Recent Developments in the Sustainable Management of Marine Resources

Michael Elliott[1,2]

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Managing marine resources sustainably: A proposed integrated systems analysis approach

Michael Elliott [a,b,*], Ángel Borja [c], Roland Cormier [d]

Paper I

Marine Pollution Bulletin 155 (2020) 111201

Contents lists available at ScienceDirect

Marine Pollution Bulletin

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

Activity-footprints, pressures-footprints and effects-footprints – Walking the pathway to determining and managing human impacts in the sea

Michael Elliott [a,d,*], Angel Borja [b], Roland Cormier [c]

frontiers | Frontiers in Marine Science

POLICY AND PRACTICE REVIEWS
published: 24 May 2022
doi: 10.3389/fmars.2022.869992

Managing Marine Resources Sustainably – The 'Management Response-Footprint Pyramid' Covering Policy, Plans and Technical Measures

Roland Cormier [1], Michael Elliott [2,3] and Ángel Borja [4,5]*

Paper II

Marine Pollution Bulletin 193 (2023) 115177

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Marine Pollution Bulletin

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Editorial

Marine Ecosystem Services and Integrated Management: "*There's a crack, a crack in everything, that's how the light gets in*"!

Ocean and Coastal Management 245 (2023) 106875

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Ocean and Coastal Management

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

Managing marine resources sustainably – Ecological, societal and governance connectivity, coherence and equivalence in complex marine transboundary regions

Michael Elliott [a,b,*], Ángel Borja [c], Roland Cormier [d]

Paper III

Contents lists available at ScienceDirect

Ocean and Coastal Management

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

Review

Managing marine resources sustainably – But how do we know when marine management has been successful?

Michael Elliott [a,b,*], Ángel Borja [c], Roland Cormier [d]

Paper IV

Recent & Ongoing European Projects

Invest4Nature

GuardIAS
GUARDING EUROPEAN WATERS FROM INVASIVE ALIEN SPECIES

GES4 SEAS

MARBEFES

MarinePlan

PLAN4BLUE

ACTNOW

CLIMAREST

MaCoBioS

MPA
MARINE PROTECTED AREAS EUROPE

BIOcean5D

OBAMA-NEXT

Future MARES

MSP4BIO

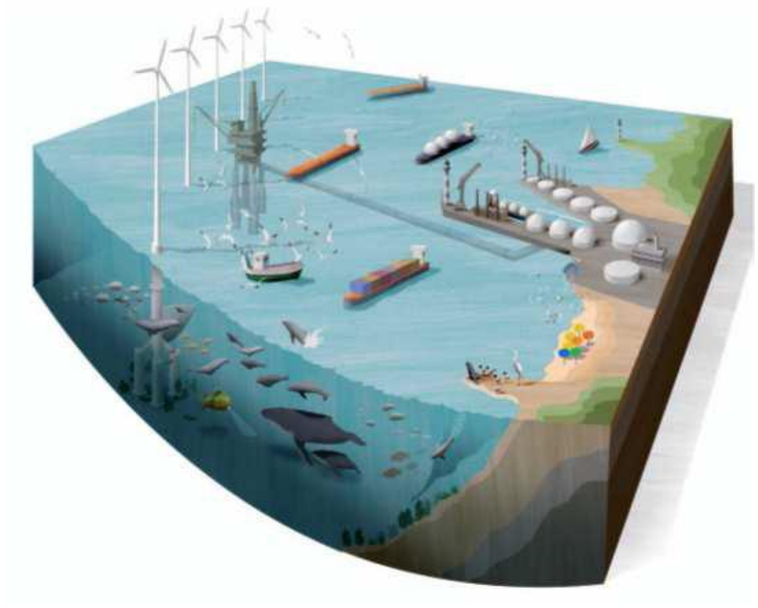
MARINE SABRES

MARCO-BOLO
STRENGTHENING BIODIVERSITY OBSERVATION IN SUPPORT OF DECISION MAKING

MISSION ATLANTIC

BLUEMISSION AA

Challenges for estuarine/marine science & management:



There is only one big idea: *how to maintain and protect ecological structure and functioning while at the same time allowing the system to produce ecosystem services from which we derive societal benefits.*

- Recovery/coping with historical legacy
- Endangered coastal and marine ecosystem functions
- Legal & administrative framework
- Economic prosperity and delivery of societal benefits
- Coping with climate change & moving baselines

The MSFD, UK and Marine Scotland vision: "*clean, healthy, safe, productive, biologically diverse marine and coastal environments, managed to meet the long-term needs of people and nature*".

In other words:

"to look after the natural stuff and deliver the human stuff"

The Ecosystem Approach

- First developed by the UN Convention for Biological Diversity as a set of 12 principles.
- Defined as '*a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way*'.
- As such, its application will help to reach a balance of these three objectives of the Convention.
- It is based on applying appropriate scientific methodologies focused on levels of biological organization which encompass the essential processes, functions and interactions among organisms and their environment.
- Furthermore, it recognizes that humans, with their cultural diversity, are an integral component of ecosystems.

Ecosystem-Based Management

“Ecosystem-based approach (to management), an 'ecosystem-based approach' or 'ecosystem-based management’:

is an integrated approach to management of human activities that considers the entire ecosystem including humans. The goal is to maintain ecosystems in a healthy, clean, productive and resilient condition, so that they can provide humans with the services and goods upon which we depend. It is a spatial approach that builds around a) acknowledging connections, b) cumulative impacts and c) multiple objectives”

(GES4SEAS Glossary)

No	EBM Principles
1	Consider Ecosystem Connections
2	Appropriate Spatial and Temporal Scales
3	Adaptive Management
4	Use of Scientific Knowledge
5	Integrated Management
6	Stakeholder Involvement
7	Account for Dynamic Nature of Ecosystem
8	Ecological Integrity and Biodiversity
9	Sustainability
10	Recognise Coupled Social-Ecological Systems
11	Decisions reflect Societal Choice
12	Distinct Boundaries
13	Inter-disciplinarity
14	Appropriate Monitoring
15	Acknowledge Uncertainty
16	Acknowledge Ecosystem Resilience
17	Consider Economic Context
18	Apply the Precautionary Approach
19	Consider Cumulative Impacts
20	Organisational Change
21	Explicitly Acknowledge Trade Offs
22	Consider Effects on Adjacent Ecosystems
23	Commit to Principles of Equity
24	Develop Long Term Objectives
25	Use of All Forms of Knowledge
26	Use of Incentives

Produced by:
Gemma Smith

URBAN & INDUSTRIAL USES

LIVING RESOURCE EXTRACTION

ENERGY PRODUCTION

TRANSPORT

PHYSICAL RESTRUCTURING

TOURISM & LEISURE

LIVING RESOURCE CULTIVATION

NON-LIVING RESOURCE EXTRACTION

SECURITY & DEFENCE

EDUCATION AND RESEARCH

CARBON CAPUTRE

CONSERVATION & RESTORATION

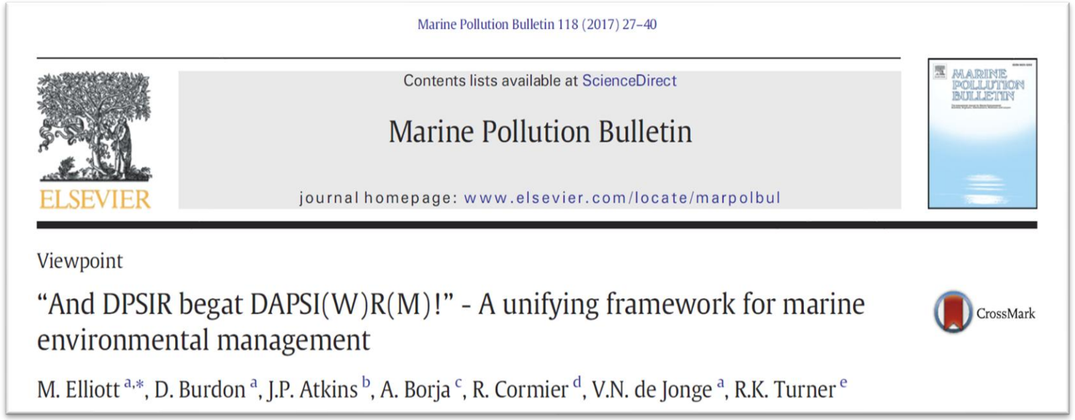
BLUE ECONOMY

ACTIVITY SECTOR

MSFD THEME

ADDITIONAL SECTOR

DAPSI(W)R(M) framework


Marine Pollution Bulletin 118 (2017) 27–40

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Marine Pollution Bulletin

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

Viewpoint

"And DPSIR begat DAPSI(W)R(M)!" - A unifying framework for marine environmental management

M. Elliott [a,*], D. Burdon [a], J.P. Atkins [b], A. Borja [c], R. Cormier [d], V.N. de Jonge [a], R.K. Turner [e]

Drivers (societal basic needs)

Activities (of society)

Pressures (resulting from activities)

State change (on the natural system)

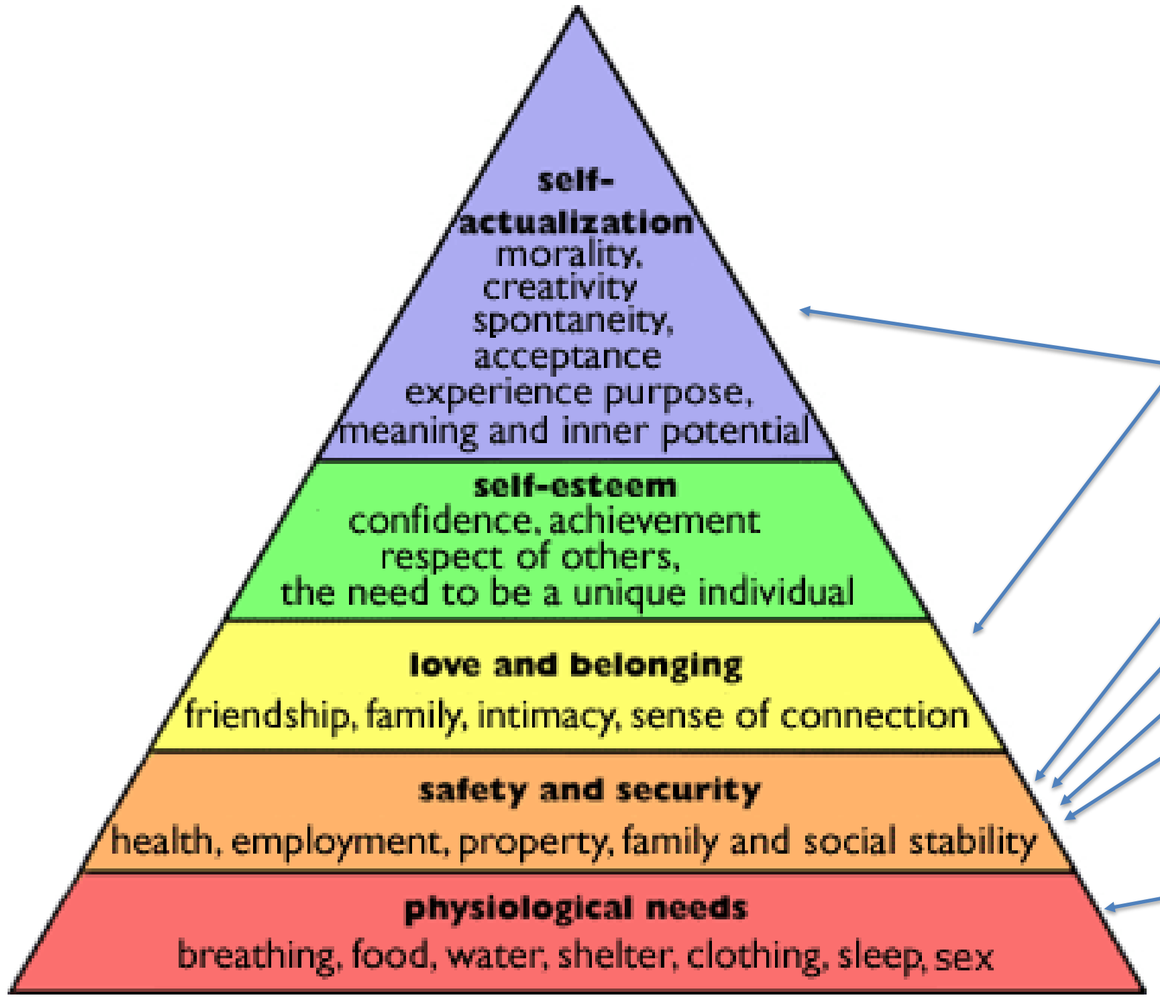
Impacts (on human **W**elfare) (changes affecting wealth creation, quality of life)

Responses (economic, legal, etc) (**M**easures)

(for each EnMP cf. Ex

Pronounced "dapsiworm"!

Drivers = Basic Human Needs:



Maslow's hierarchy of needs

WELL-BEING

Relaxation & enjoyment

Health & welfare

Employment

Security & safety

Space, shelter

Provision & delivery of goods

Results of provisioning services (food, water, O_2, space shelter)

Activities contributing to Endogenic Managed Pressures

(Elliott et al 2017)

Activity
Aquaculture
Extraction of living resources
Transport & Shipping
Renewable Energy
Non-renewable (fossil fuel) Energy
Non-renewable (nuclear) Energy
Extraction of non-living resources
Navigational Dredging
Coastal Infrastructure
Land-based Industry
Agriculture
Tourism/Recreation
Military
Research
Carbon Sequestration

Pressures
Smothering
Substratum loss
Changes in siltation
Abrasion
Selective extraction of non-living resources (habitat removal)
Underwater noise
Litter
Thermal regime change
Salinity regime change
Introduction of synthetic compounds
Introduction of non-synthetic compounds
Introduction of radionuclides
Introduction of other substances

Nitrogen and phosphorus enrichment
Input of organic matter
Introduction of microbial pathogens
Introduction of non-indigenous species and translocations
Selective extraction of species
Death or injury by collision
Barrier to species movement
Emergence regime change
Water flow rate changes
pH changes
Electromagnetic changes
Change in wave exposure

Examples of Exogenic Unmanaged Pressures

Pressure	Description
Thermal regime change	Temperature change (average, range, variability) climate change (large scale)
Salinity regime change	Temperature change (average, range, variability) due climate change (large scale)
Emergence regime change	Change in natural sea level (mean, variation, range) due climate change (large scale) and isostatic rebound
Water flow rate changes	Change in currents (speed, direction, variability) due climate change (large scale)
pH changes	Change in pH (mean, variation, range) due climate change (large scale), volcanic activity (local)
Change in wave exposure	Change in size, number, distribution and/or periodicity of waves along a coast due to climate change (large scale).
Non-indigenous species introductions	Increase in species from outside the management area

(adapted from Elliott et al 2017)

Hazard & Risk Typology: Source of Problems & Cause for Management

Hazards in Estuaries & Coast leading to Risk (depending on assets)
A) Surface hydrological hazards (e.g. flooding)
B) Surface physiographic removal by natural processes - chronic/long-term (e.g. erosion)
C) Surface physiographic removal by human actions - chronic/long-term (e.g. land-claim, space removal)
D) Surface physiographic removal - acute/short-term (e.g. cliff failure)
E) Climatological hazards - acute/short term (e.g. storminess)
F) Climatological hazards - chronic/long term (e.g. NAO changes, sea-level rise)
G) Tectonic hazards - acute/short term (e.g. earthquakes, land-slip)
H) Tectonic hazards - chronic/ long term (e.g. subsidence, isostatic rebound)

= Risk Assessment & Risk Management (RA&RM):

- Hazard Identification:
- Risk Assessment:
- Risk Management:
- Risk Communication:

(Modified and Expanded from Elliott et al., 2014, 2019; See Elliott & Kennish 2024 – Treatise on Estuarine & Coastal Science, Volume 6, Elsevier)

6.1 A Synthesis of Anthropogenic Impacts and Solutions in Estuarine and Coastal Environments

Michael Elliott, International Estuarine & Coastal Specialists (IECS) Ltd., Leven, United Kingdom and School of Environmental Sciences, University of Hull, Hull, United Kingdom
Michael J Kennish, Department of Marine and Coastal Sciences, School of Environmental and Biological Sciences, Rutgers University, New Brunswick, NJ, United States

Hazard in Estuaries & Coast leading to Risk (depending on assets)
I) Anthropogenic microbial biohazards (e.g. sewage pollution)
J) Anthropogenic macrobial biohazards (e.g. non-indigenous species)
K) Anthropogenic introduced technological hazards (e.g. infrastructure, sediments)
L) Anthropogenic extractive technological hazards (e.g. fishing, aggregates)
M) Anthropogenic acute chemical hazards (e.g. oil spills)
N) Anthropogenic chronic chemical hazards (e.g. diffuse and point-source contaminants)
O) Anthropogenic acute geopolitical hazards (e.g. wars, unrest, terrorism)
P) Anthropogenic chronic geopolitical hazards (e.g. human migrations, civil-war)

All hazards caused or exacerbated by climate change or the societal responses to climate change!!

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Review

A typology of marine and estuarine hazards and risks as vectors of change: A review for vulnerable coasts and their management

Michael Elliott [a,*], Nicholas D. Cutts [a], Anna Trono [b]

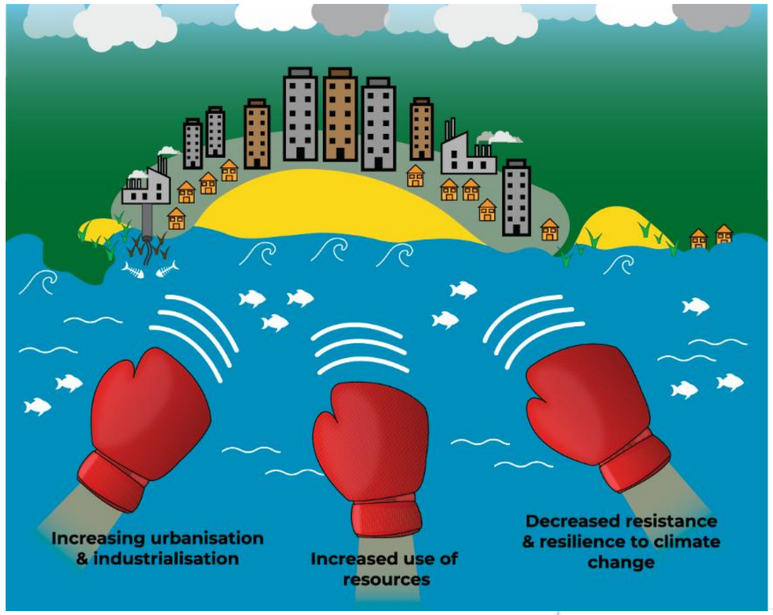
What are we managing? - Hazards, risks and their prevention, from single activities to whole areas

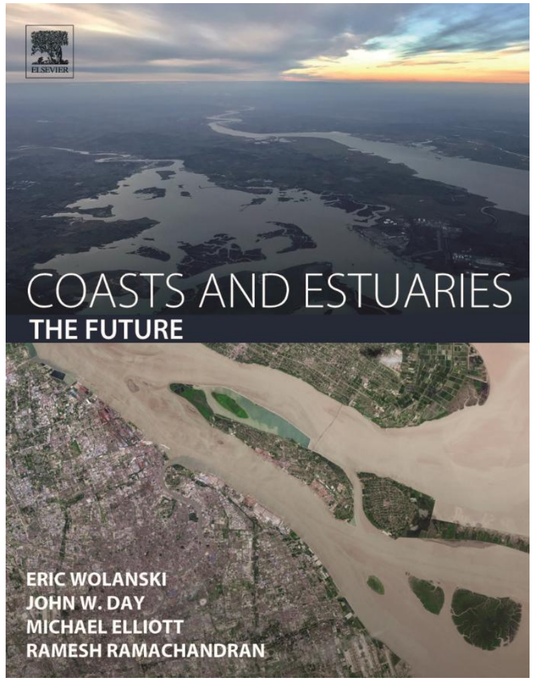
Exogenic unmanaged pressures ***(where the consequences are managed in the management area but the causes require global action)***	**Endogenic managed pressures** ***(where the causes and consequences are managed within the management area)***
Alien species	New infrastructure
Sea level rise (or loss?)	Energy generation
Increased temperature	Petrochemical industries
Increased storminess	Dredging and navigation
Flooding and erosion	Wetland loss and gain
Changes to catchment run-off	Urban discharges
Repercussions of NAO	Mine-water discharges
Agricultural runoff in catchment	Subsidence
Saline ingression	Historical pollution residues

And opportunities!

The ‘Triple Whammy’ – Present & future threats for estuaries and coasts worldwide

- Increased industrialisation and urbanisation
- Increased use of physical (space, energy, water, etc.) and biological (fish, shellfish) resources
- Decreased resistance and resilience to climate change (temperature, acidification, storminess, species distribution changes, alien species, etc)






Chapter 1

A Synthesis: What Is the Future for Coasts, Estuaries, Deltas and Other Transitional Habitats in 2050 and Beyond?

