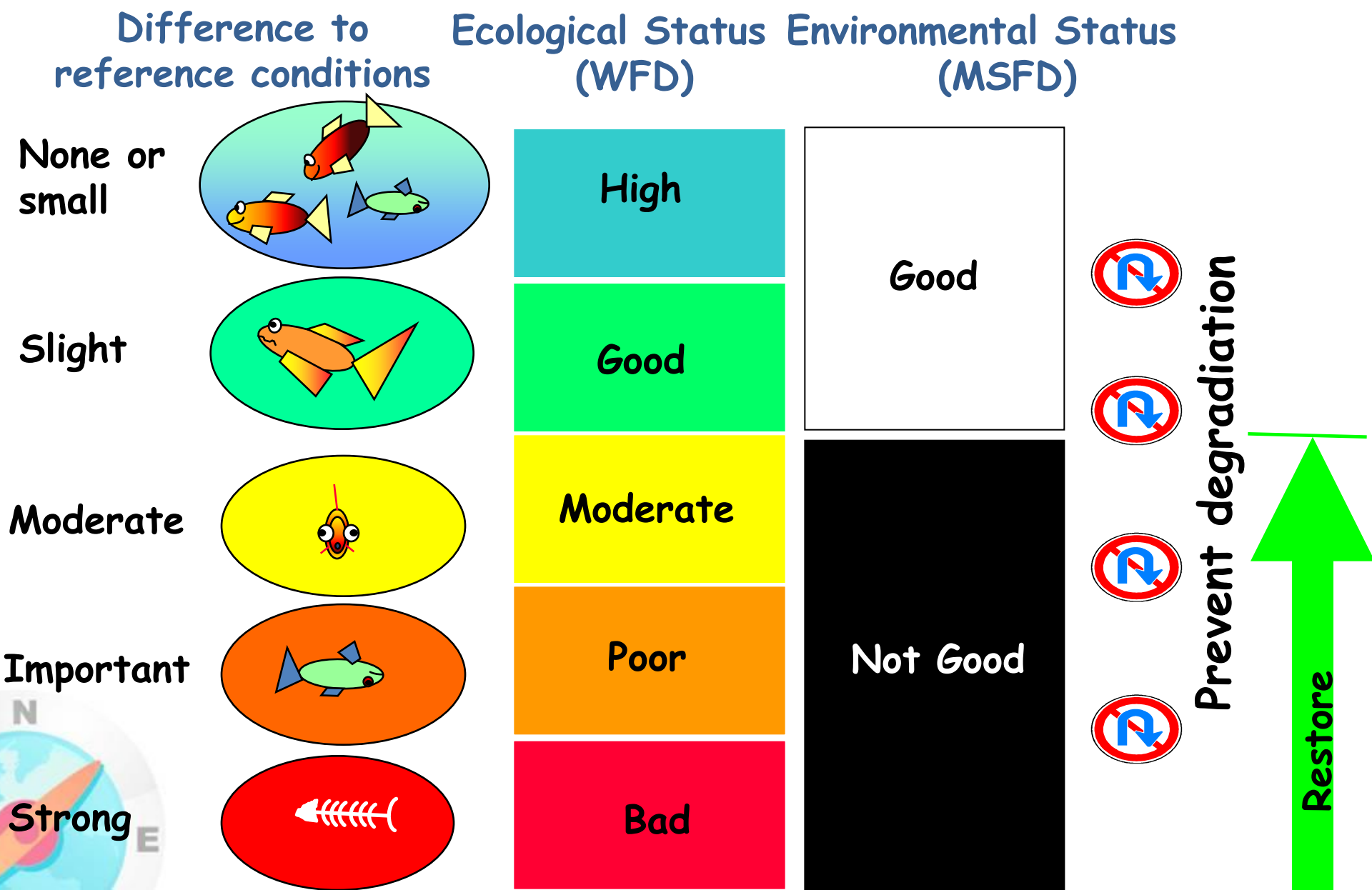
- Water Framework Directive (WFD: 2000)
- Marine Strategy Framework Directive (MSFD: 2008)