Michael Elliott*, John W. Day†, Ramesh Ramachandran‡, Eric Wolanski§


Marine Pollution Bulletin 163 (2021) 111832

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Marine Pollution Bulletin

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

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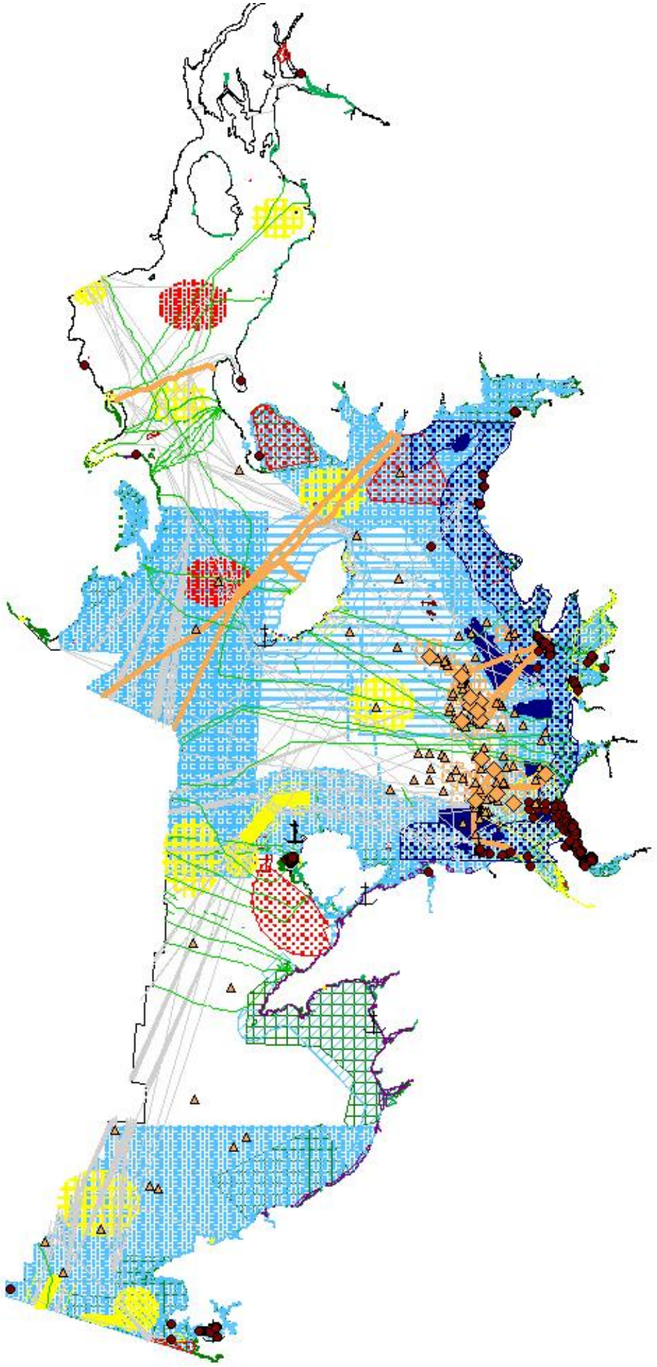
Editorial

The ‘triple whammy’ of coasts under threat – Why we should be worried!

(Defeo & Elliott Mar. Poll. Bull. 2021)



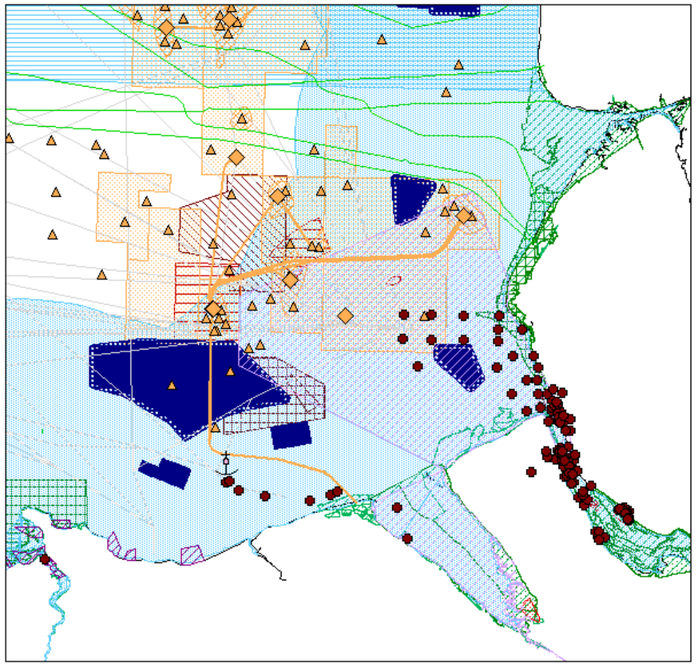
Available online at www.sciencedirect.com
ScienceDirect
Marine Policy 31 (2007) 287–298
MARINE POLICY
www.elsevier.com/locate/marpol

A proposed multiple-use zoning scheme for the Irish Sea. An interpretation of current legislation through the use of GIS-based zoning approaches and effectiveness for the protection of nature conservation interests

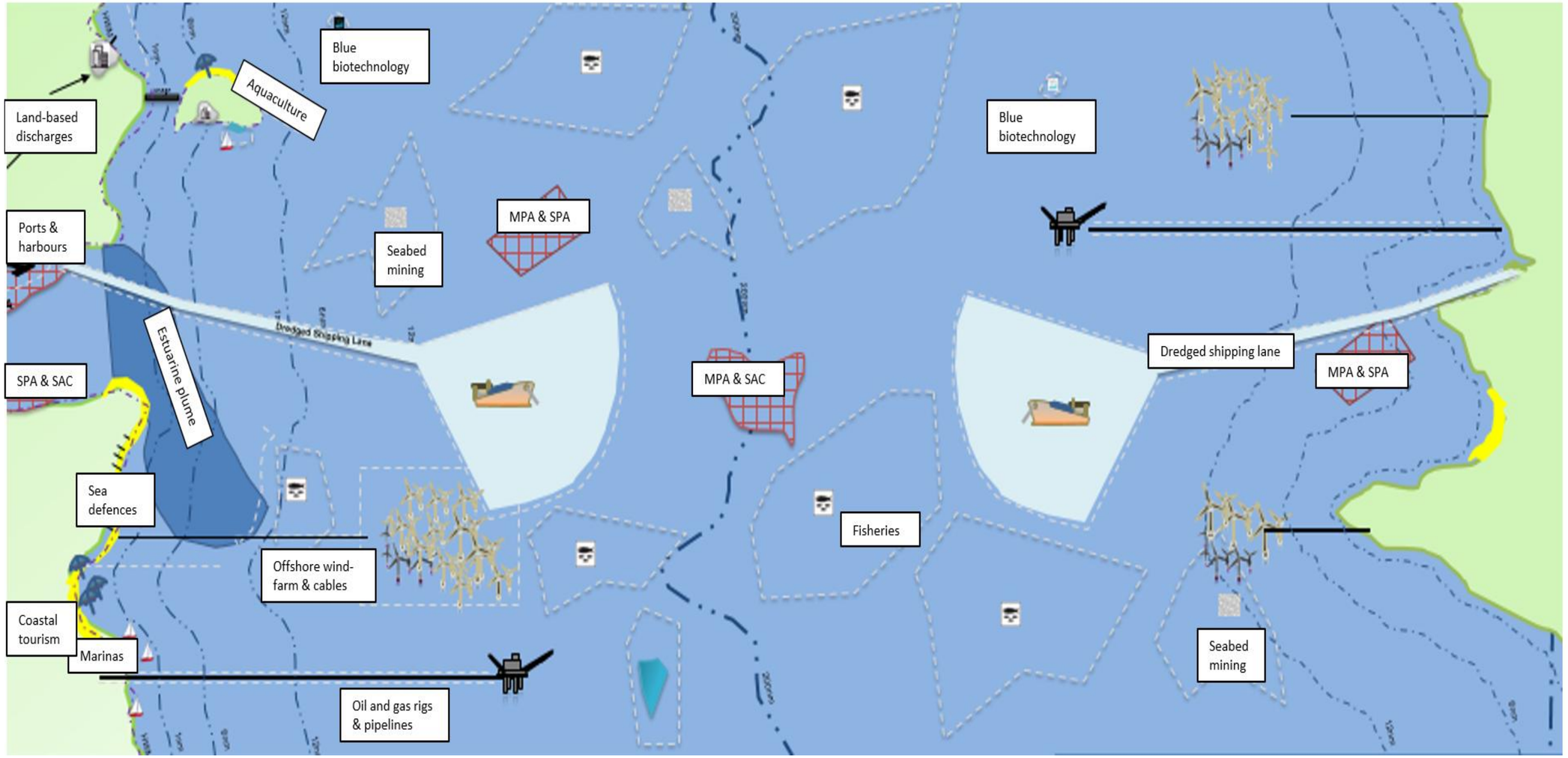
Suzanne J. Boyes[a,*], Michael Elliott[a], Shona M. Thomson[a], Stephen Atkins[b], Paul Gilliland[c]

To plan:

Land use & infrastructure
Tourism & recreation
Coastal defence
Ports & navigation
Military activities
Conservation
Dredging & disposal
Fishing & aquaculture
Renewable energy
Submarine communication cables
Mineral extraction (oil, gas, sand)



(Elliott, Borja & Cormier 2020 Mar. Poll. Bull.; OCMA 2023)



Challenge of multi-use international seas: Stylised transnational sea area showing activity footprints and transboundary Marine Protected Areas and fishing grounds – to reflect the challenges of complex marine management

Management of a complex transboundary area

Activity-footprint

That area and/or time, based on the duration, intensity and frequency of an activity which ideally has been legally sanctioned by a regulator in an authorisation, licence, permit or consent.

Pressures-footprint

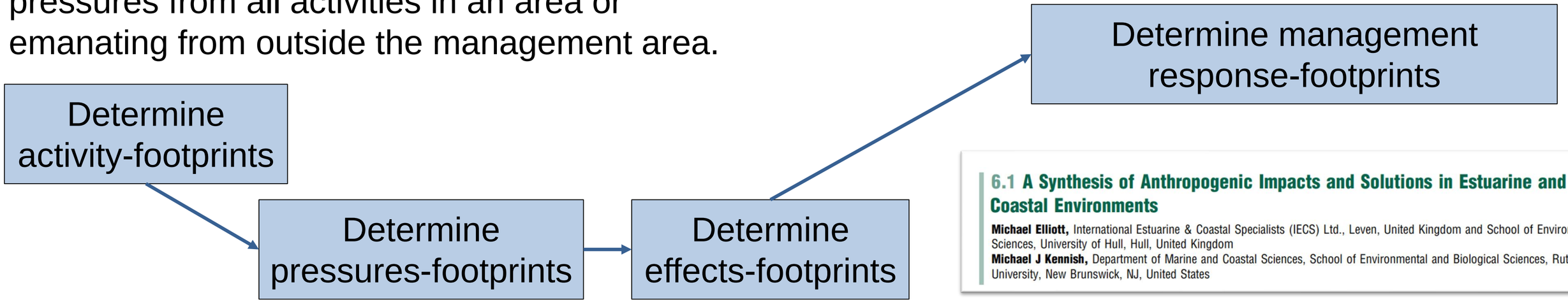
The mechanism(s) of change resulting from a given activity or all the activities in an area once avoidance and mitigation measures have been employed (the endogenic managed pressures).

Effects-footprint

The spatial (extent), temporal (duration), intensity, persistence and frequency characteristics resulting from (a) a single pressure from a marine activity, (b) all the pressures from that activity, (c) all the pressures from all activities in an area, or (d) all pressures from all activities in an area or emanating from outside the management area.

Management response-footprint

The area and/or time covered by the marine management action and measures (or programme of measures), including the distribution range of a species.



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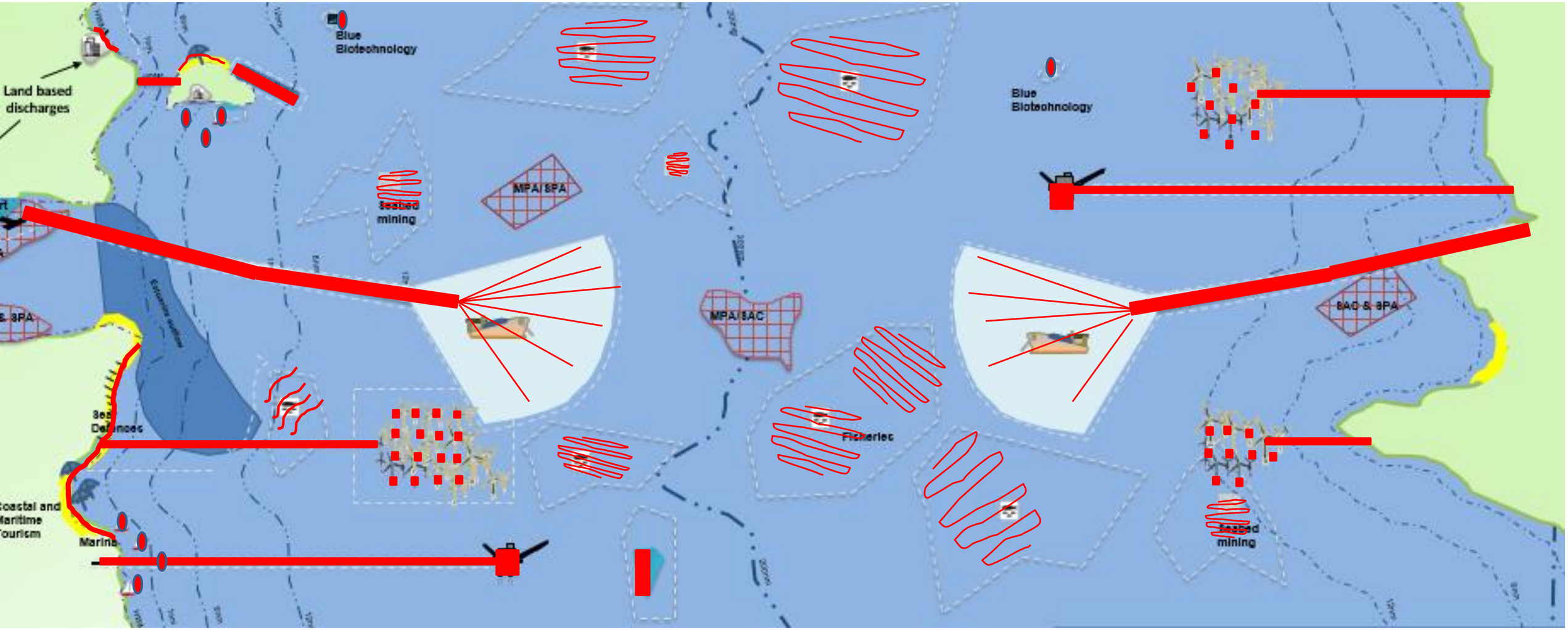
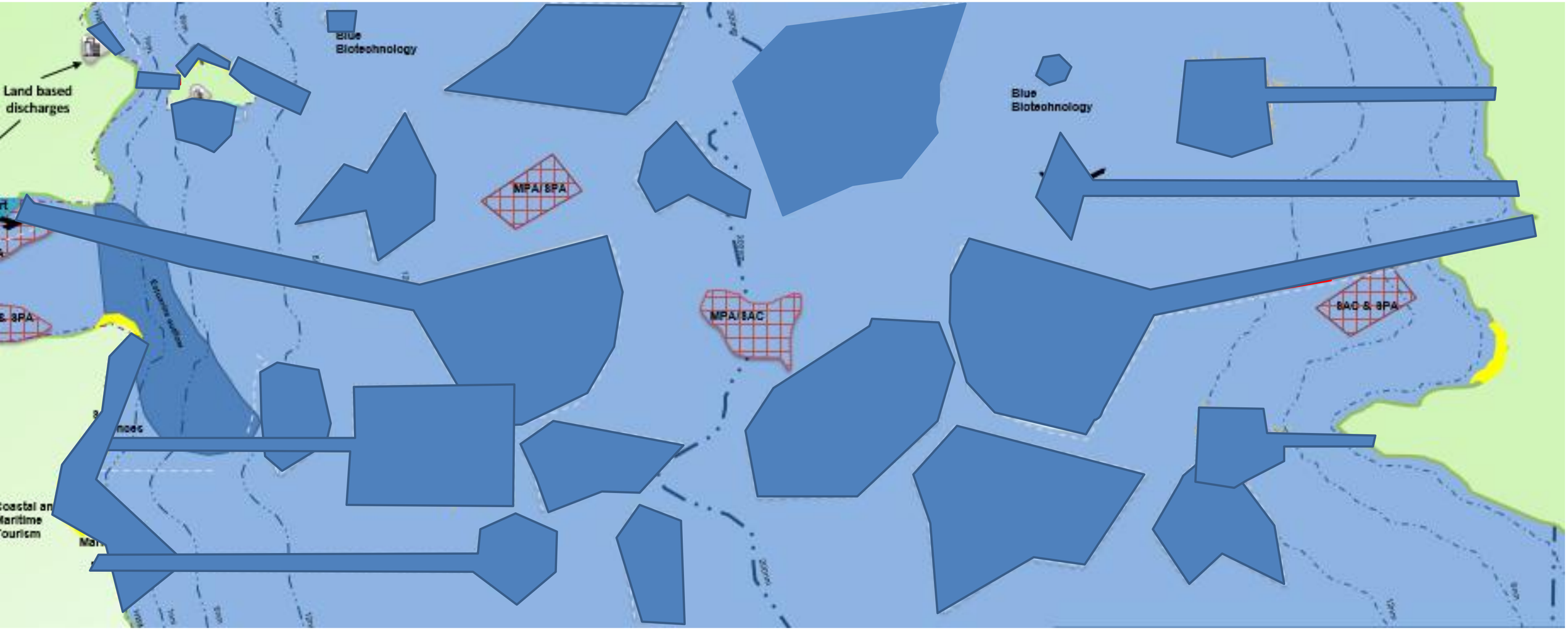


Activity-footprint

Management of a complex transboundary area

Seabed dredging – an example of the licence area being much bigger than the activity-footprint

Trailing suction hopper dredger



Activity-footprint

Pressures-footprint & EIA area? = Σ
Cumulative Effects Assessment?

Management of a complex transboundary area

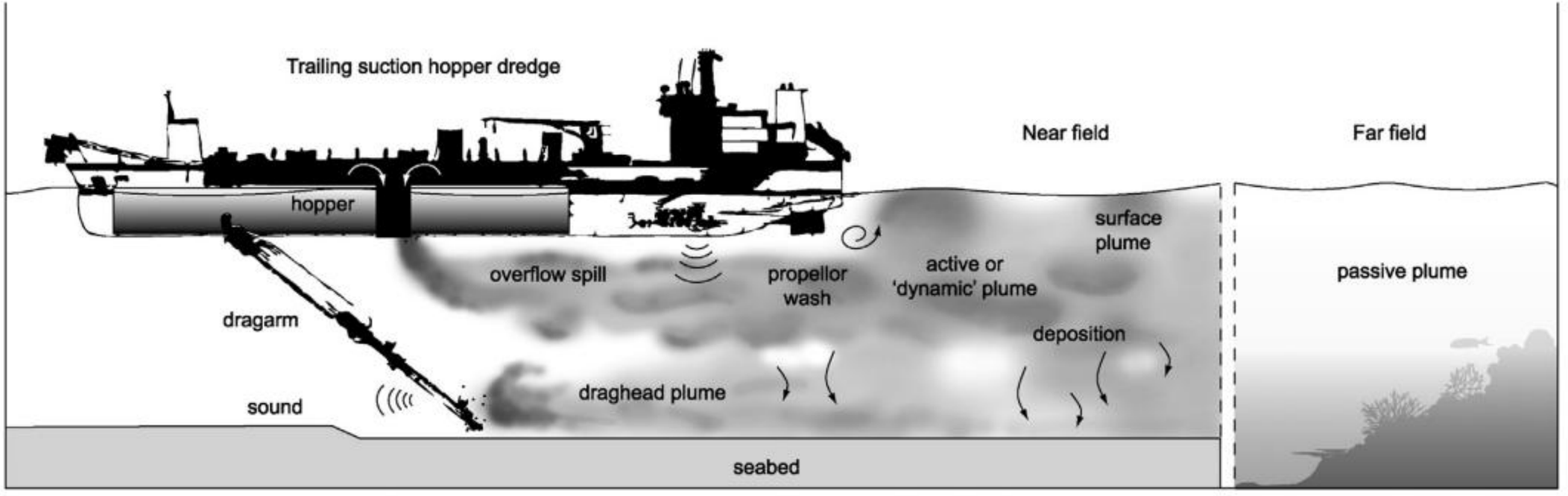
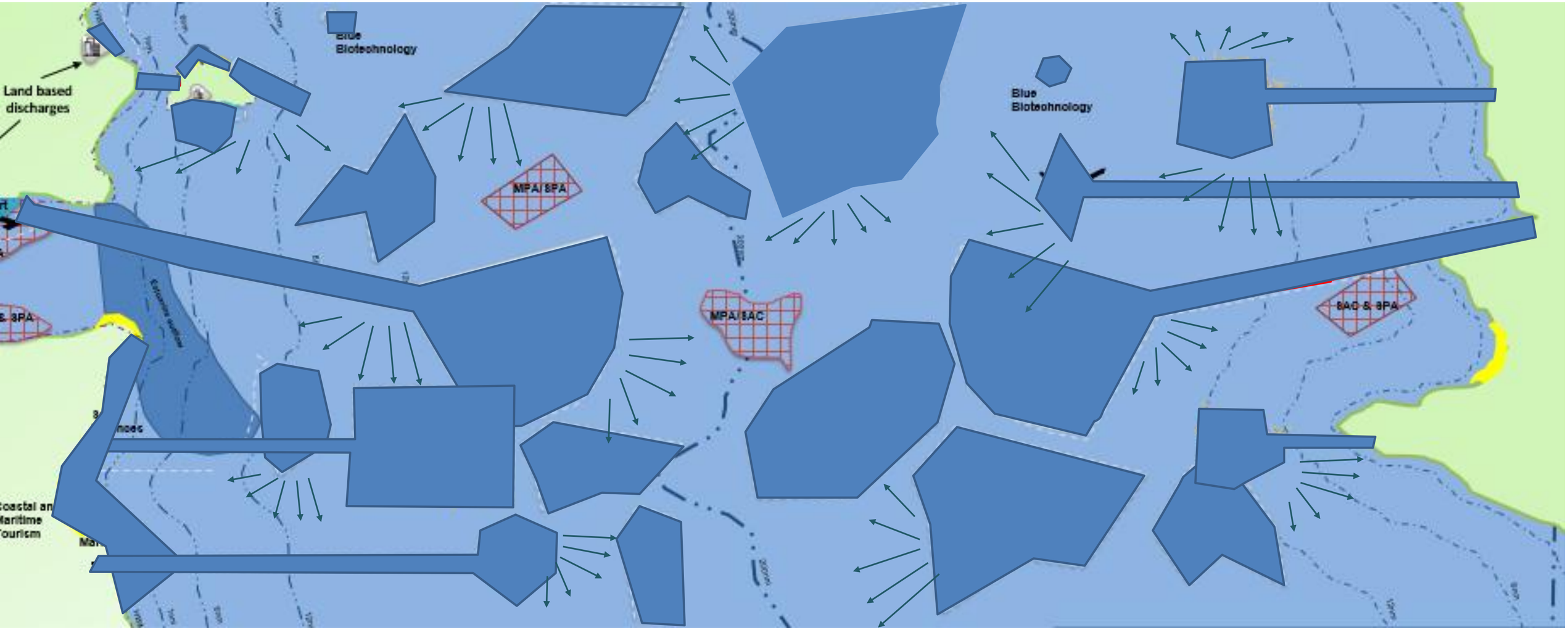


Fig. 2. Stylized representation of plume generation by a trailing suction hopper dredge, the most commonly used of the hydraulic dredges for soft sediments (see Foster et al., 2010). Turbidity is generated at the drag-head and at the surface if sediment-laden water inside the hopper is allowed to discharge (overflow). This can occur from the ship's sides but usually through a vertical shaft inside the hopper, exiting below water level (Foster et al., 2010; VBKO, 2003).

Please cite this article as: Jones, R., et al., Assessing the impacts of sediments from dredging on corals, Marine Pollution Bulletin (2015), http://dx.doi.org/10.1016/j.marpolbul.2015.10.049

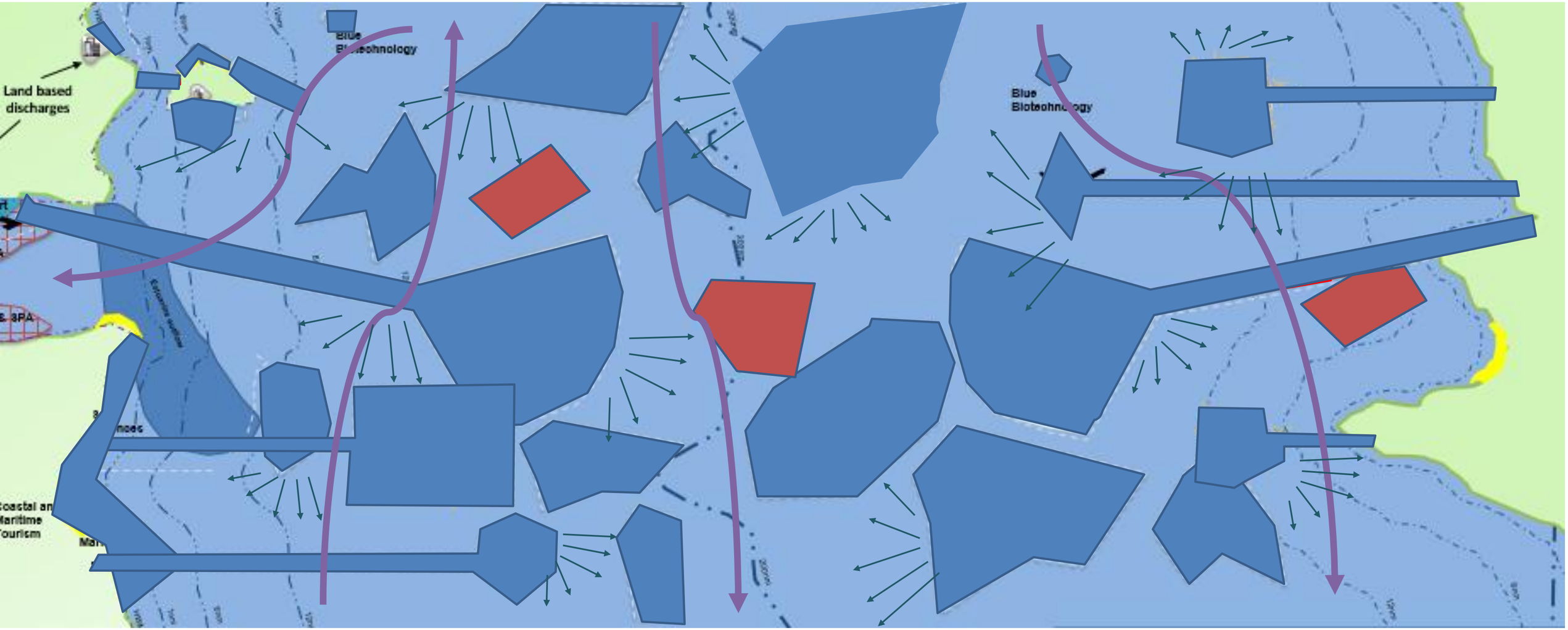


Activity-footprint

Pressures-footprint & EIA area? = Σ
Cumulative Effects Assessment?

Effects-footprint

Management of a complex transboundary area



Activity-footprint

Pressures-footprint & EIA area? = Σ
Cumulative Effects Assessment?

Effects-footprint

Static feature conservation management

Highly mobile feature conservation management

AND RESPONSES-FOOTPRINTS?

Management of a complex transboundary area

Country	Pipeline length (km)	Cable length (km)	Footprint km² (*)
The Netherlands	4,500	6,000	2,625
Belgium	163	914	269.25
UK	45,000	?	11,250
Norway	8,800	?	2,200
Germany	?	?	?
Denmark	?	?	?
Total			>16,350

(* assuming 250m width as a conservative estimate for the area disturbed)

Main message – if it is difficult calculating the activity-footprint, how difficult will it be to calculate the pressures- and effects-footprints?!

Preliminary estimates of activity-footprints:

North Sea Estimates	Km²
Area occupied by oil and gas rigs	165.6
OWF Turbine + scour protection	13.7
Wind farm occupied area	6,732.8
Aggregate extraction (UK North Sea)	licensed area 623.25 dredged 64.16 (10% of licensed area)
Seabed dredging (NL, DK, D, BE, UK)	5,528
Total (O&G, OWF, cables, pipelines, dredged)	>28,800
Total area North Sea	575,000 (i.e. >5% seabed occupied)

Oil and gas and offshore wind infrastructure operation and decommissioning

Smyth, K., Elliott, M., et al. (2015). Mar. Poll. Bull. 90: 247-258. https://doi.org/10.1016/j.marpolbul.2014.10.045

Burdon, D., Elliott, M. et al. (2018). Mar. Poll. Bull., 135: 739-758. https://doi.org/10.1016/j.marpolbul.2018.07.077

Elliott, M., Birchenough, S.N.R. (2022) Mar. Poll. Bull. 176: 113468; https://doi.org/10.1016/j.marpolbul.2022.113468

Knights, A.M., Elliott, M., et al. (2024). J. Env. Man. 352: 119897; https://doi.org/10.1016/j.jenvman.2023.119897

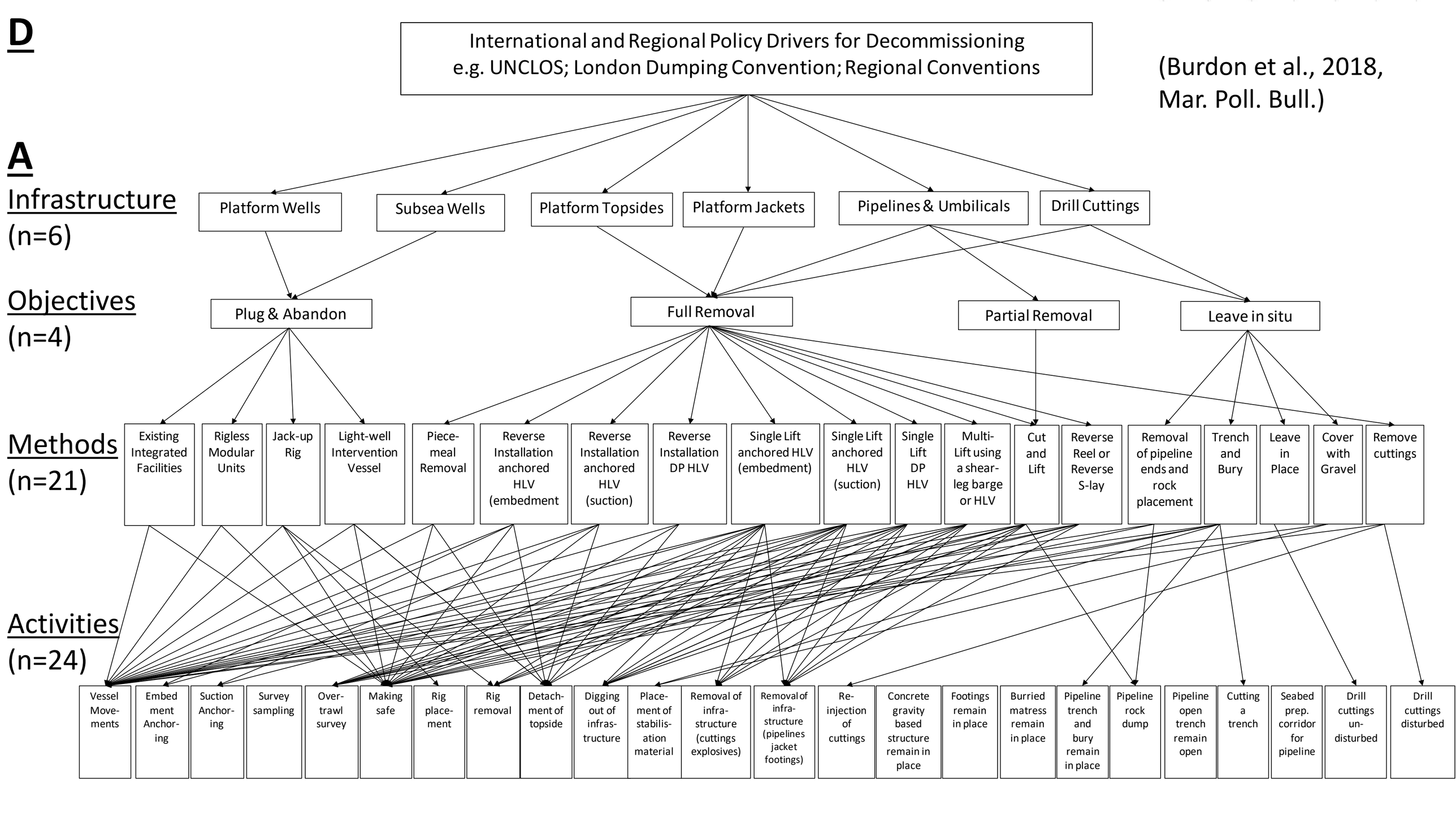
Knights, A.W., Elliott, M., et al. (2024). J. Env. Man. 350: 119644, https://doi.org/10.1016/j.jenvman.2023.119644

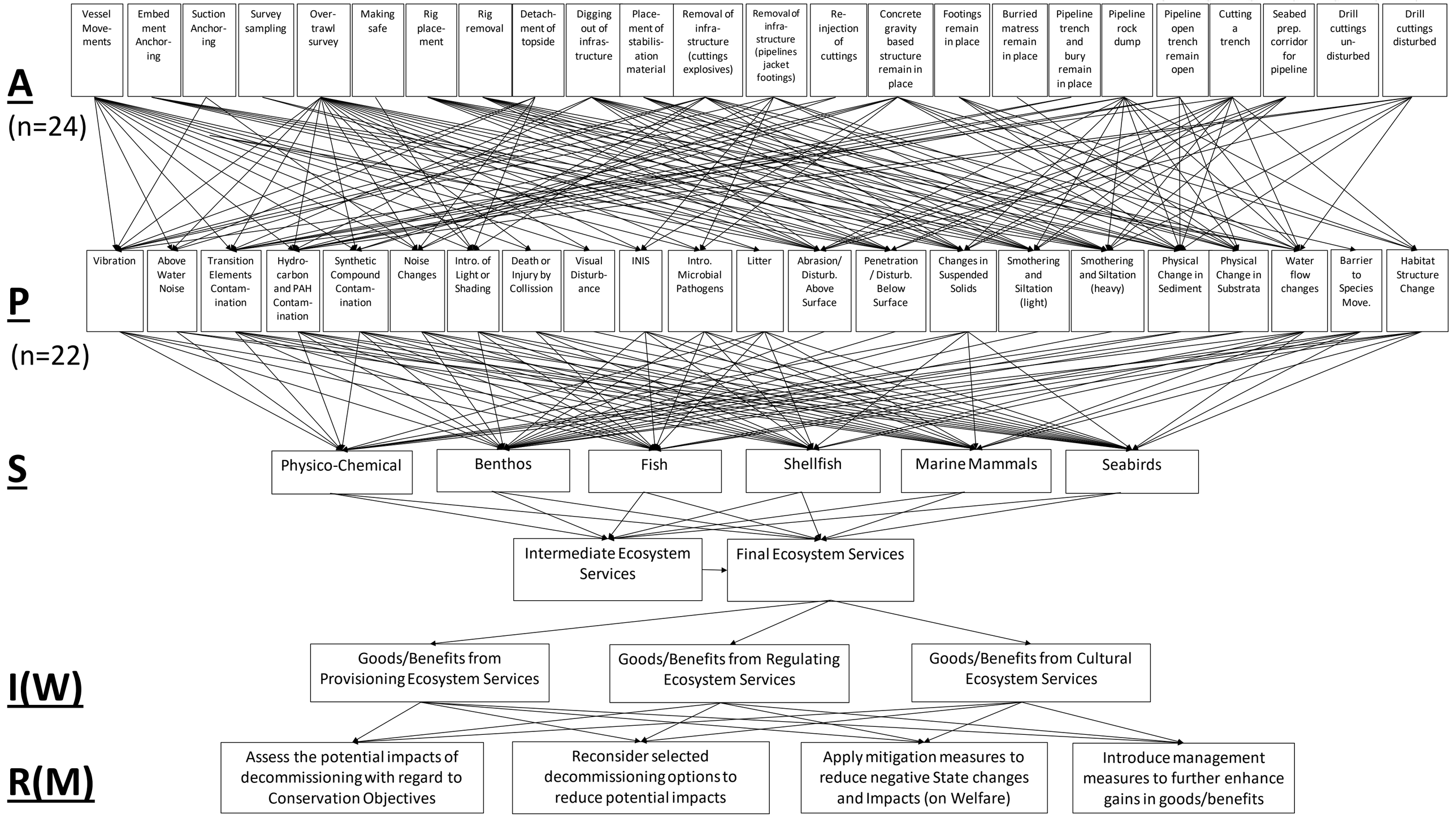
D

International and Regional Policy Drivers for Decommissioning
e.g. UNCLOS; London Dumping Convention; Regional Conventions

(Burdon et al., 2018, Mar. Poll. Bull.)

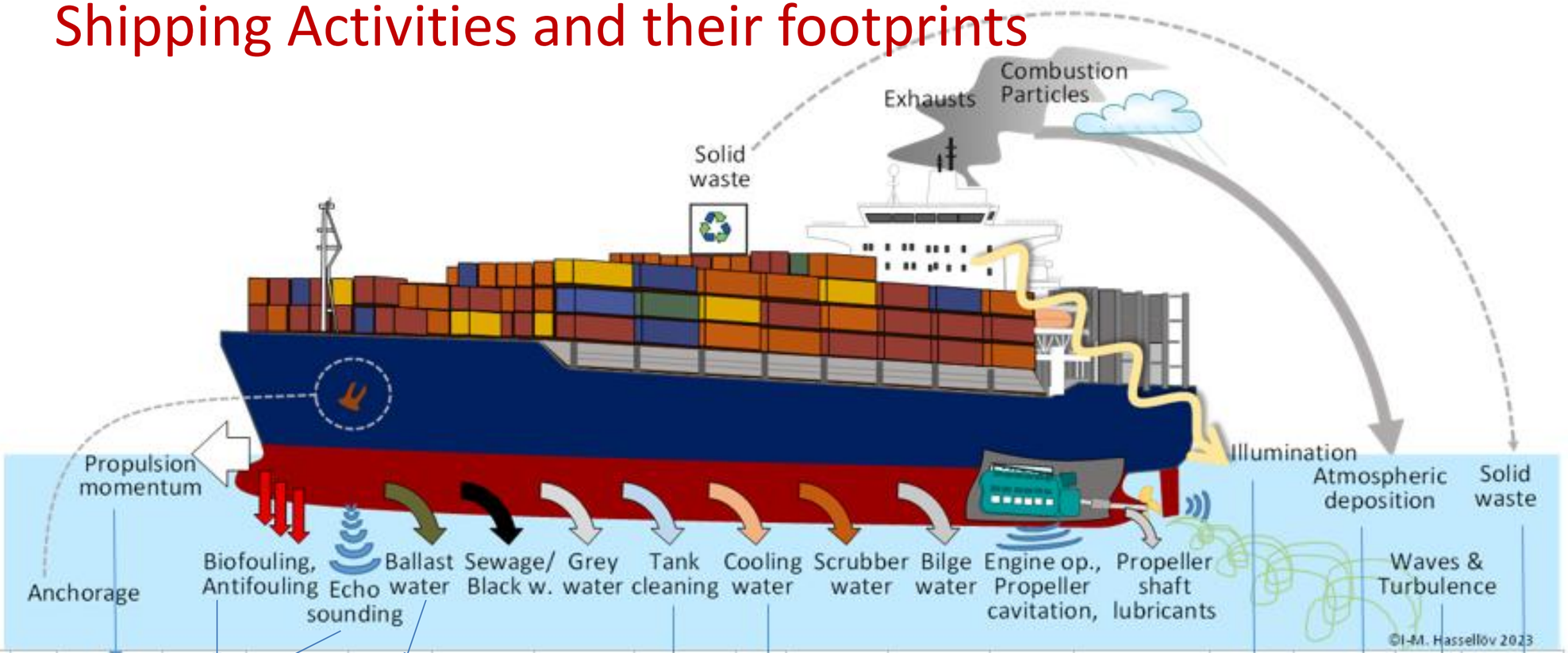
A




A
(n=24)
Vessel Move-ments
Embed ment Anchor-ing
Suction Anchor-ing
Survey sampling
Over-trawl survey
Making safe
Rig place-ment
Rig removal
Detach-ment of topside
Digging out of infras-tructure
Place-ment of stabilis-ation material
Removal of infra-structure (cuttings explosives)
Removal of infra-structure (pipelines jacket footings)
Re-injection of cuttings
Concrete gravity based structure remain in place
Footings remain in place
Burried matress remain in place
Pipeline trench and bury remain in place
Pipeline rock dump
Pipeline open trench remain open
Cutting a trench
Seabed prep. corridor for pipeline
Drill cuttings un-disturbed
Drill cuttings disturbed
P
(n=22)
Vibration
Above Water Noise
Transition Elements Contam-ination
Hydro-carbon and PAH Contam-ination
Synthetic Compound Contam-ination
Noise Changes
Intro. of Light or Shading
Death or Injury by Collission
Visual Disturb-ance
INIS
Intro. Microbial Pathogens
Litter
Abrasion/ Disturb. Above Surface
Penetration / Disturb. Below Surface
Changes in Suspended Solids
Smothering and Siltation (light)
Smothering and Siltation (heavy)
Physical Change in Sediment
Physical Change in Substrata
Water flow changes
Barrier to Species Move.
Habitat Structure Change
S
Physico-Chemical
Benthos
Fish
Shellfish
Marine Mammals
Seabirds
Intermediate Ecosystem Services
Final Ecosystem Services
I(W)
Goods/Benefits from Provisioning Ecosystem Services
Goods/Benefits from Regulating Ecosystem Services
Goods/Benefits from Cultural Ecosystem Services
R(M)
Assess the potential impacts of decommissioning with regard to Conservation Objectives
Reconsider selected decommissioning options to reduce potential impacts
Apply mitigation measures to reduce negative State changes and Impacts (on Welfare)
Introduce management measures to further enhance gains in goods/benefits