- To prevent degradation and protect and restore aquatic ecosystems quality
- To promote sustainable use of the seas and conserve marine ecosystems.
- To promote specific measures for a progressive reduction of discharges (priority substances)
- Achieve Good Status by 2015 (WFD) and 2020 (MSFD)



Introduction



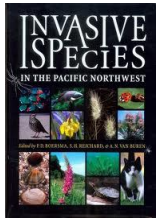
Introduction

Biological/Physico-chemical elements (WFD)

Structural

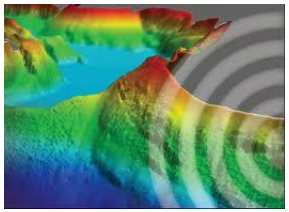
Qualitative Descriptors (MSFD)

Biodiversity



Alien

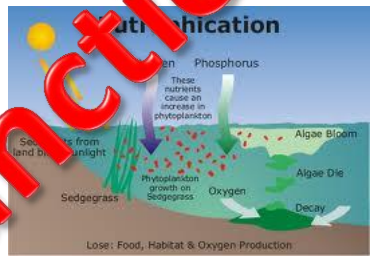
Foodwebs



Seafloor integrity

Functional

Fishing

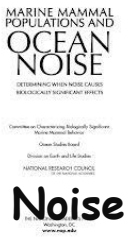


Eutrophication

Hydrography

Pollution

Litter



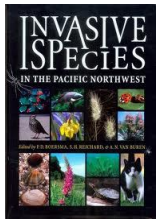
Noise

Introduction

WFD

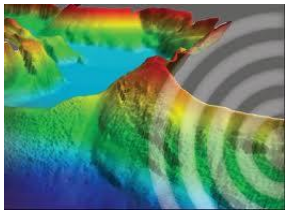
MSFD

Biodiversity



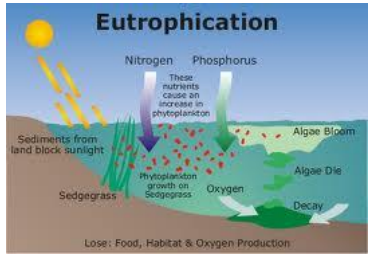
Alien

Foodwebs



Seafloor integrity

Fishing

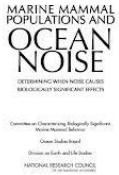


Eutrophication

Hydrography

Pollution

Litter



Noise

One out, all out

Ecosystem-based approach

DEVelopment **O**f innovative **T**ools for understanding marine biodiversity and assessing good **E**nvironmental **S**tatus

EU FP7 project 'Ocean of Tomorrow'

www.devotes-project.eu

DEVOTES background

Physical control
Pressures on the system
Pressure descriptors
Biological descriptors
escriptors

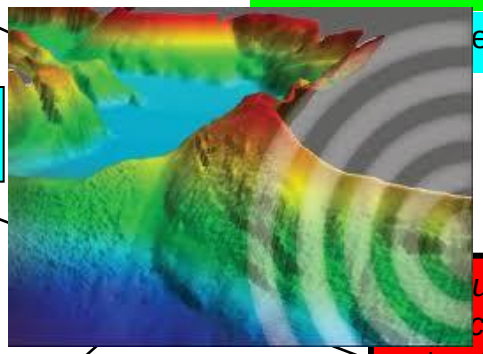
Climate change

Physical control of the ecological system

Pressure 1: Physical, chemical & biological inputs

8. Stop contamination becoming pollution *stricto sensu*

7. Protect hydrographical regime



9. Stop contamination harming consumers

5. Minimise eutrophication and its undesirable effects

ures 2: cal & biological extraction (water, space, substrata, fisheries)

2. No alien species

3. Protect commercial species

10. Prevent harm from marine litter

11 Prevent harm from energy inputs, including noise

Pressures 1 & 2 are 'endogenic (regionally) managed pressures' onto which are superimposed 'exogenic unmanaged pressures' (e.g. climate change); for the latter the consequences rather than the causes are managed.

Borja, A., M. Elliott, J. Carstensen, A.-S. Heiskanen, W. van de Bund, 2010. Marine management – towards an integrated implementation of the European Marine Strategy Framework and the Water Framework Directives. *Marine Pollution Bulletin*, 60(12): 2175-2186.