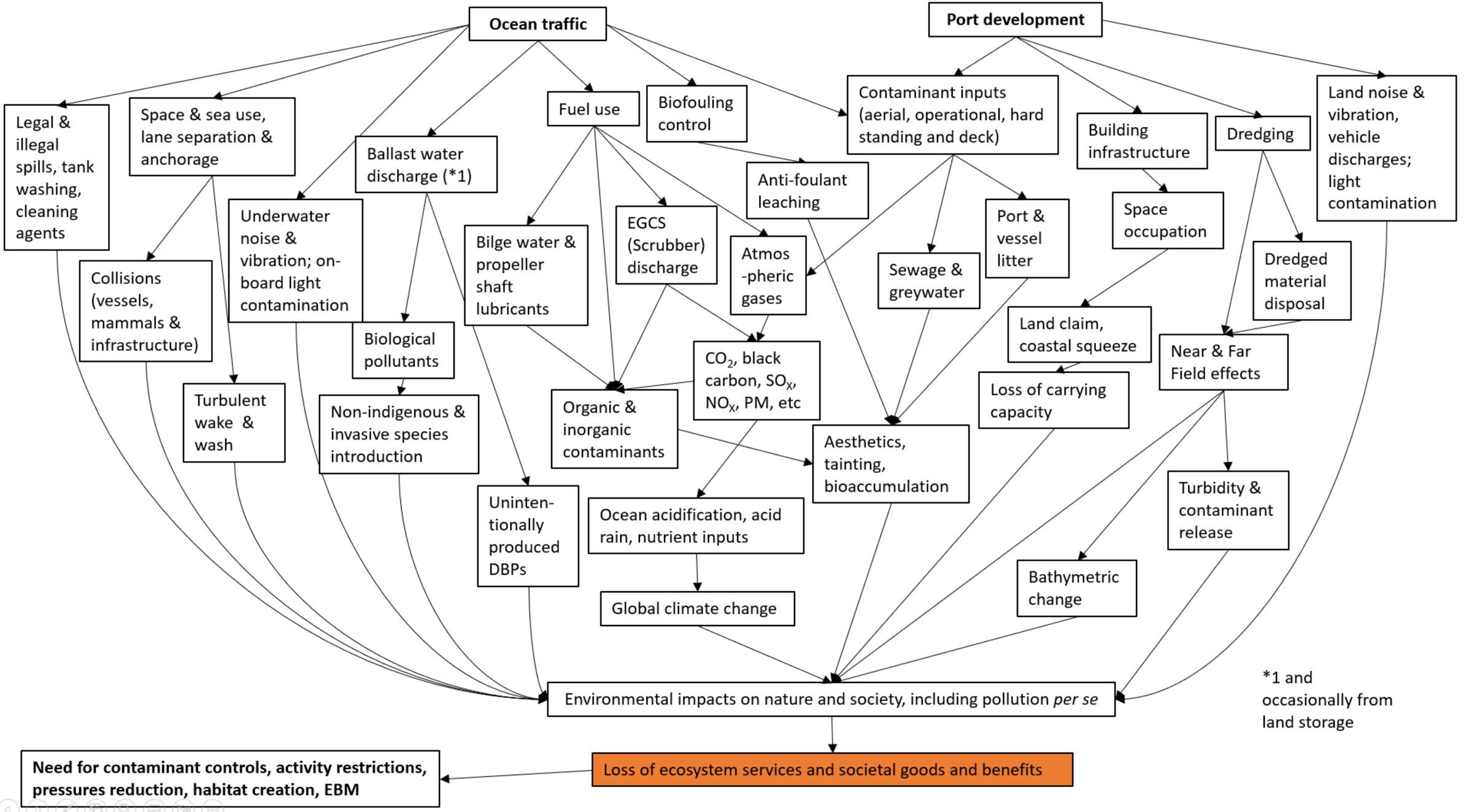
Shipping Activities and their footprints

Shipping regulations govern where and how e.g. discharges are permitted



Activity characteristics																	
Continuous		X	X	X	X				X	X		X	X		X	X	
Intermittent	X					X	X	X			X			X			X
Spatial extent area	X	X?	XX	XX	X?									X?	XXX	X	
Spatial extent volume					X?	X	X	X	X	X	X	X?	X	X?		X	X

(from Ida-Maja Hassellöv, Chalmers Uni, Gothenburg)

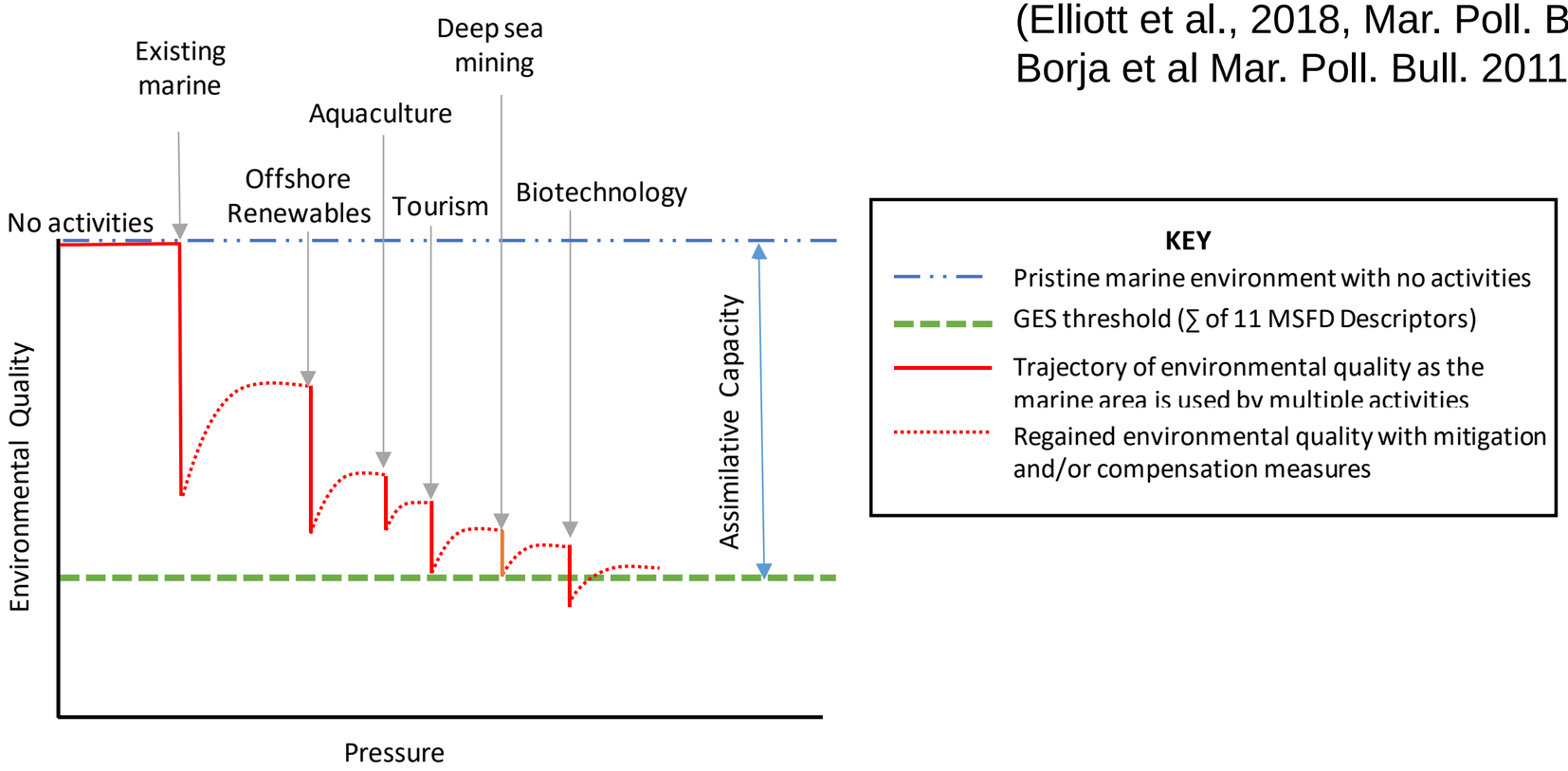


Horrendogram of the environmental consequences of ports, shipping and navigation (Elliott & Hassellöv in press)

How to manage the impacts and what are we trying to protect and restore: Assimilative Capacity/Carrying Capacity

	Previous Definition	Proposed Definition	Re. shipping and navigation
Assimilative capacity	the ability of a body of water to assimilate a contaminant without showing adverse changes	the amount of an activity or activities allowed in a body of water before it adversely affects the quality	The assimilative capacity reduces with each vessel passing but the amount of reduction depends on short-term dissipation of **intermittent pressures** (gases/fumes, noise, turbulence, bed-resuspension, etc) versus **remaining residual pressures** (litter, trace contaminants, NIS)
Carrying capacity	the amount of biota (e.g. number of birds or fishes) that a given habitat can support	the ability of a body of water to support a given amount of activity or activities or ecological component	the amount of vessel traffic allowed/possible within a shipping lane (governed by safety and economic considerations rather than environmental ones)

Environmental Quality Model incl. mitigation measures for cumulative Blue Growth Activities



(Elliott et al., 2018, Mar. Poll. Bull.; Borja et al Mar. Poll. Bull. 2011)

Challenge – how do we cope with cumulative effects and the availability/loss of assimilative and carrying capacities?!

Challenges for management (RA&RM; OA&OM):

Risk Assessment:

- Where are the problems and what changes do they cause? (ExUP & EnMP)
- What is their impact on ecosystem structure and functioning?
- What are the repercussions for ecosystem valuation based on economy-ecology interactions?
- What are the future environmental changes and economic futures?

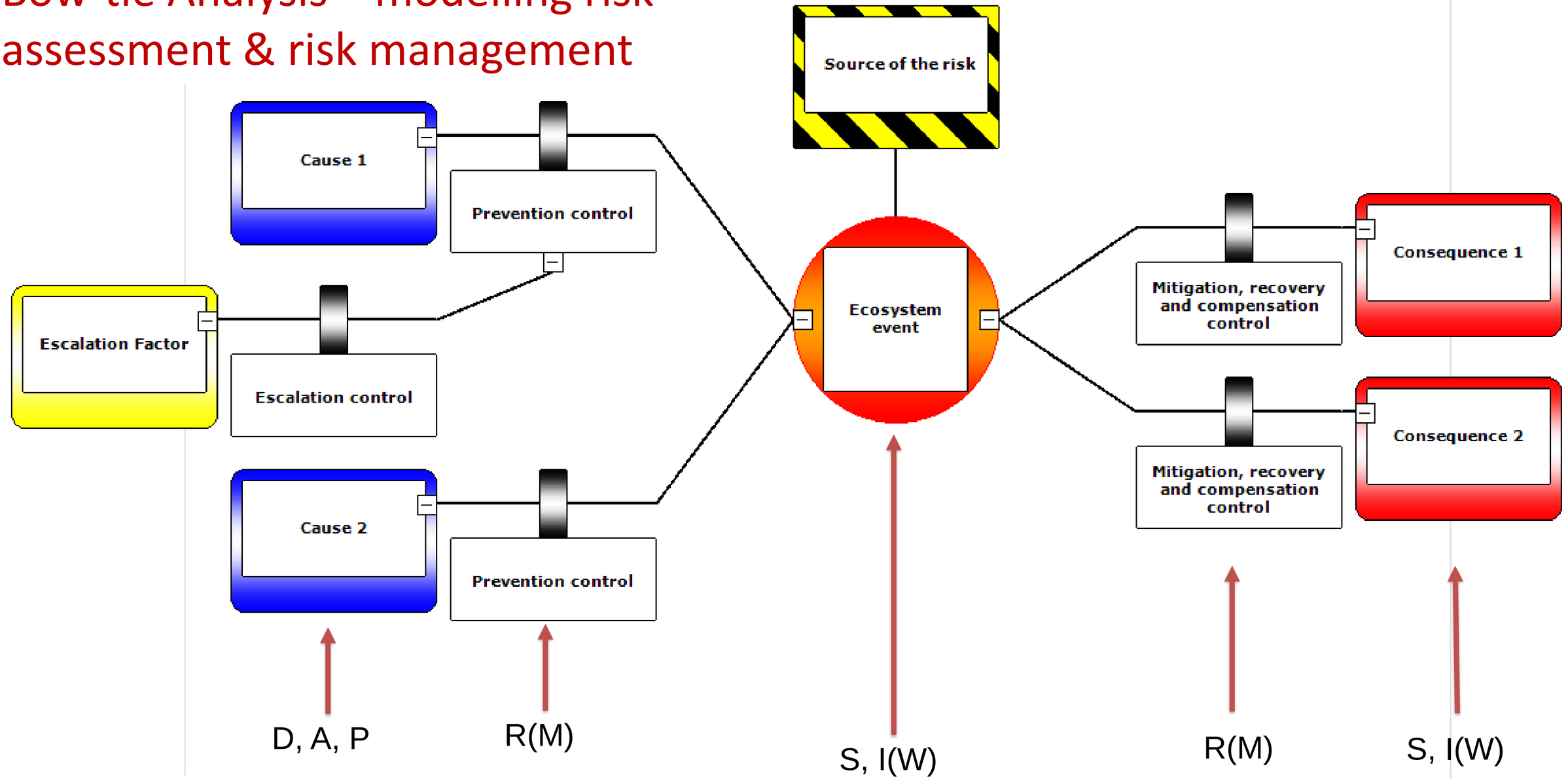
Risk Management:

- What governance framework is there, what do stakeholders need & what are successes & failures?
- What can we do about the problems, hazards & risks and how to address them now and in the future?
- How ‘good’ is the decision-making?

And the corollary: Opportunity Assessment and Management

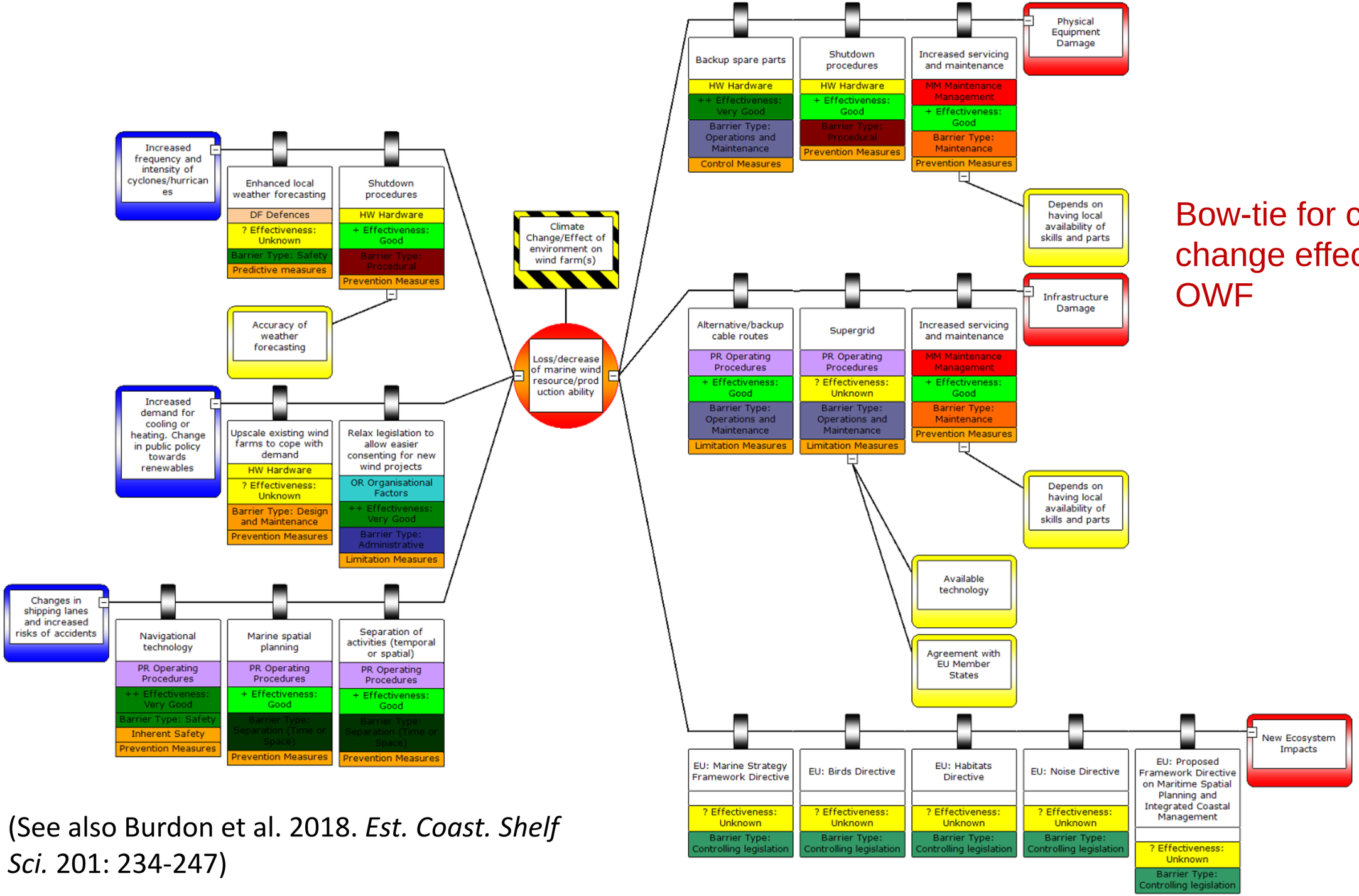
(Elliott, 2014 Mar. Poll. Bull.; Cormier et al 2019 OCMA, and others)

Bow-tie Analysis – modelling risk assessment & risk management



(Cormier et al., 2019, Sci. Tot. Env.)

Stakeholder consultation – to determine causes and consequences and to agree the responses throughout the sequence

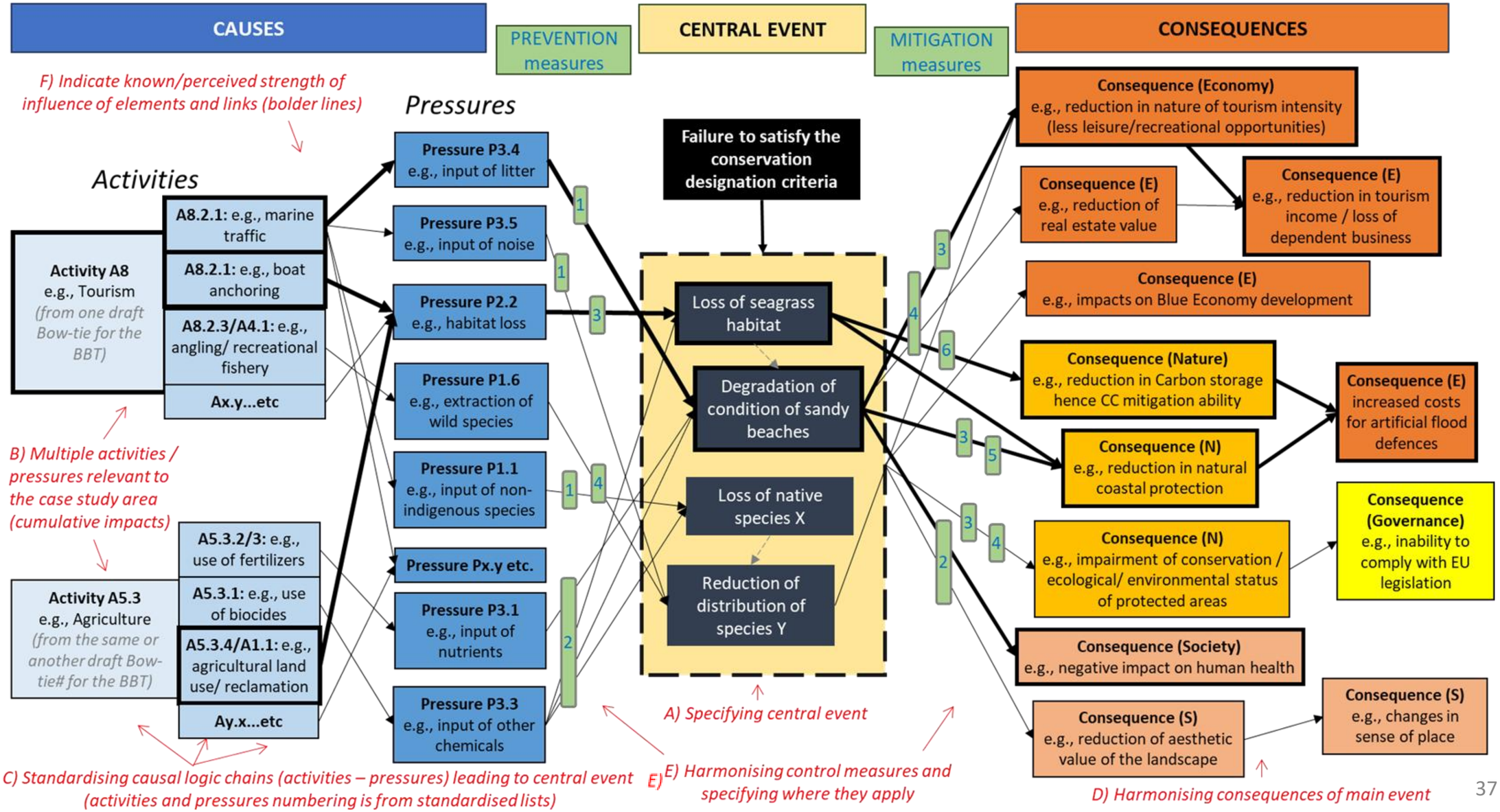


Bow-tie for climate change effects on OWF

(See also Burdon et al. 2018. *Est. Coast. Shelf Sci.* 201: 234-247)

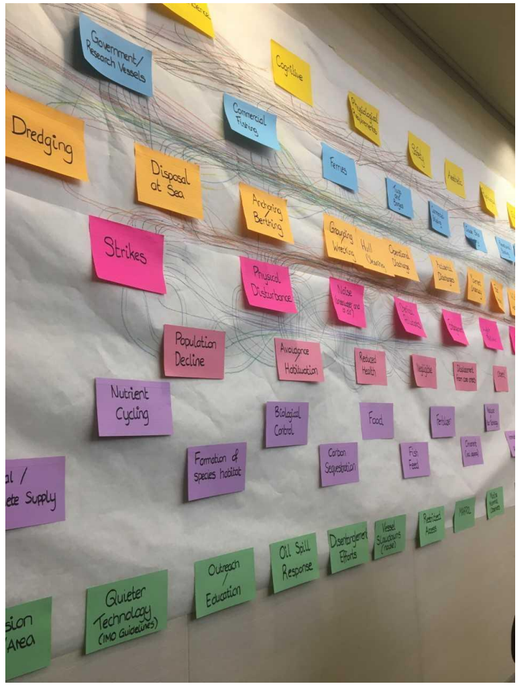
Bow-tie example and steps to build it (F)

Example of final Bow-tie diagram for a PS (mock-up) *(in red are the steps to follow)*



Framework for tackling the problem and identifying opportunities:

- Define the central problem and the framework for opportunities
- Create risk- and opportunity-based generic Bow-ties with Drivers and Activities
- Analyse previous experience, projects and literature
- Incorporate the 10-tenets for management responses
- Produce a ‘strawman’ for discussion with stakeholders
- Refine and produce the site- and topic-specific Bow-ties
- Interrogate Bow-Ties to show the gaps and opportunities for nature and society
- Interrogate Bow-Ties to show the gaps and opportunities for science and management



(Photo. Lauren McWhinnie, UVIC workshop, 2018)

GES4 SEAS

MarinePlan

MARBEFES

Challenges – measuring change

- Defining thresholds, tipping points, reference conditions
- Separate surveillance from true monitoring
- Achieving criteria for monitoring
- Defining and testing indicators – criteria for indicators
- But also defining targets against which change measured by monitoring is judged

Monitoring:

Definition:

observing and checking the progress or quality of an attribute over a given extent or period of time; keeping under systematic review.

Discuss:

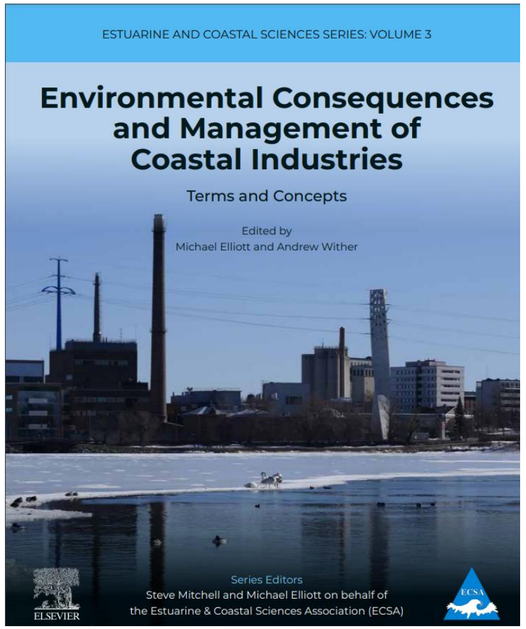
"monitoring is not a management measure <u>per se</u> but rather a tool to indicate what management measures are required or whether they have been successful"

Types of monitoring:

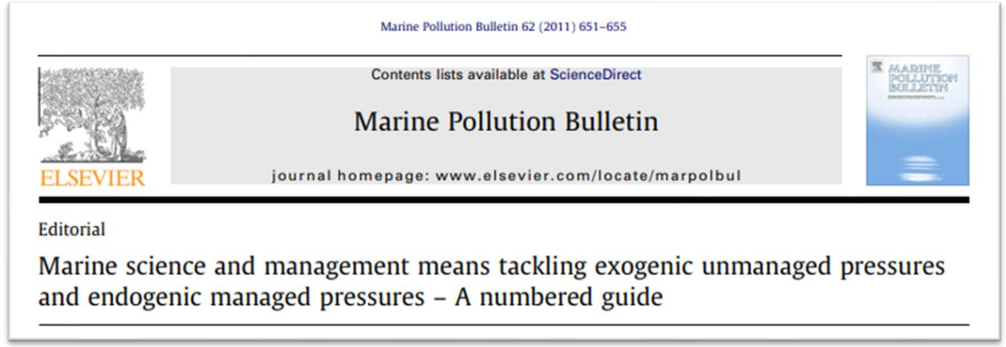
- Surveillance monitoring
- ‘True’ monitoring
- Condition monitoring
- Operational monitoring
- Environmental Assessment monitoring
- Compliance monitoring
- Self-monitoring
- Check monitoring
- Toxicity testing
- Investigative monitoring
- Diagnostic monitoring
- Feedback monitoring

All of these are terms mentioned in legal instruments (e.g. Directives, Acts and Regulations), guidelines, protocols, SOPs, CEN and ISO standards, etc.

(Expanded and modified from various publications)



The required properties of indicators and monitoring parameters for successful management (expansion of SMART)



Marine Pollution Bulletin 62 (2011) 651–655

Contents lists available at ScienceDirect

Marine Pollution Bulletin

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

Editorial

Marine science and management means tackling exogenic unmanaged pressures and endogenic managed pressures – A numbered guide

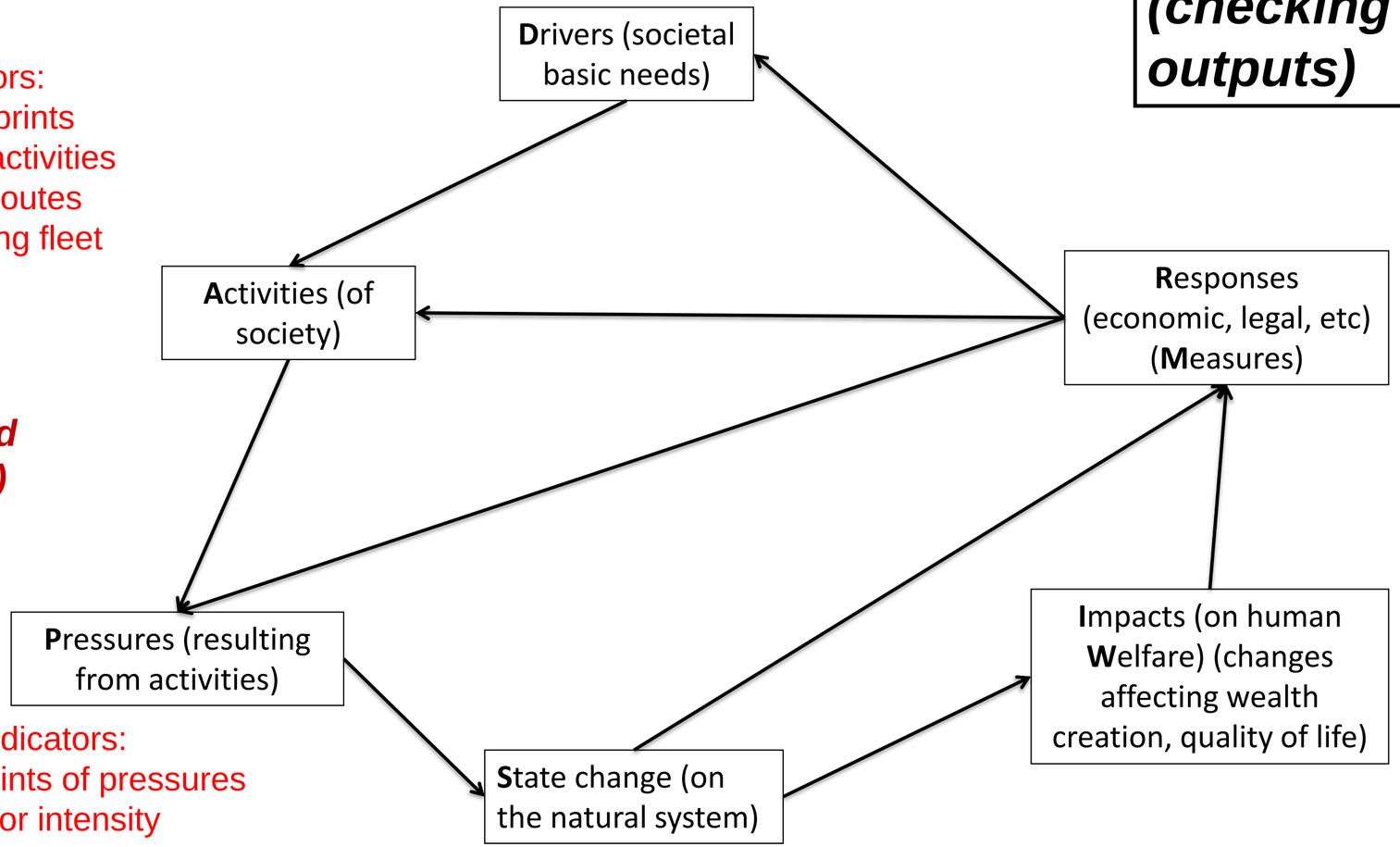
Modified and expanded from Elliott 2011
doi:10.1016/j.marpolbul.2010.11.033

Property
Anticipatory
Biologically important
Broadly applicable and integrative over space and time
Concrete and results focussed
Continuity over time and space
Cost-effective
Grounded in theory, relevant and appropriate
Interpretable
Low redundancy
Measurable
Non-destructive
Realistic / attainable (achievable)
Responsive feedback to management
Sensitive to a known stressor or stressors
Socially relevant
Specific
Time-bounded
Timely

(Analysis of indicators for GES Descriptors, Criteria and Targets for MSFD and MSPD in CINEA EMODNet project)

Achievement Sub-system *(checking outcomes vs. outputs)*

E.g. Indicators:
Activity footprints
Number of activities
Navigation routes
Size of fishing fleet



E.g. Indicators:
Number of regulations
Economic costs
10-tenets values

Indicator-based DAPSI(W)R(M) framework

E.g. Indicators:
Footprints of pressures
Stressor intensity

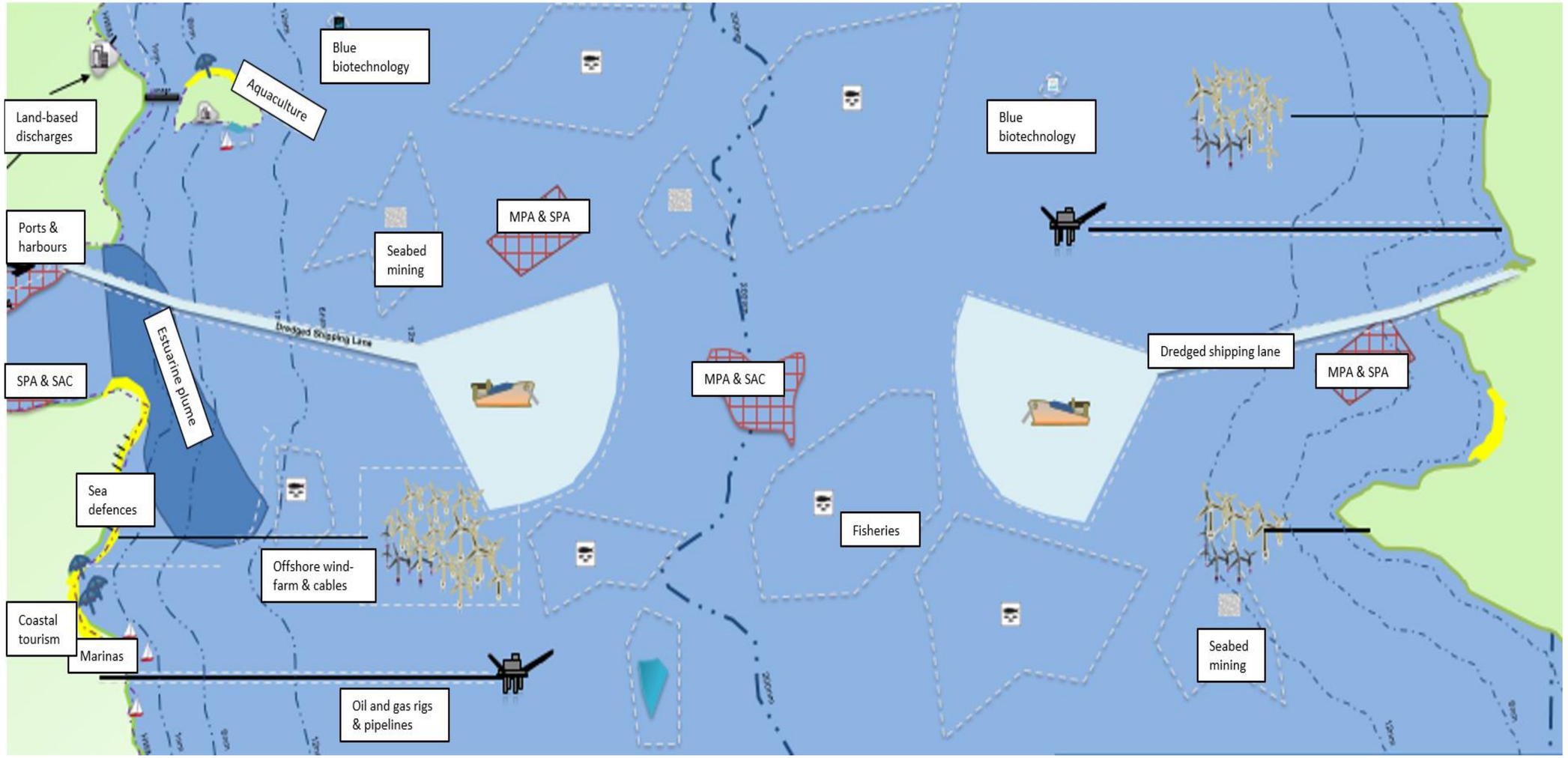
E.g. Indicators:
Footprints of societal effects
Societal goods and benefits
Human health status

E.g. Indicators:
Footprints of ecological effects
Natural health status
Ecosystem services levels
Population levels
Community structure

(See Elliott et al., *Mar. Poll. Bull.* 2017, 118: 27-40)

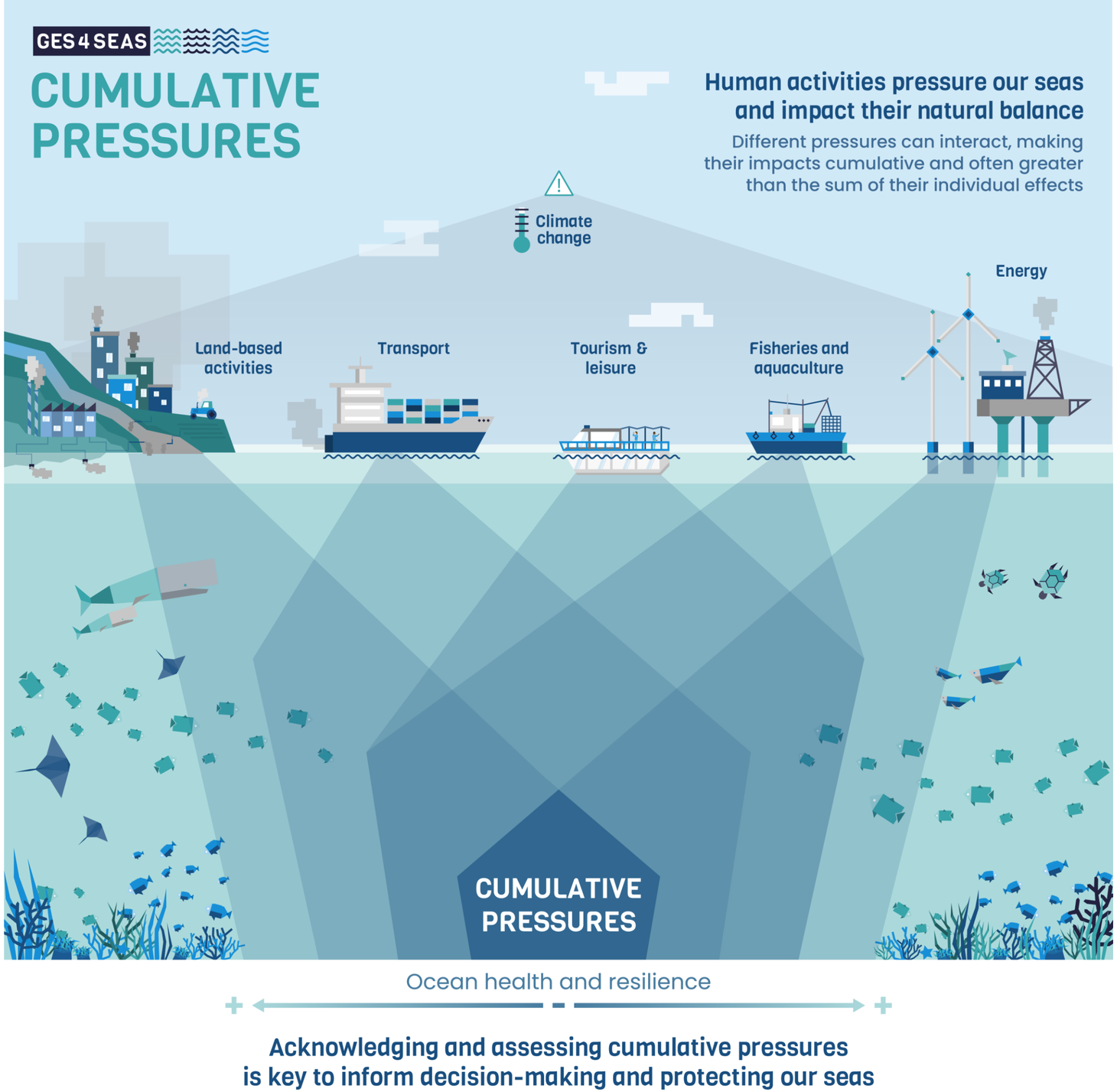
'You cannot manage it unless you can measure it'

(Elliott, Borja & Cormier 2020 Mar. Poll. Bull.; OCMA 2023)



Challenge of multi-use international seas: Stylised transnational sea area showing activity footprints and transboundary Marine Protected Areas and fishing grounds – to reflect the challenges of complex marine management

Management of a complex transboundary area



Creation of a toolbox for determining the effects of cumulative pressures on achieving Good Environmental Status – to calculate cumulative pressures and link to available indicators – based on NEAT from the DEVOTES project

GES4 SEAS

Cumulative/In-combination Impacts/Effects Assessment (CEA/CIA)

A practical definition: '*a systematic procedure for identifying and evaluating the significance of impacts from individual or multiple sources and/or activities*'.

The aim is to:

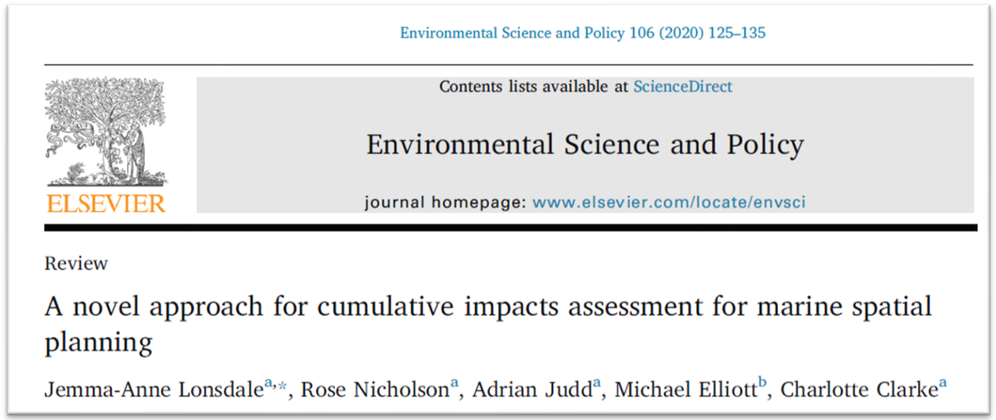
- understand the causes (as the source of pressures and effects),
- produce an estimate of the overall expected impact,

and

- help inform management decisions

in order to

- identify pathways and consequences of these spatial and temporal effects-footprints on receptors.


Environmental Science and Policy 106 (2020) 125–135

Contents lists available at ScienceDirect

Environmental Science and Policy

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

Review

A novel approach for cumulative impacts assessment for marine spatial planning

Jemma-Anne Lonsdale[a,*], Rose Nicholson[a], Adrian Judd[a], Michael Elliott[b], Charlotte Clarke[a]

Marine and Estuarine Management and Governance Sub-system
(who, how)

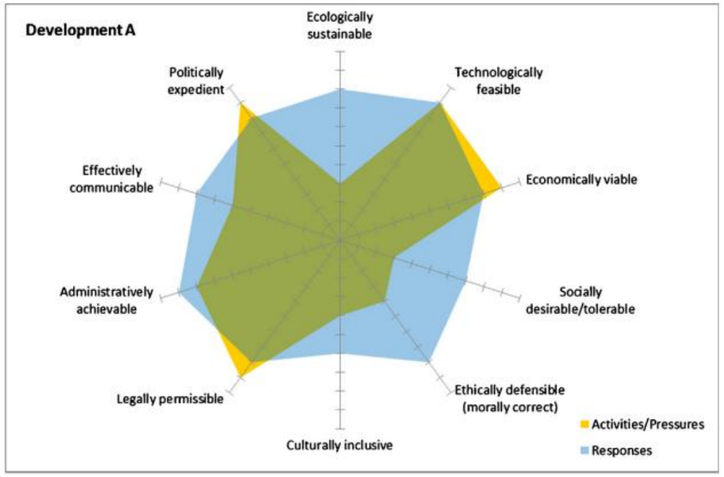
incorporating internationally recognised policies, politics, legislation and administration by horizontal and vertical integration of the management organogram to accomplish the vision of The Ecosystem Approach.