DEVOTES and Horizon 2020

EUROPE 2020 targets

Biodiversity Strategy

Bluegrowth Strategy

Horizon2020

Health, demographic change and well-being

Food security, sustainable agriculture, bioeconomy and marine and maritime research

Secure, clear and efficient energy

Smart, green and integrated transport

Climate action, resource efficiency and raw materials

Inclusive, innovative and secure societies

MSFD Schedule	Year	DEVOTES work plan
Initial assessment Environmental Status	2012	Project starts in October
Definition GES	2012	Assist MSs with DEVOTES partners' experience
Definition targets/indicators	2012	Assist MSs with DEVOTES partners' experience
	2013	Initial selection of indicators and monitoring tools
Member States monitoring starts	2014	Testing/model of indicators and monitoring tools
Programme of measures	2015	Validation & proposal of GES integration
Measures to reduce pressures: start	2016	Most papers published: project ends
Second round of assessment	2018	All results and data from DEVOTES available
Achievement GES	2020	

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'.**

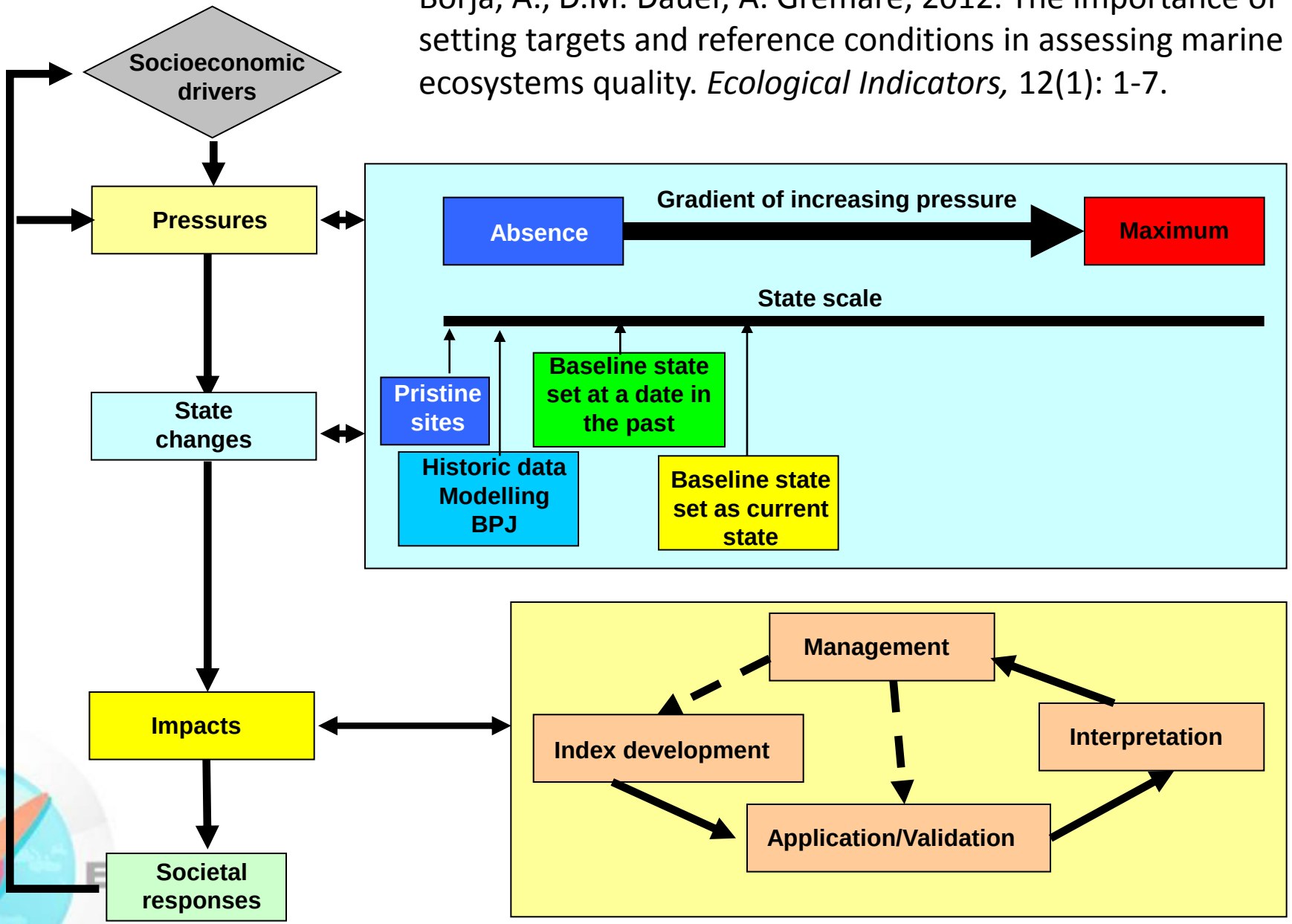
A question, a problem

What is Good Environmental Status and how do we know when it is attained?

Borja, A., M. Elliott, J.H. Andersen, A.C. Cardoso, J. Carstensen, J.G. Ferreira, A.S. Heiskanen, J.C. Marques, J. Neto, H. Teixeira, L. Uusitalo, M.C. Uyarra, N. Zampoukas, 2013. Good Environmental Status of marine ecosystems: What is it and how do we know when we have attained it? *Marine Pollution Bulletin*.

Human pressures and status assessment

Borja, A., D.M. Dauer, A. Grémare, 2012. The importance of setting targets and reference conditions in assessing marine ecosystems quality. *Ecological Indicators,* 12(1): 1-7.



Need for a definition of GEnS

Good Environmental Status under the MSFD

It is achieved when physicochemical (including contaminants, litter and noise) and hydrographical conditions are maintained at a level that main structuring components of the ecosystem are present, allowing the functionality of the system to provide resistance and resilience (ability to withstand stress and also ability to recover after a stressor) against deleterious effects of human pressures/activities/impacts, maintaining and delivering the ecosystem services that provide societal benefits in a sustainable way (i.e. pressures associated with uses cumulatively do not hinder the ecosystem components to retain their natural diversity, productivity and dynamic ecological processes, and recovery is rapid and secure if a use ceases)