- ecologically sustainable development
- inter-generational equity
- the precautionary principle
- conservation of biological diversity and ecological integrity
- ecological valuation
- economic valuation of environmental factors
- the ‘damager debt’ / ‘polluter pays’ principle
- waste minimisation, and
- public participation - the role of individuals and ethics.

Solutions - The 10-tenets:

To be successful, management measures or responses to changes resulting from human activities should be:

- Ecologically sustainable
- Technologically feasible
- Economically viable
- Socially desirable/tolerable
- Legally permissible
- Administratively achievable
- Politically expedient
- Ethically defensible (morally correct)
- Culturally inclusive
- Effectively communicable



Marine Pollution Bulletin 74 (2013) 1–5

Contents lists available at ScienceDirect

Marine Pollution Bulletin

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

Editorial

The *10-tenets* for integrated, successful and sustainable marine management

ENVIRONMENTAL SCIENCE & POLICY 51 (2015) 181–191

Available online at www.sciencedirect.com

ScienceDirect

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

The 10-tenets of adaptive management and sustainability: An holistic framework for understanding and managing the socio-ecological system

Steve Barnard *, *Michael Elliott*

Ocean and Coastal Management 163 (2018) 162–172

Contents lists available at ScienceDirect

Ocean and Coastal Management

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

A proposed interdisciplinary framework for the environmental management of water and air-borne emissions in maritime logistics

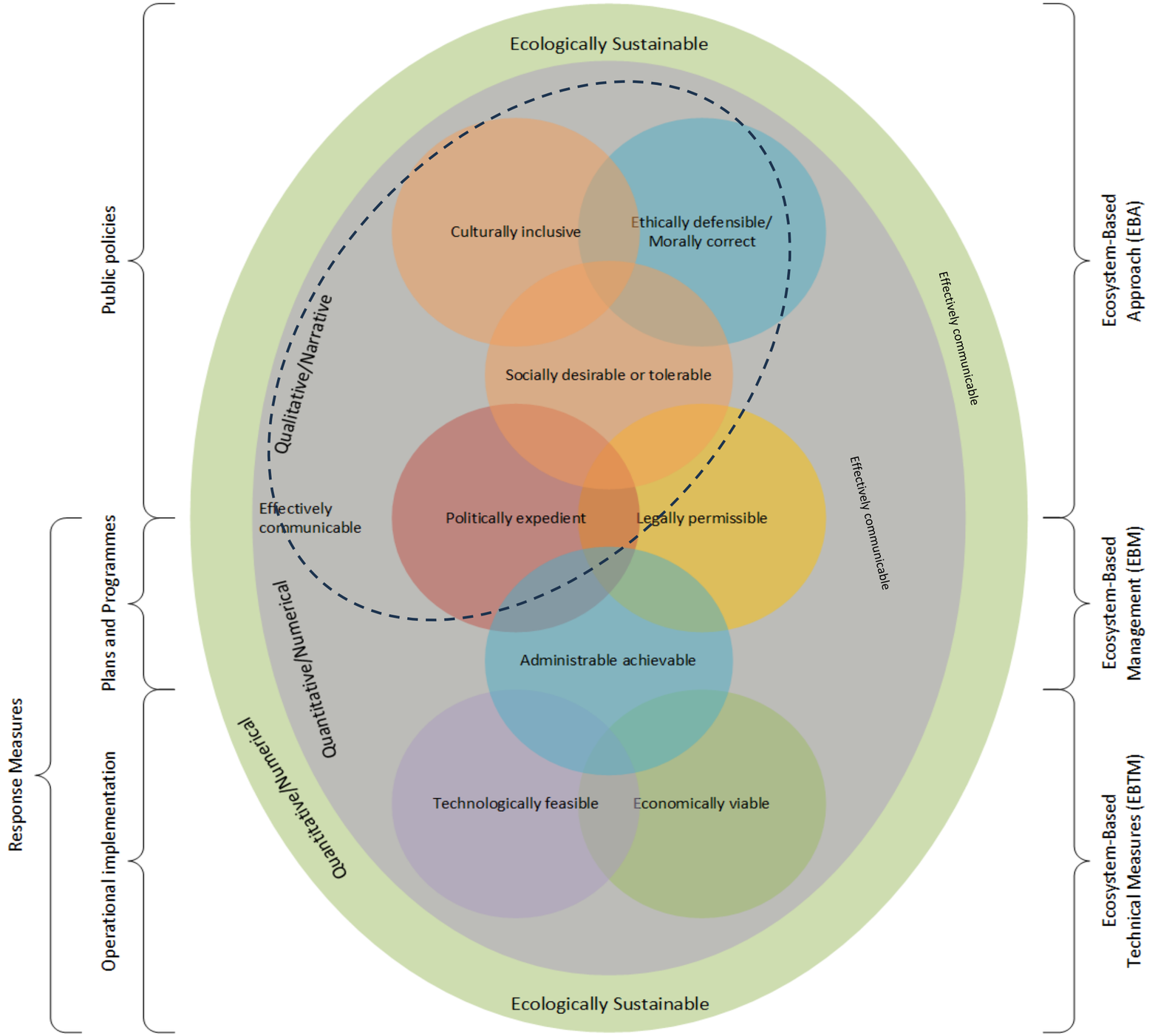
David B. Grant[a,b,*], Michael Elliott[c]

(NB spellcheck - not "10 Tennents – that's a good night in Scotland"!)

10 tenets of successful and sustainable environmental management – disciplines, data and information required – objective ways of determining success

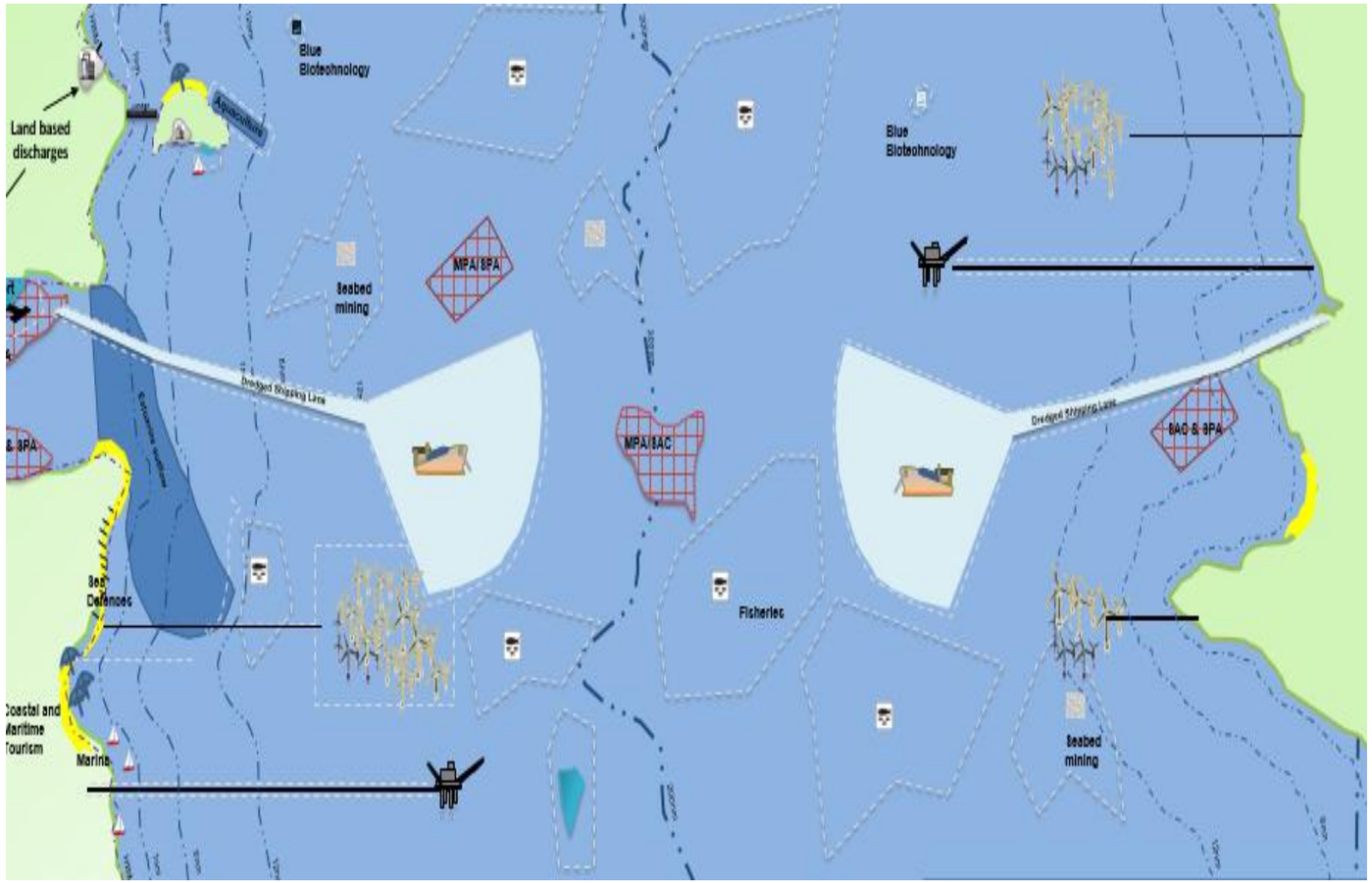
Ecosystem-Based Approach (EBA) to Ecosystem-Based Management (EBA) to Ecosystem-Based Technical Measures (EBMT)

(Elliott 2013 Mar. Poll. Bull.; Elliott et al., OCMA 2025, paper in prep., and other papers)



Where are we managing?

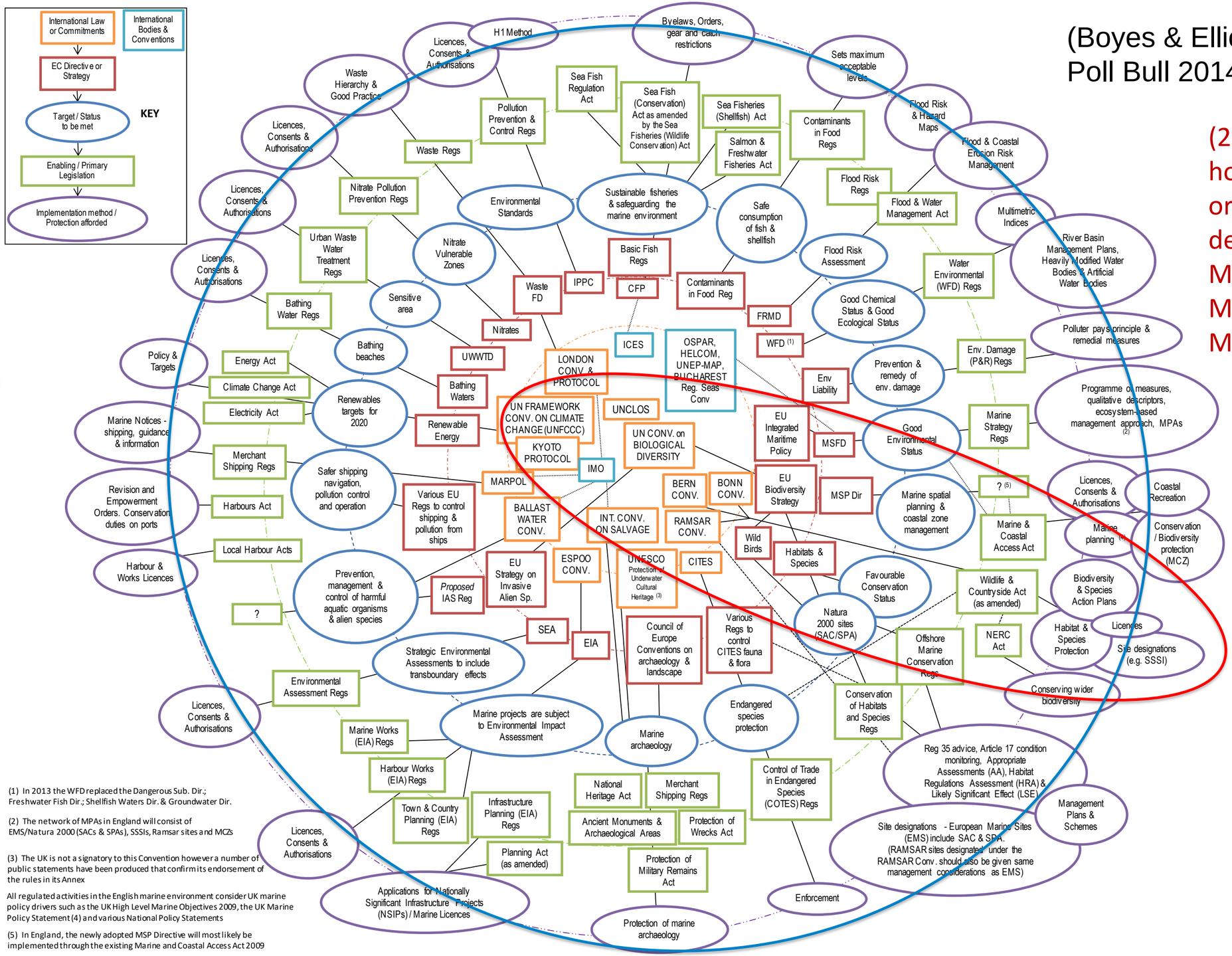
- A small area (the activity footprint)
- A middle-sized area (pressures footprints)
- Middle to large areas (effects footprints)
- Whole estuaries
- Whole catchments/river basins
- Catchment-estuary-coastal areas
- Seas and sea regions
- Regional seas
- Areas Beyond National Jurisdictions
- The globe



How are we managing it/them? - Responses (using management Measures) (R(M)) (Programmes of Measures in WFD/MSFD/UKMS)

- By management action
- By developing programmes of measures
- By developing monitoring schemes
- By linking monitoring to SMART indicators
- By feedback to check if management is working
- By implementing laws
- By having lots of management bodies
- By making industry get their house in order
- By realizing the management footprint
- By having visions, objectives, policies
- By using good and fit for purpose science

Cf.



(Boyes & Elliott, Mar Poll Bull 2014)

(29 geographical horrendograms and organograms developed in MarineSABRES, MarinePlan and MARBEFES)

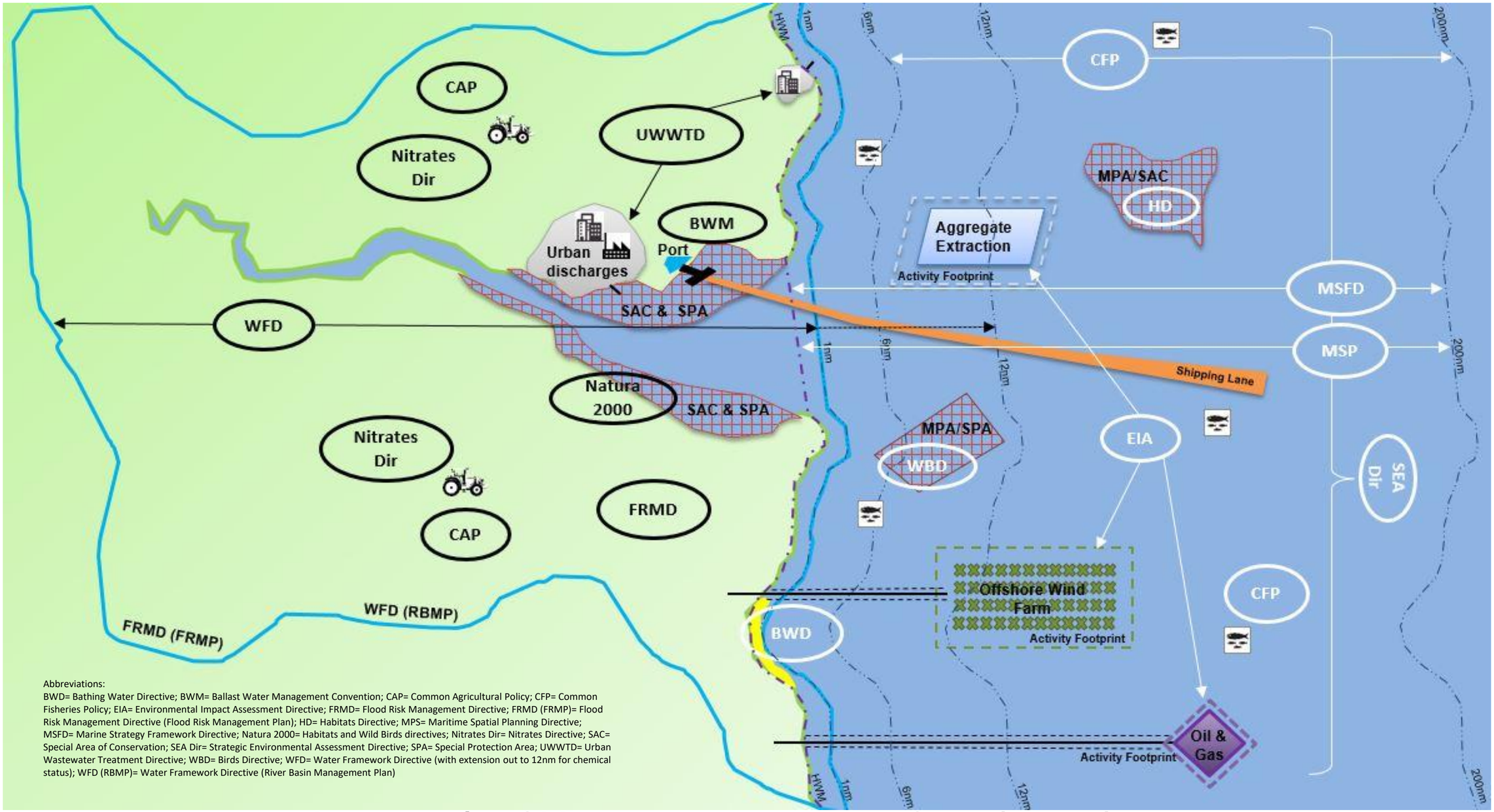
(1) In 2013 the WFD replaced the Dangerous Sub. Dir.; Freshwater Fish Dir.; Shellfish Waters Dir. & Groundwater Dir.

(2) The network of MPAs in England will consist of EMS/Natura 2000 (SACs & SPAs), SSSIs, Ramsar sites and MCZs

(3) The UK is not a signatory to this Convention however a number of public statements have been produced that confirm its endorsement of the rules in its Annex

All regulated activities in the English marine environment consider UK marine policy drivers such as the UK High Level Marine Objectives 2009, the UK Marine Policy Statement (4) and various National Policy Statements

(5) In England, the newly adopted MSP Directive will most likely be implemented through the existing Marine and Coastal Access Act 2009

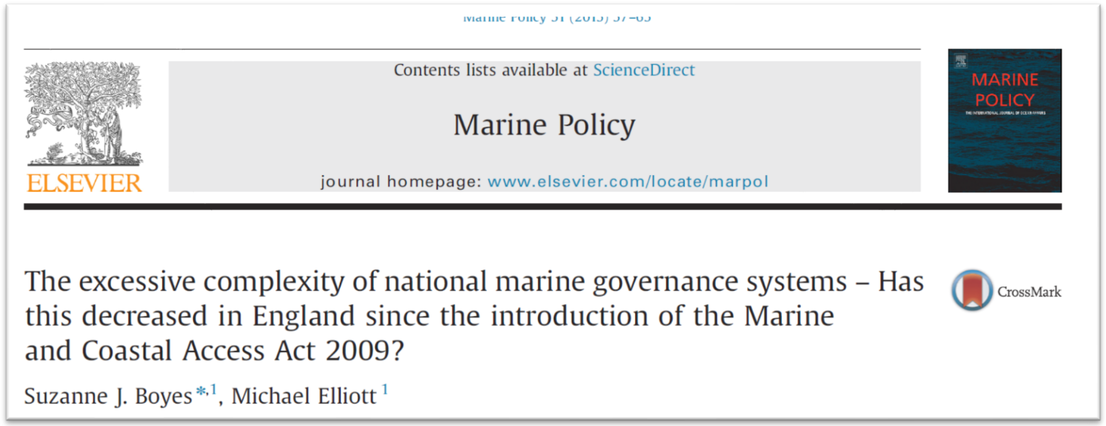


Abbreviations:
BWD= Bathing Water Directive; BWM= Ballast Water Management Convention; CAP= Common Agricultural Policy; CFP= Common Fisheries Policy; EIA= Environmental Impact Assessment Directive; FRMD= Flood Risk Management Directive; FRMD (FRMP)= Flood Risk Management Directive (Flood Risk Management Plan); HD= Habitats Directive; MPS= Maritime Spatial Planning Directive; MSFD= Marine Strategy Framework Directive; Natura 2000= Habitats and Wild Birds directives; Nitrates Dir= Nitrates Directive; SAC= Special Area of Conservation; SEA Dir= Strategic Environmental Assessment Directive; SPA= Special Protection Area; UWWTD= Urban Wastewater Treatment Directive; WBD= Birds Directive; WFD= Water Framework Directive (with extension out to 12nm for chemical status); WFD (RBMP)= Water Framework Directive (River Basin Management Plan)

An example of Management response-footprints – the geographical scope and competencies of EU legislation

Who is doing the managing?