Borja, A., M. Elliott, J.H. Andersen, A.C. Cardoso, J. Carstensen, J.G. Ferreira, A.S. Heiskanen, J.C. Marques, J. Neto, H. Teixeira, L. Uusitalo, M.C. Uyarra, N. Zampoukas, 2013. Good Environmental Status of marine ecosystems: What is it and how do we know when we have attained it? *Marine Pollution Bulletin*.

A definition, a problem

The main challenge is to translate this definition into terms suitable to provide an operational tool for policy-makers and stakeholders

Borja, A., M. Elliott, J.H. Andersen, A.C. Cardoso, J. Carstensen, J.G. Ferreira, A.S. Heiskanen, J.C. Marques, J. Neto, H. Teixeira, L. Uusitalo, M.C. Uyarra, N. Zampoukas, 2013. Good Environmental Status of marine ecosystems: What is it and how do we know when we have attained it? *Marine Pollution Bulletin*.

An example from seafloor integrity

INDICATOR	SAMPLING	CLASSIFICATION	ASSESSMENT
6.1.1 Type, abundance, biomass and areal extent of relevant biogenic substrate	Habitat: remote sensing (multibeam), ROV, video, etc.	EUNIS, habitat suitability modelling, GIS	Approaches used in Habitats Directive
6.1.2 Extent of the seabed significantly affected by human activities for the different substrate types	Habitat: remote sensing (multibeam), ROV, video, etc.	EUNIS, habitat suitability modelling, GIS	Approaches used in Habitats Directive
6.2.1 Presence of particularly sensitive and/or tolerant species	Species: ROV, video, grabs, diving	Traditional identification, metagenomics, GIS	Indices using ratio of sensitive/opportunistic (e.g. AMBI), species protected under some Directives (e.g. habitats)
6.2.2 Multi-metric indices assessing benthic community condition and functionality, such as species diversity and richness, proportion of opportunistic to sensitive species	Species: grabs, diving	Traditional identification, metagenomics	Indices used in the WFD, Biological Trait Analysis
6.2.3 Proportion of biomass or number of individuals in the macrobenthos above specified length/size	Species: grabs, diving	Length measurement	Allometric analysis?
6.2.4 Parameters describing the characteristics of the size spectrum of the benthic community	Species: grabs, diving	Size-spectra measurement	Size-spectra analysis

An example from seafloor integrity





One day


Several months

Traditional analysis

Several days-weeks

Genomic analysis

An example from seafloor integrity

Barcoding

Classification

Taxonomic identification

Species	Sequence
Phylocheras trispinosus	AGGCTCCA
Hydractinia carnea	AGTCTTCA
Obelia dichotoma	AGGCTTCA
Cavernularia pusilla	AGGCTCCA
Actinia equina	AGACACCA
Tubulanus polymorphus	AGACTCCA
Cerebratulus marginatus	AGGATCCA
Harmothoe glabra	AGGCTCAA
Malmgreniella andreapolis	AGGCTCGA
Malmgrenia andreapolis	AAGCTGCA
Cirriformia tentaculata	ATGCTCCA

Massive sequencing

Species	Abundance
Phylocheras trispinosus	5
Hydractinia carnea	6
Obelia dichotoma	73457
Cavernularia pusilla	4
Actinia equina	6
Tubulanus polymorphus	756
Cerebratulus marginatus	677
Harmothoe glabra	87
Malmgreniella andreapolis	46
Malmgrenia andreapolis	3
Cirriformia tentaculata	31

Separation

Standard sequencing

Towards a genomic AMBI!

Bourlat, S.J., A. Borja, J. Gilbert, M.I. Taylor, N. Davies, S.B. Weisberg, J. Griffith, T. Lettieri, D. Field, J. Benzie, F.O. Glöckner, N. Rodríguez-Ezpeleta, D.P. Faith, T.P. Bean, M. Obst, 2013. Genomics in marine monitoring: new opportunities for assessing marine health status. *Marine Pollution Bulletin*, 74: 19-31.

Making GEnS definition operational

'GEnS is achieved when	How is this determined?	What data/information are available?	Which targets or limits to be used?
.....physicochemical (including contaminants, litter and noise)	Rapid assessment of pressures using GIS	RSC databases, summed point-source inputs of contaminants; VMS for fishing	Targets established in ad-hoc Directives or RSC
.....and hydrographical conditions are maintained at a level	aerial/satellite sensing; habitat surveys; traditional sampling	Seabed maps, modelling , satellite data (waves, currents, temperature)	RSC, expert judgment
.....where the structuring components of the ecosystem are present and functioning, ...	Habitat maps, habitat suitability modelling, genomics, traditional sampling, ...	EUNIS, regional characterisation ; mammal and bird records; fish stock assessments; ecosystem functioning surveys	Habitats and Birds Directives targets; CFP targets; expert judgement
.....enabling the system to be resistant and resilient to harmful effects of human pressures...	Multimetric & functional indices, size-spectra analyses; evidence of recovery	National and RSC databases, case-studies and EIA extrapolated to wider areas; Alien and invasive species databases	Adapted targets from other directives (e.g. WFD) or RSC; expert judgement
.....where they maintain and provide the ecosystem services	Analysis of ecosystem services, Contingency and biological valuation	Modelling , GIS analysis of habitats and ecosystems to ecosystem services; data from QSR	None available; some indicators of trends
.....that deliver societal benefits	Economic valuation techniques	Fisheries statistics, monitoring of seafood quality, Databases of uses; fisheries (VMS data), oil & gas, aggregate returns, etc.	Limits for contaminants in seafood, fish stocks under safe limits, seabed extraction within permits...
.....in a sustainable way in order to retain their natural diversity, productivity and dynamic ecological processes...	Productivity values, separation of natural from anthropogenic production; alien species are minimised	National and RSC databases; use of data from small areas extrapolated to larger areas; Alien and Invasive species databases.	Legal limits for contaminants in seafood, fish stocks under safe limits; expert judgement
..... and where recovery is rapid and sustained if a use ceases'.	Traditional sampling, trend analysis, recovery after removing stressors	Long-term monitoring series; Alien and Invasive species databases.	Tendency towards the previous state (before pressure)

Borja, A., M. Elliott, J.H. Andersen, A.C. Cardoso, J. Carstensen, J.G. Ferreira, A.S. Heiskanen, J.C. Marques, J. Neto, H. Teixeira, L. Uusitalo, M.C. Uyarra, N. Zampoukas, 2013. Good Environmental Status of marine ecosystems: What is it and how do we know when we have attained it? *Marine Pollution Bulletin*.