- Environmental protection agencies
- Nature conservation bodies
- Fisheries departments
- Developers
- Municipal authorities
- Environmental health departments
- Port authorities
- Industries
- NGOs

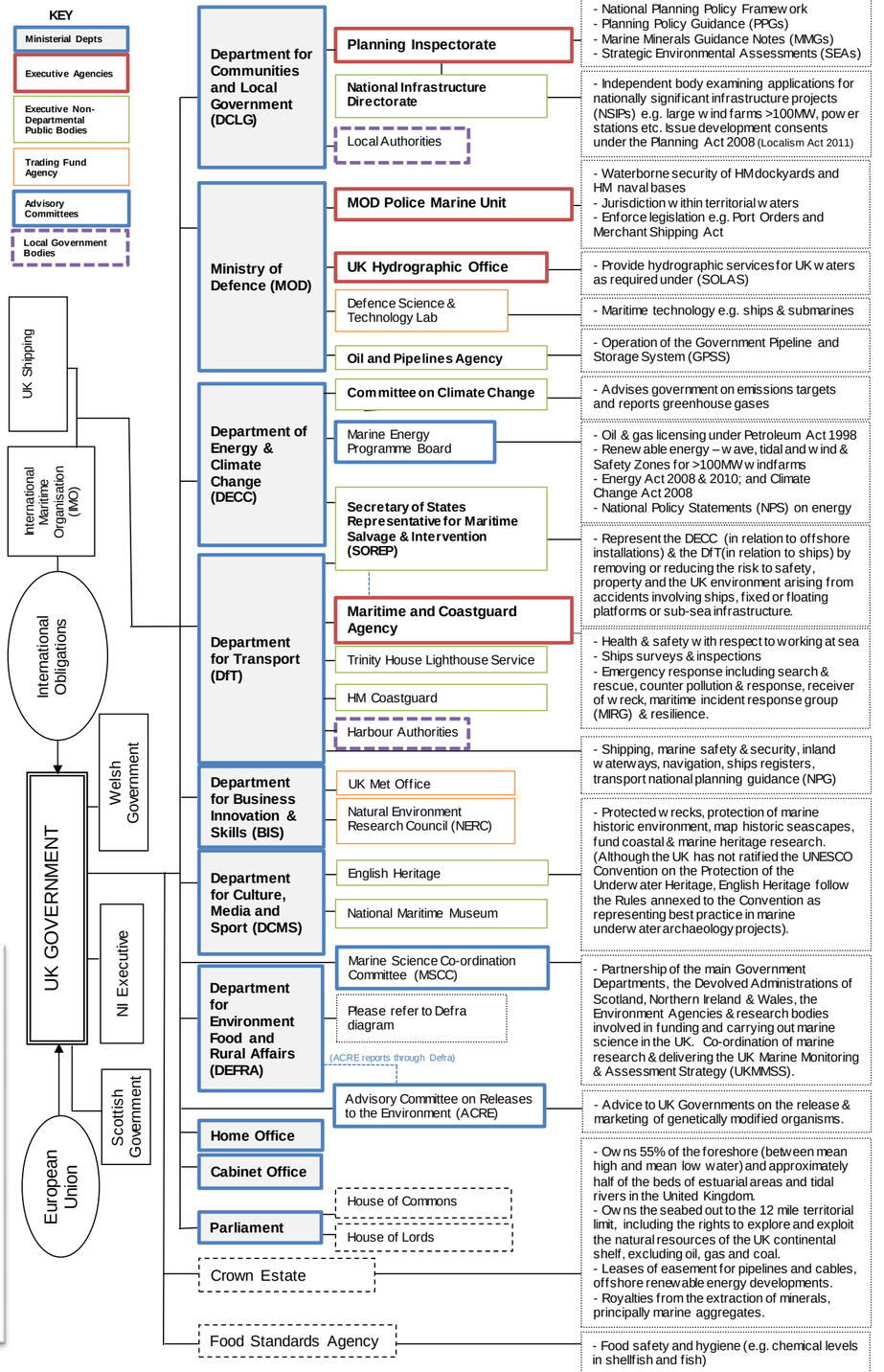

Contents lists available at ScienceDirect

Marine Policy

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

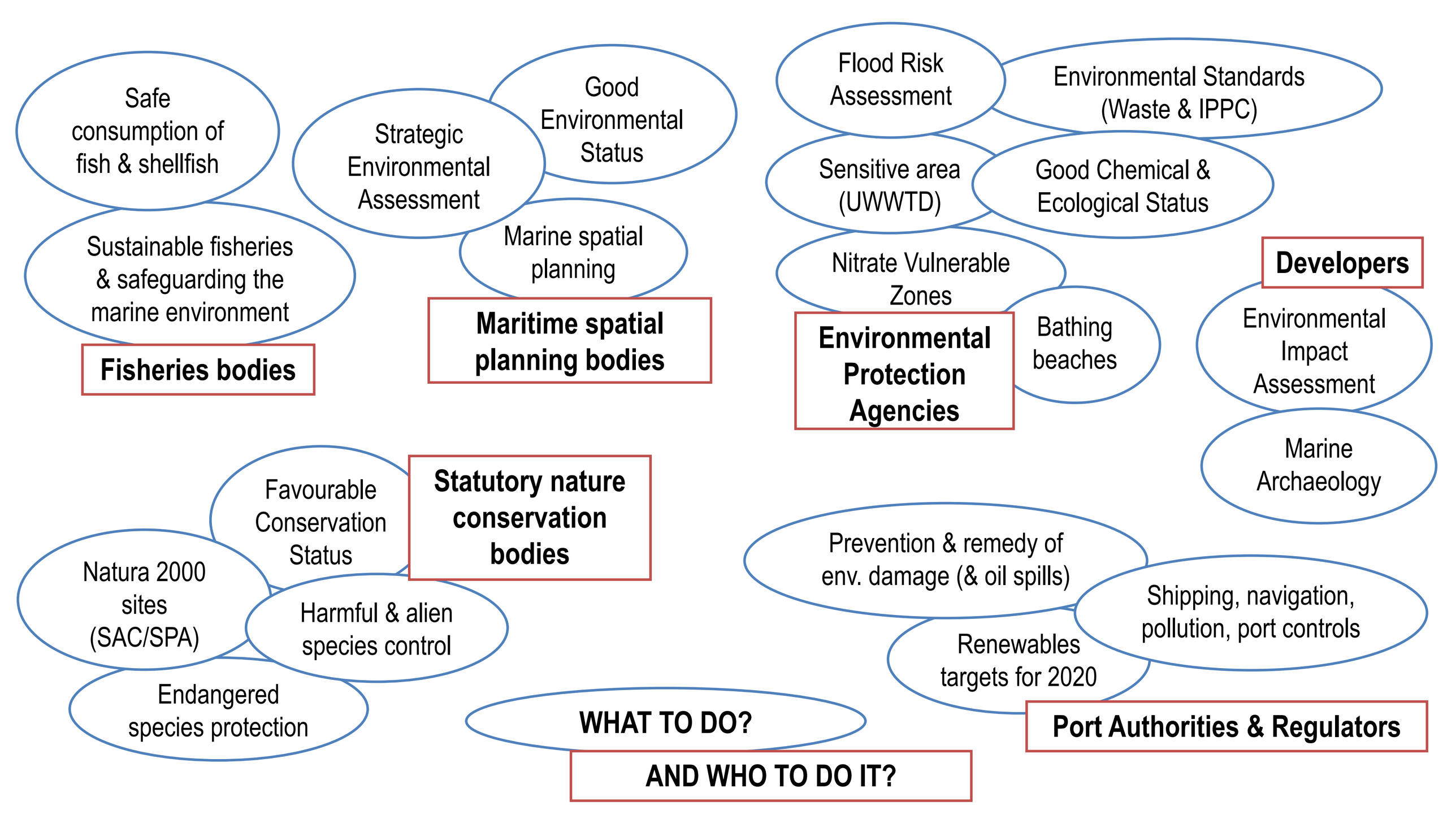
The excessive complexity of national marine governance systems – Has this decreased in England since the introduction of the Marine and Coastal Access Act 2009?

Suzanne J. Boyes *,[1], Michael Elliott [1]

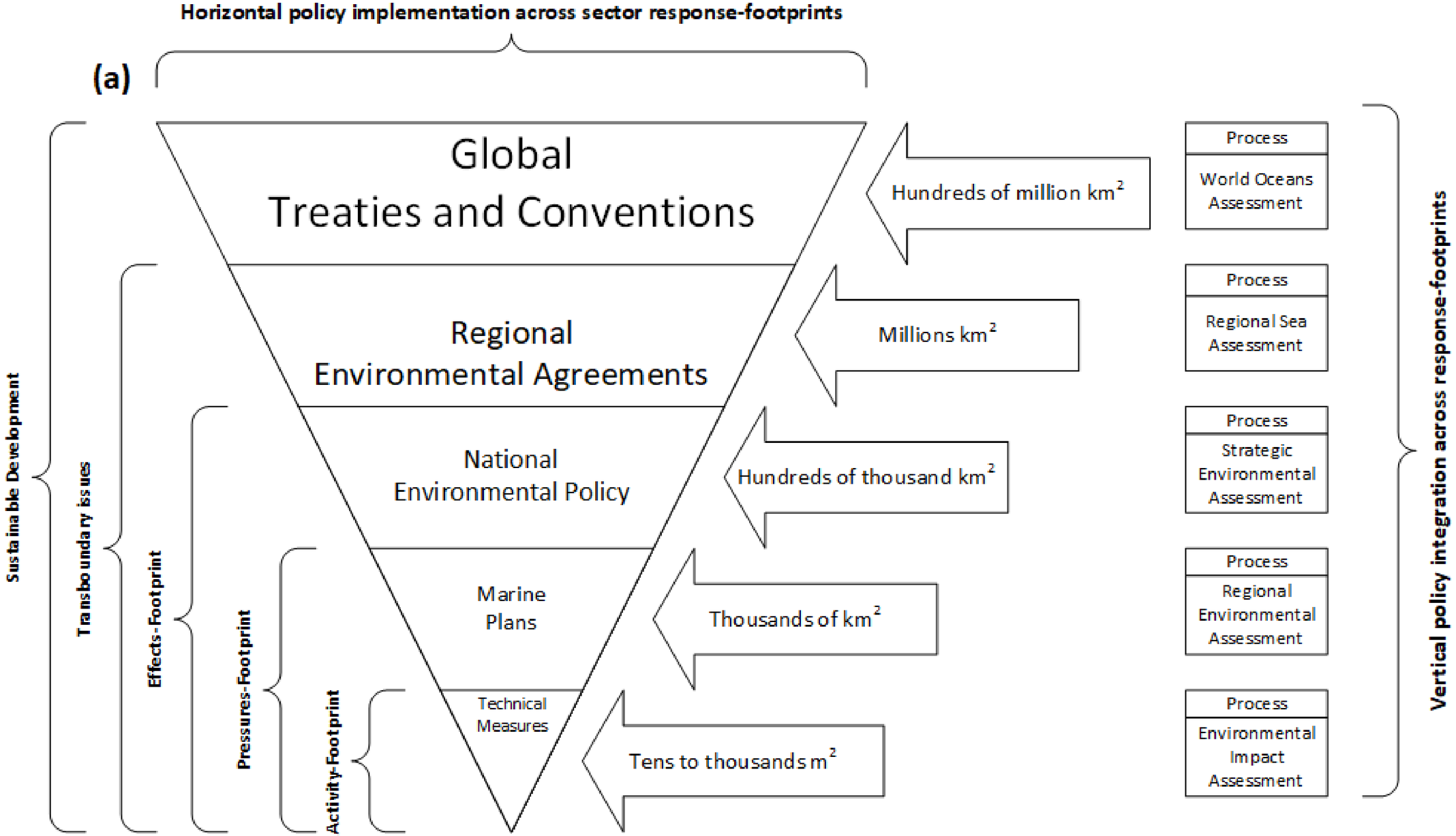


Types of Government departments with a marine competency (with their agencies):

- Environment, food and rural affairs
- Fisheries and conservation
- Business, skills, innovation, energy and climate change
- Foreign office
- International development office
- Defence
- Transport
- Communities and local government
- Culture, media and sport
- Home office
- Cabinet office


Safe consumption of fish & shellfish
Sustainable fisheries & safeguarding the marine environment
Fisheries bodies
Strategic Environmental Assessment
Good Environmental Status
Marine spatial planning
Maritime spatial planning bodies
Flood Risk Assessment
Environmental Standards (Waste & IPPC)
Sensitive area (UWWTD)
Good Chemical & Ecological Status
Nitrate Vulnerable Zones
Bathing beaches
Environmental Protection Agencies
Developers
Environmental Impact Assessment
Marine Archaeology
Favourable Conservation Status
Statutory nature conservation bodies
Natura 2000 sites (SAC/SPA)
Harmful & alien species control
Endangered species protection
Prevention & remedy of env. damage (& oil spills)
Shipping, navigation, pollution, port controls
Renewables targets for 2020
Port Authorities & Regulators
WHAT TO DO?
AND WHO TO DO IT?

Management response-footprint triangle (Cormier et al., Front. Mar. Sci. 2022)

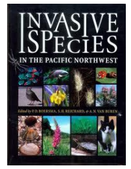


Marine Strategy Framework Directive (MSFD, 2008/56/EC)
(*the marine environmental quality directive!*)

There is only one big idea in marine management: *how to maintain and protect ecological structure and functioning while at the same time allowing the system to produce ecosystem services from which we derive societal benefits.*

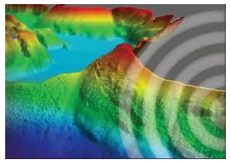
Qualitative Descriptors


Biodiversity

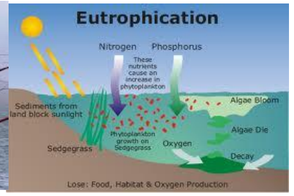


NIS

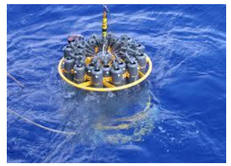

Foodwebs


Seafloor integrity


Fishing

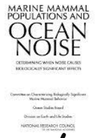


Eutrophication

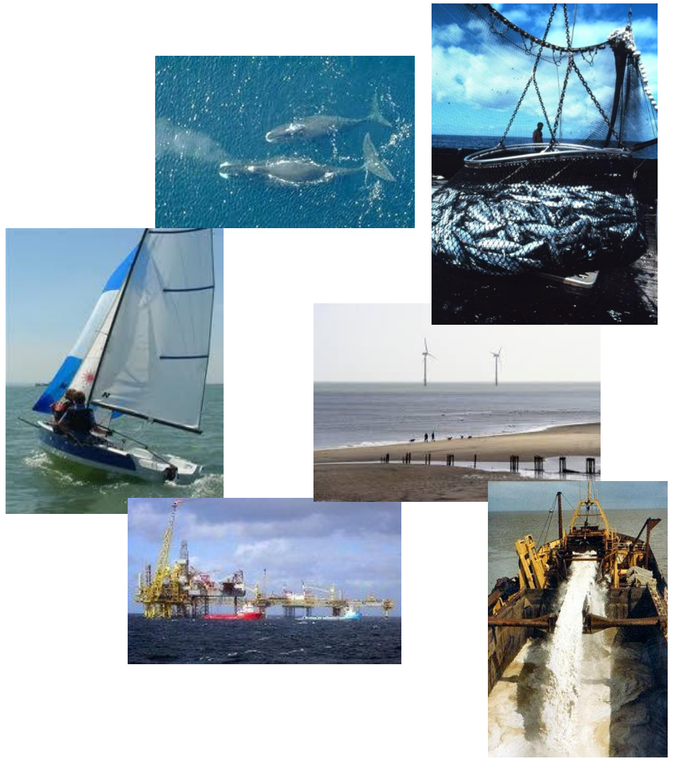

Hydrography


Pollution


Litter

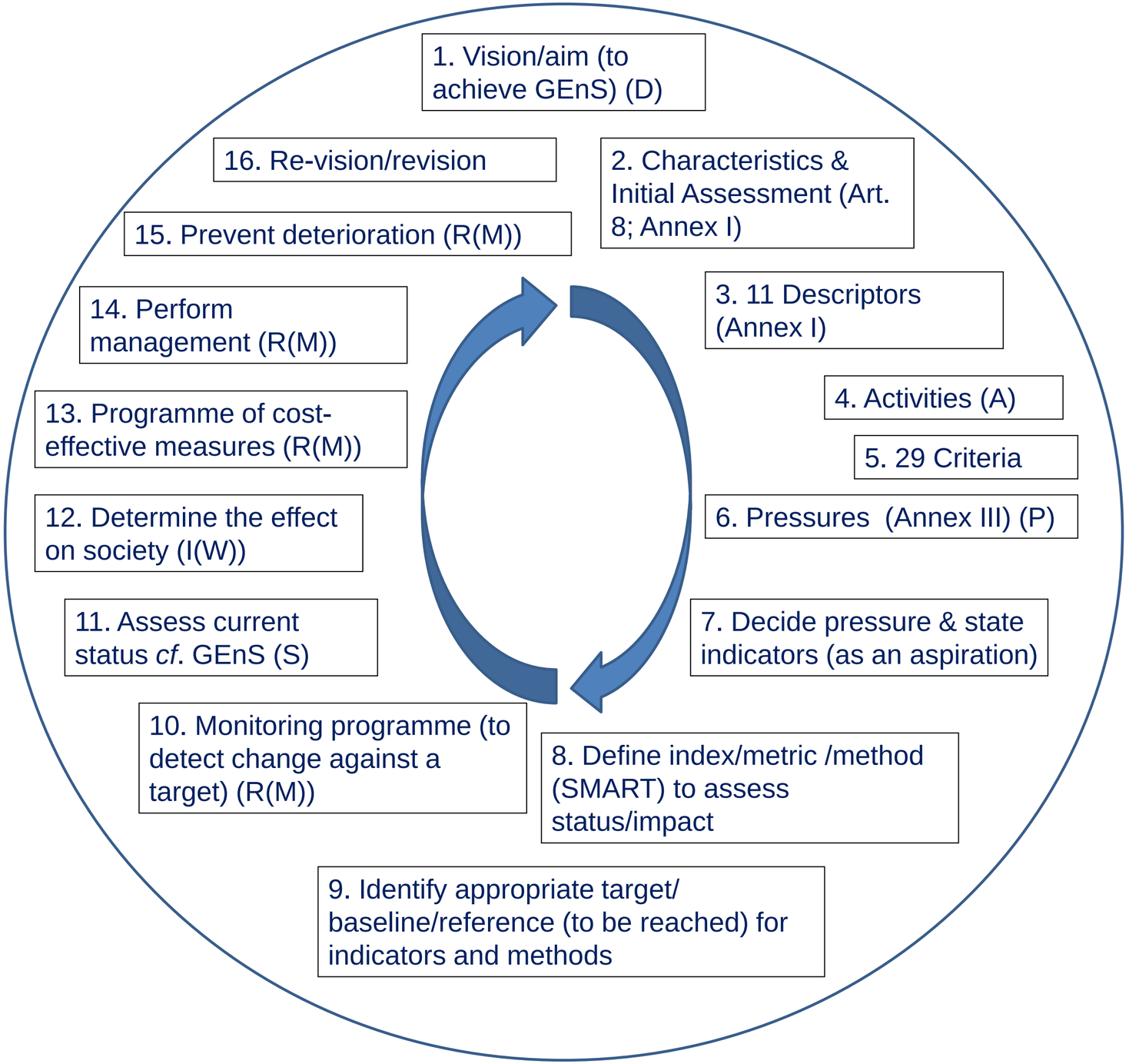


Energy/noise



Framework Directive on Maritime Spatial Planning (MSP, 2014/89/EU)
(the marine blue growth directive!)