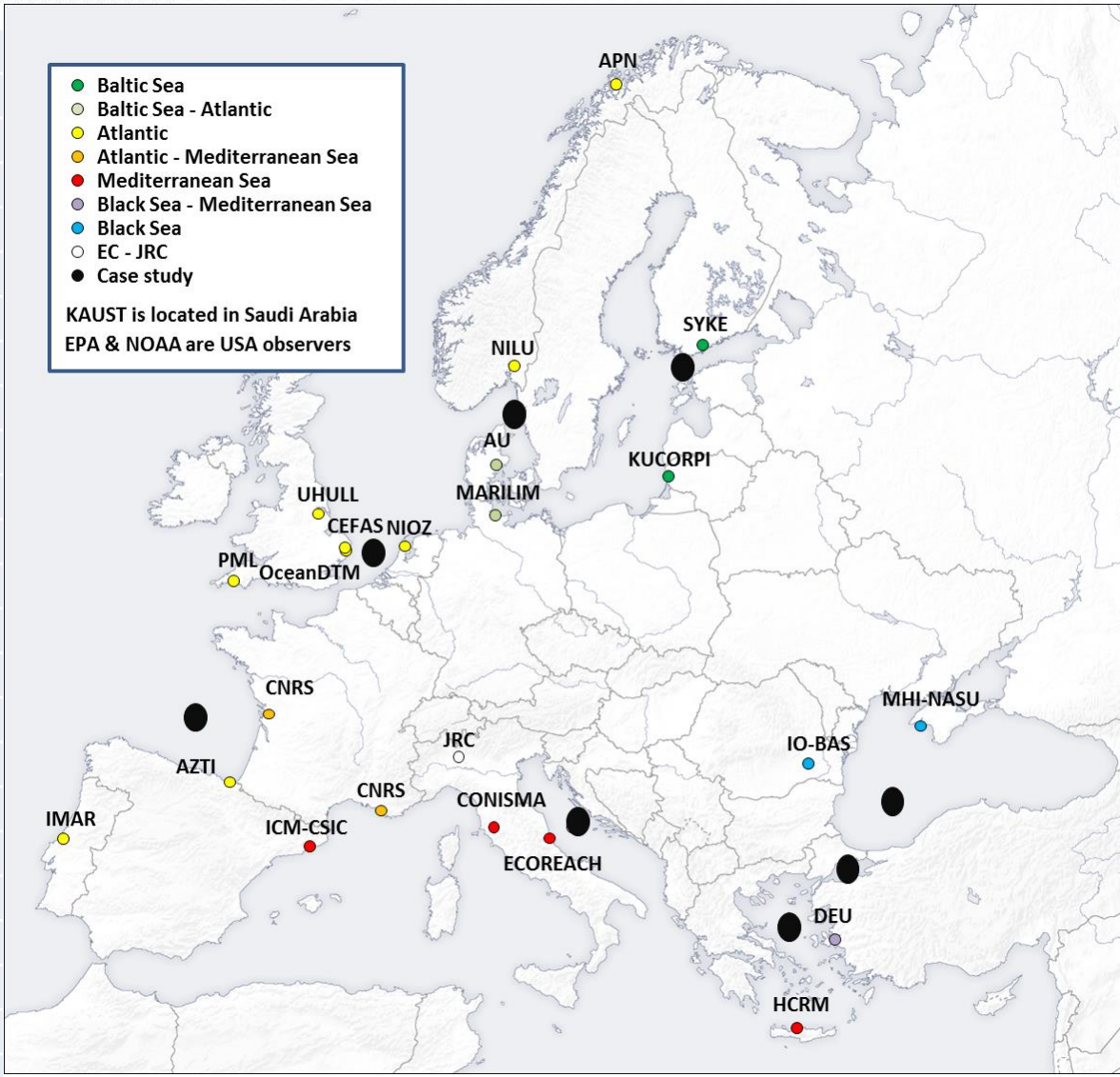
An example from integration

Qualitative Descriptors	Explanation of the indicators used	Reference conditions/EQS	Recent trend	Reliability (%)	Weight (%)	EQR	Final Environmental Status	Final Confidence ratio
1.- Biological diversity	integrated biological value		NA	69	15	0.51	0.08	10.35
2.- Non-indigenous species	ratio non-indigenous sp.	OSPAR	▲	80	10	0.98	0.10	8
3.- Exploited fish and shellfish			▼	100	15	0.48	0.07	15
	fishing mortality <reference			100		0.18		
	Spawning stock <reference			100		0.67		
	% large fish			100		0.59		
4.- Marine food webs			▼	70	10	0.40	0.04	7
5.- Human-induced eutrophication		WFD	▼	94	10	0.96	0.10	9.4
	Nutrients in good status			100		0.80		
	Chlorophyll in high status			100		1.00		
	Optical properties in high status			100		1.00		
	Bloom frequency in high status			70		1.00		
	Oxygen in high status			100		1.00		
6.- Seafloor integrity		WFD	►	100	10	0.89	0.09	10
	Area not affected			100		0.87		
	% presence sensitive sp.			100		0.98		
	Mean M-AMBI value			100		0.83		
7.- Alteration of hydrographical conditions			►	100	2	1.00	0.02	2
8.- Concentrations of contaminants	High % of samples <EQS	WFD	▼	100	9	0.80	0.07	9
9.- Contaminants in fish and other seafood	Values are 30% of the most affected in the NEA	WFD	▼	30	9	0.60	0.05	2.7
10.- Marine litter	Values are 50% of the most affected in Europe	OSPAR	▲	30	5	0.57	0.03	1.5
11.- Energy & underwater noise	Moderate ship activity	OSPAR	NA	10	5	0.70	0.04	0.5
Final assessment					**100**		**0.68 Good**	**75.5 High**

Borja, Á., I. Galparsoro, X. Irigoien, A. Iriondo, I. Menchaca, I. Muxika, M. Pascual, I. Quincoces, M. Revilla, J. Germán Rodríguez, M. Santurtún, O. Solaun, A. Uriarte, V. Valencia, I. Zorita, 2011. Implementation of the European Marine Strategy Framework Directive: A methodological approach for the assessment of environmental status, from the Basque Country (Bay of Biscay). *Marine Pollution Bulletin,* 62(5): 889-904.

DEVOTES structure and partners

Number	Partner	Country
1	AZTI	Spain
2	NILU	Norway
3	SYKE	Finland
4	Aarhus University	Denmark
5	University of Hull	UK
6	CEFAS	UK
7	PML	UK
8	IMAR	Portugal
9	IO-BAS	Bulgaria
10	JRC	EU
11	HCMR	Greece
12	KUCORPI	Lithuania
13	APN	Norway
14	University of Ancona	Italy
15	NIOZ	Netherlands
16	CSIC	Spain
17	Dokuz Eylul Uni	Turkey
18	MHI-NASU	Ukraine
19	MARILIM	Germany
20	CNRS	France
21	OceanDTM	UK
22	Ecoreach	Italy
23	KAUST	Saudi Arabia



Duration of 48 months, from 1st November 2012 to 30st October 2016

Total cost: 12 million euros, requested EC contribution: 9 million euros

Conclusions

- Impleme r than the WFD, based or ns and existing datasets
- Need to conservation of marine e m services and societal b
- Need of ing, focusing on processes nteractions
- Quantitat ert judgement needed social science requirem
- DEVOTES demands from stakehold ve

Thank you!

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

Grant agreement nº 308392

SEVENTH FRAMEWORK PROGRAMME

Project co-funded by the European Commission within the Seventh Framework Programme (2007-2013)

www.devotes-project.eu

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

17th -20th September 2013, Varna (Bulgaria)