Step in MSFD implementation including DAPSI(W)R(M)



Marine Strategy:

- *Initial assessment*
- *GES definition*
- *Targets*
- *Indicators*
- *Monitoring*
- *Measures*

A conceptual model of the implementation of the MSFD

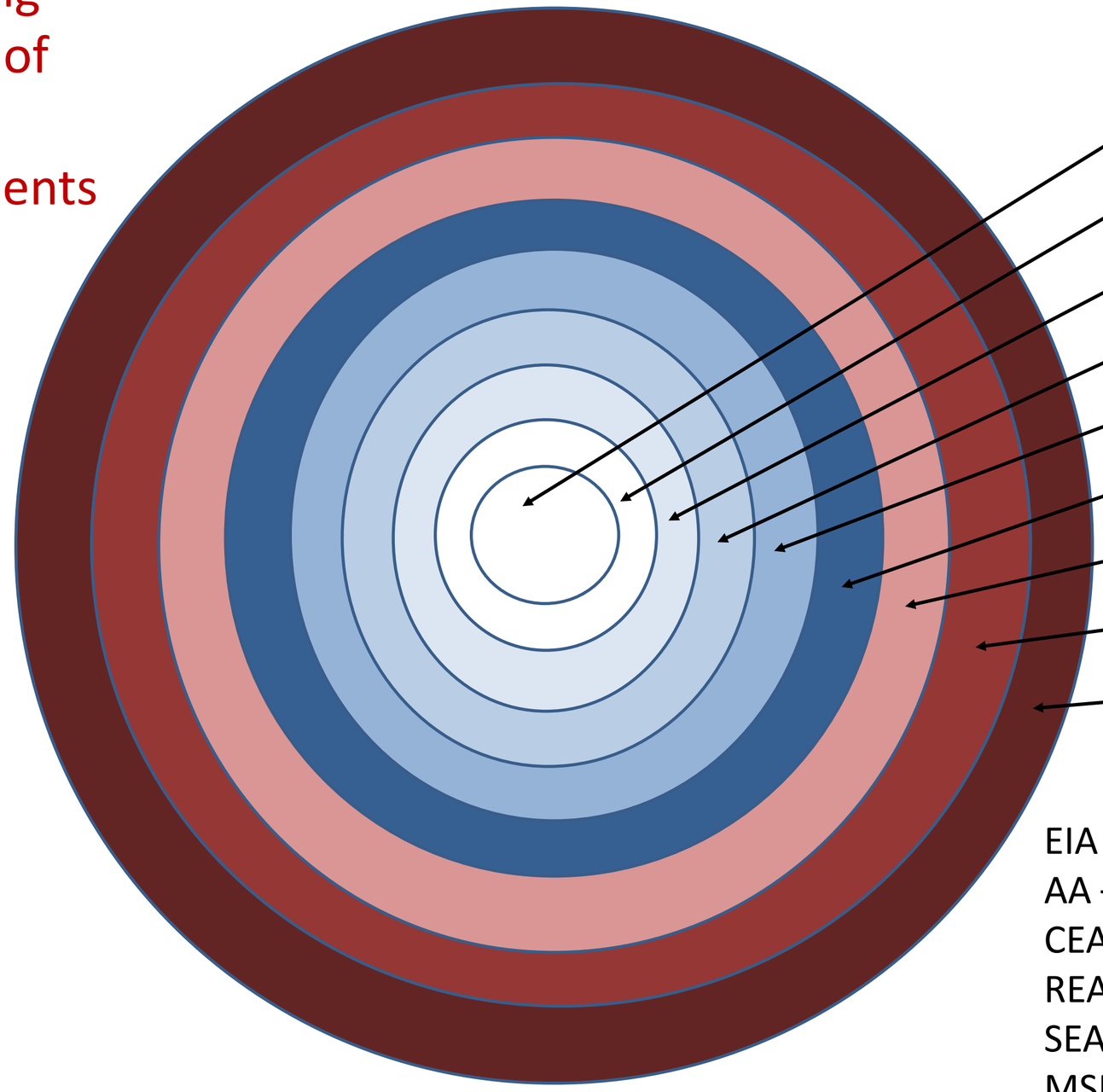
(Elliott et al, 2015 Mar Poll Bull)

Maritime Spatial Planning

- Aim: “the sustainable growth of maritime and coastal economies and the sustainable use of marine and coastal resources”.
- MSP is about planning **when and where human activities take place at sea** – to ensure these are as efficient and sustainable as possible.
  - ensure a coordinated approach to MSP throughout Europe;
  - enable the efficient and smooth application of MSP in cross-border marine areas;
  - to favour the development of maritime activities; and
  - the protection of the marine environment based on a common framework
  - the MSPD is regarded in the Programme of Measures (PoM) of the MSFD

Increasing Spheres of Marine Assessments

ABMT:
PSSA
SAC
SPA
EBSA
OECM
KBA
Ramsar
VME
MPA



EIA/AA
Developer CEA
Sectoral REA
National Regulatory SEA
National SEA
National MSP
Transboundary SEA
Regional Sea/ICES CEA
Ocean Health Index

National GES-MSFD Assessment

Transnational/ Ecoregion GES-MSFD Assessment

EIA – Environmental Impact Assessment (EIAD)
AA – Appropriate Assessment (HSD/WBD)
CEA – Cumulative Effects/Impacts Assessment (EIAD)
REA – Regional Environmental Assessment
SEA – Strategic Environmental Assessment (SEAD)
MSP – Maritime Spatial Planning (MSPD)
GES – Good Environmental Status (MSFD)

MarinePlan

GES4 SEAS

- PSSA – Particularly Sensitive Sea Areas (global, navigation)
- SAC – Special Areas of Conservation (HSD)
- SPA - Special Protected Areas (WBD)
- MPA - Marine Protected Areas (MSPD)
- SSSI – Sites of Special Scientific Interest (UK)
- OECM – Other Effective Conservation Measures (global)
- EBSA – Ecologically and/or Biologically Sensitive Areas (global)
- HPMA - Highly Protected Marine Areas (UK)
- MCZ – Marine Conservation Zones (UK)
- NTZ – No-Take Zones
- EFH – Essential Fish Habitat (US, UK, etc)
- BSH – Broad Scale Habitats
- Habitats and Species of Conservation Importance
- EMS – European Marine Sites (aka Natura 2000 Site)
- FOCI – Feature of Conservation Importance
- VMEs – Vulnerable Marine Ecosystems (FAO)

'Alphabetti spaghetti' – types of conservation designations & their links:

Status (& Coherence and equivalence between these?):

- FCS – Favourable Conservation Status (Natura 2000)
- GES (or GEcS) – Good Ecological Status (WFD)
- GES (or GEnS) – Good Environmental Status (MSFD)

Mapping Designations:

- EUNIS
- CORINE

MarinePlan

(Amorim and Elliott, submitted)

Definitions for Transboundary Analysis in Marine Planning

Connectivity – the state of being or being able to be connected; marine features that are linked and contiguous in some way, either naturally by ecology and hydrodynamics or by management measures (human interventions and actions); ***i.e. elements are joined/linked across boundaries***.

Coherence – the quality of being logical and consistent and/or the quality of being regarded as forming a whole; that there is a clear relationship between the parts, that the whole is greater than the sum of the individual parts; that there is a similarity in marine aspects in adjoining transboundary areas; that similar actions and features occur either side of a boundary; ***i.e. actions are the same on each side of a boundary***.

Equivalence – that a relationship exists between two (or more) entities (e.g. national marine areas), and the relationship is described as one of likeness/sameness/similarity/equality in terms of one or more potential qualities; that the same and comparable outputs and outcomes occur either side of a boundary even if the methods used differ; i.e. ***actions have the same outcome on each side of a boundary irrespective of the methods used***.

MarinePlan

(Elliott, Borja & Cormier, 2023 OCMA)

(Estuarine examples of connectivity in Elliott & Whitfield ECSS 2025)

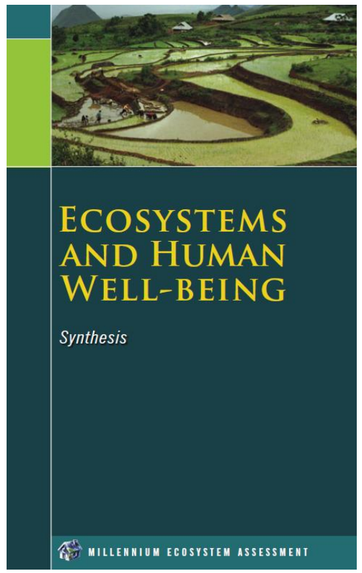
Challenge – how do we ensure the connectivity, coherence and/or equivalence between transboundary areas?

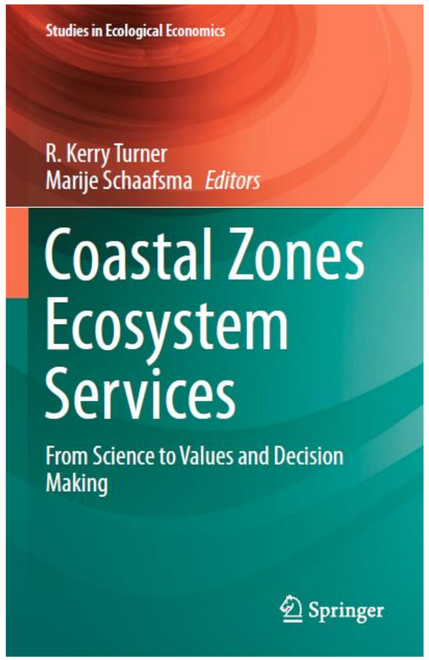
Typology of Marine Connectivity, Coherence and Equivalence
A.In natural sciences - Physico-chemical connectivity; Ecological connectivity; nature conservation coherence, equivalence and connectivity.
B.In socio-economy - societal connectivity and equivalence; cultural connectivity and equivalence; economic connectivity, equivalence and coherence; sectoral connectivity, coherence and equivalence.
C.In marine management - connectivity of human activity-, pressures- and effects-footprints and equivalence of management response-footprints; equivalence, connectivity and coherence of monitoring, assessment and reporting.
D.In marine governance - administrative equivalence; legislative equivalence; coherence and equivalence of Maritime Spatial Planning (MSP) and Marine Protected Areas (MPA)-designation; this includes equivalence of internationally-adopted principles.

(Elliott, Borja & Cormier, 2023 OCMA)

(Estuarine examples of connectivity in Elliott & Whitfield ECSS 2025)

Ecosystem Services – Historical Frameworks





- Millennium Ecosystem Assessment (MA, 2005):
  - **Provisioning services** are the products obtained from the ecosystem;
  - **Regulating services** are the benefits obtained from the regulation of ecosystem processes;
  - **Cultural services** are the nonmaterial benefits people obtain from ecosystems; and
  - **Supporting services** are those that are necessary for the production of all other ecosystem services, but do not yield direct benefits to humans.

(but this relates to societal goods and benefits)

(but this relates to normal ecosystem functioning)

(but 'nature' doesn't know 'culture')

(but this relates to normal ecosystem functioning)

Confusion by mixing ecosystem services and societal goods and benefits!

(Elliott 2023 Mar. Poll. Bull.)

MARINE ENVIRONMENT

NATURAL DOMAIN

Natural Capital

Ecosystem features that are internally and externally regulated, supported and provided, and which can be valued in ecological terms:

- Ecosystem structure (stocks): *e.g. marine habitats, species, biodiversity*
- Ecosystem functioning (flows): *e.g. primary production; gamete and larval supply; water and nutrient cycling; formation of physiography, habitats, conductivity and barriers; physico-chemical and biological controls; carbon flows and storage*

Ecosystem Services

The components and products (stocks) and functions (flows) provided by nature with a capacity and potential to be societal goods and benefits:

- Provisioning aspects (i.e. materials and structures provided by a fully-functioning marine ecosystem): *e.g. vertebrates, invertebrates, macrophytes; genetic resources; water and minerals; places and seascapes*
- Regulating processes: *e.g. climate regulation; natural hazard protection; waste breakdown and detoxification*

HUMAN DOMAIN

Inputting Complementary Capital and Human Assets (Activities)

The introduction of time, money, energy, skills and knowledge and the ability of being sentient as necessary to release the societal goods and benefits

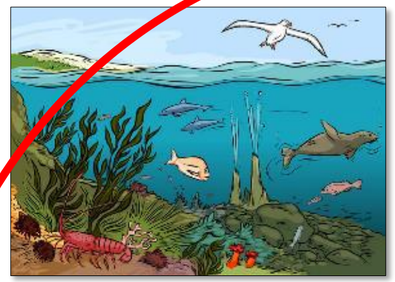
From Ecosystem Service flows to Societal Benefits flows

Societal Goods and Benefits (well-being and the fulfilment of basic human needs)

(to be valued in monetary/non-monetary, material/non-material and/or tangible/non-tangible terms)

- Extracted provisions: *e.g. wild, gathered and farmed food and fish feed; fertilisers, energy as fuel and biofuels; medicines and biotechnology*
- Environmental regulation, hazard and risk reduction including safety: *e.g. suitable climate, sea defences and erosion protection; waste burial, removal and neutralization*
- Cultural, aesthetic and health benefits (interaction provisions): *e.g. tourism, ecotourism and recreation; ornaments and aquaria; spiritual well-being and satisfaction; education and research*

Ecosystem services are the link between ecosystems and the goods and benefits that they provide for society



Marine Ecosystem Structure and Functioning (Stocks & Processes)

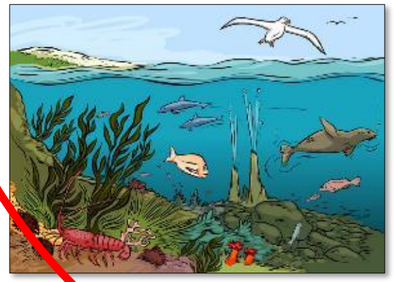
Ecological valuation

Ecosystem Services (Flows)

Input of Human Capital*

Societal Goods & Benefits (Well-being)

Socio-economic valuation



Socio-ecological valuation

"Grab them by the 'wallet' and their hearts and minds will follow!"

(* Human complementary assets – time, money, skills, energy required to obtain the goods and benefits, being sentient)

Evidence Needs - Recipe Leading to Integrated Marine Management

- Need to understand how our activities lead to which pressures
- Need to understand which pressures are within and outside our control
- Need to understand ecological structure and functioning
- Need to understand what state changes on the natural system occur from those pressures (effects-footprints)
- Lead to describing the impact on human welfare as effects on Ecosystem services and Societal goods and benefits
- Lead to defining the appropriate responses as management measures
- Require implementation of governance (policies, politics, administration and legislation)
- Within a multiuser system requiring resolution of conflicts amongst users
- Communicate by working with stakeholders

Bringing it all together – Systems Analysis Approaches, Decision Support Systems, Estuarine Planning Support Systems

- A Systems Analysis Approach (SAA) is needed to bring all the elements together for a logical and structured approach to study, assessment and management
- A Decision Support System (DSS) is needed to enable managers to cost-effectively decide solutions and to check if solutions are effective
- An Estuarine Planning Support System (EPSS) is a framework that defines a clear planning or management process and the tools available to support the process
- These all take into account the different disciplines to ensure the management of a system is holistic and encompass all the relevant stakeholder views
- The approaches and tools should be applicable to all environmental systems

MARINE SABRES

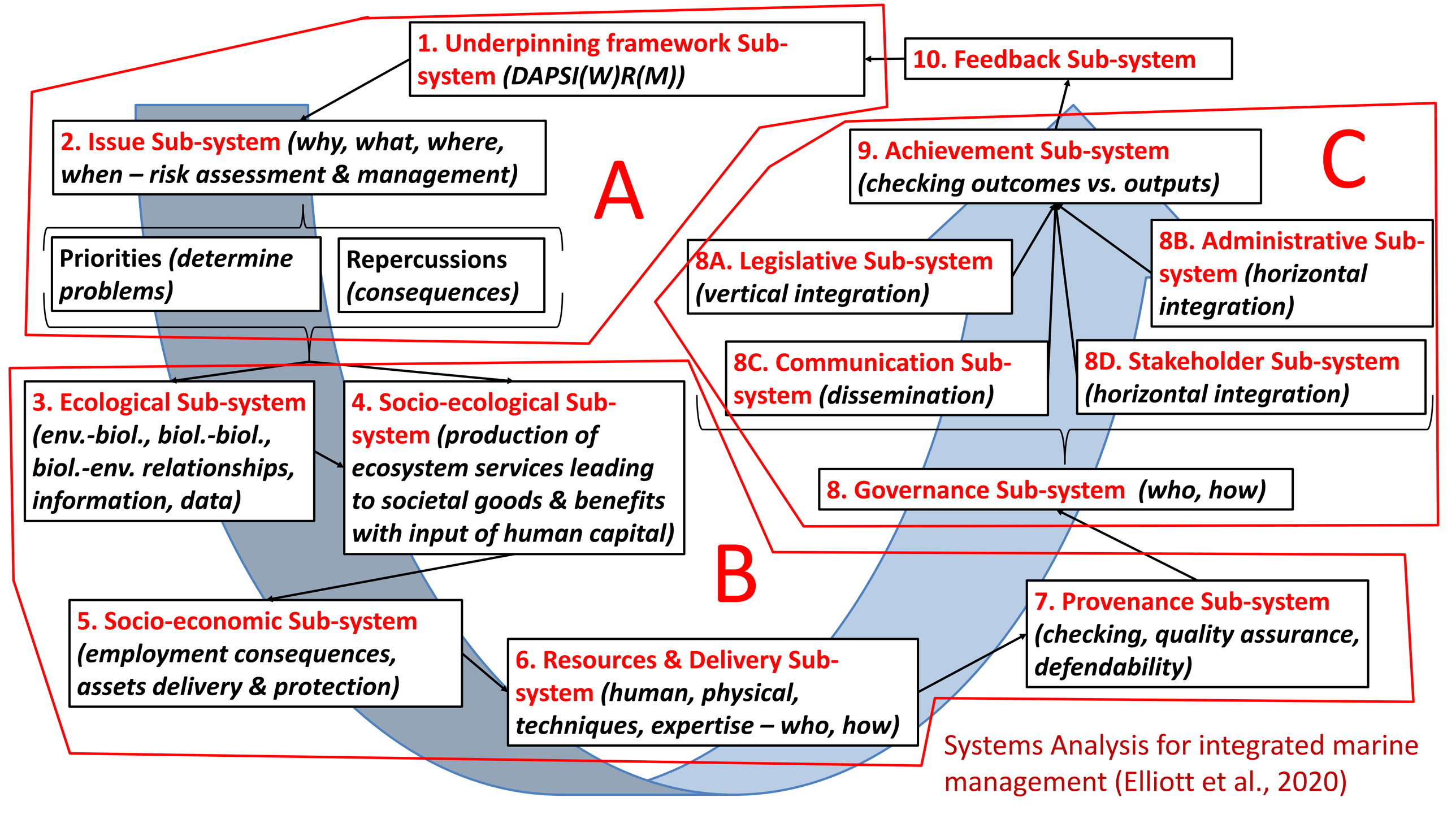
Bringing it all together - Managing marine resources sustainably: a proposed integrated systems analysis approach

A. Setting priorities, visions and issues: need for information for and from habitats, species, human activities ….

B. Getting and ensuring the provenance of the information: natural and social scientists need to obtain environmental information, using monitoring and laboratory methods

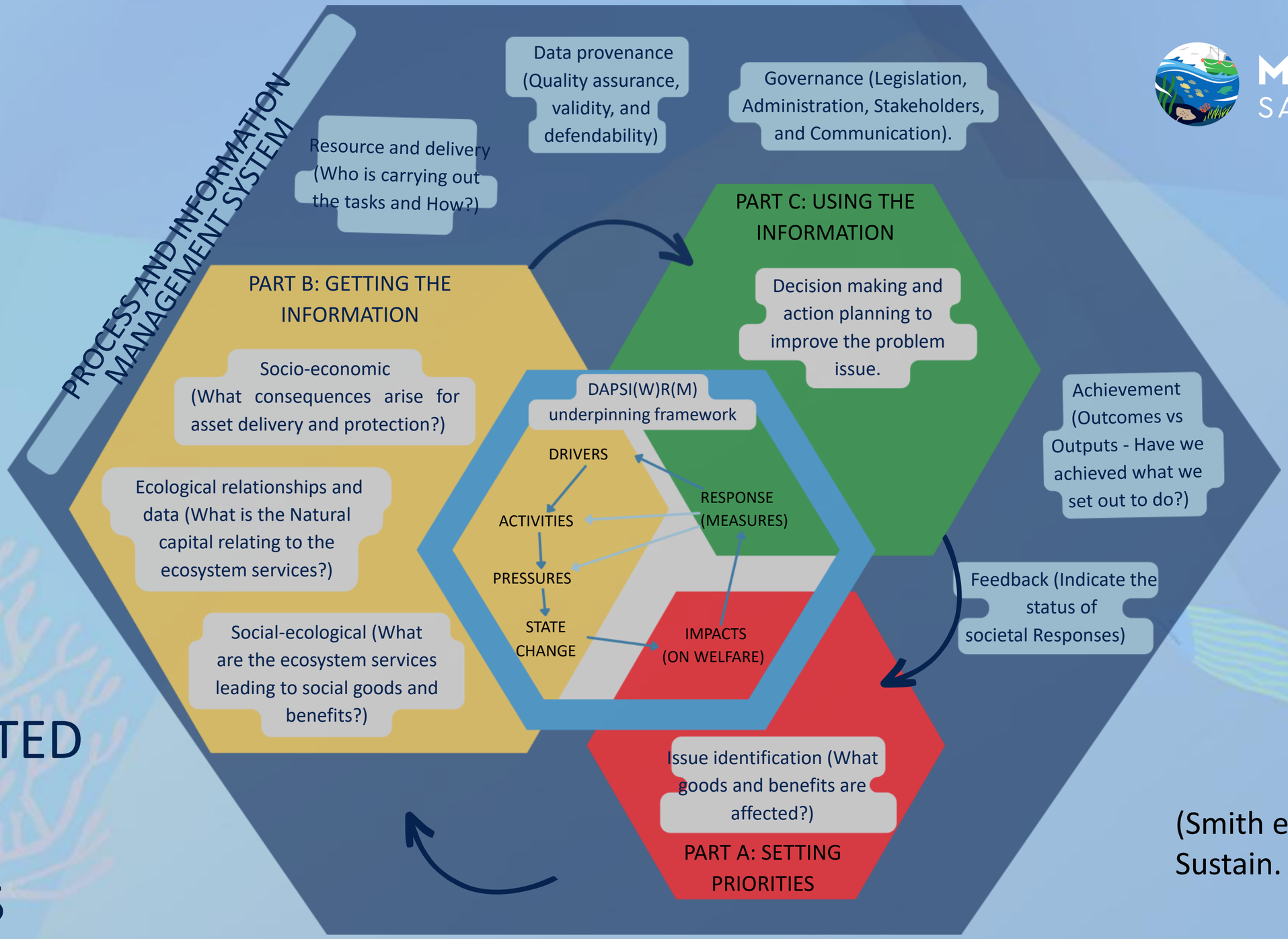
C. Using the information: governance and management imperatives, stakeholder meetings and consultation

(Elliott, Borja & Cormier 2020 Ocean & Coastal Management; basis for Smith et al., 2025 Sustain. Futures)



Systems Analysis for integrated marine management (Elliott et al., 2020)

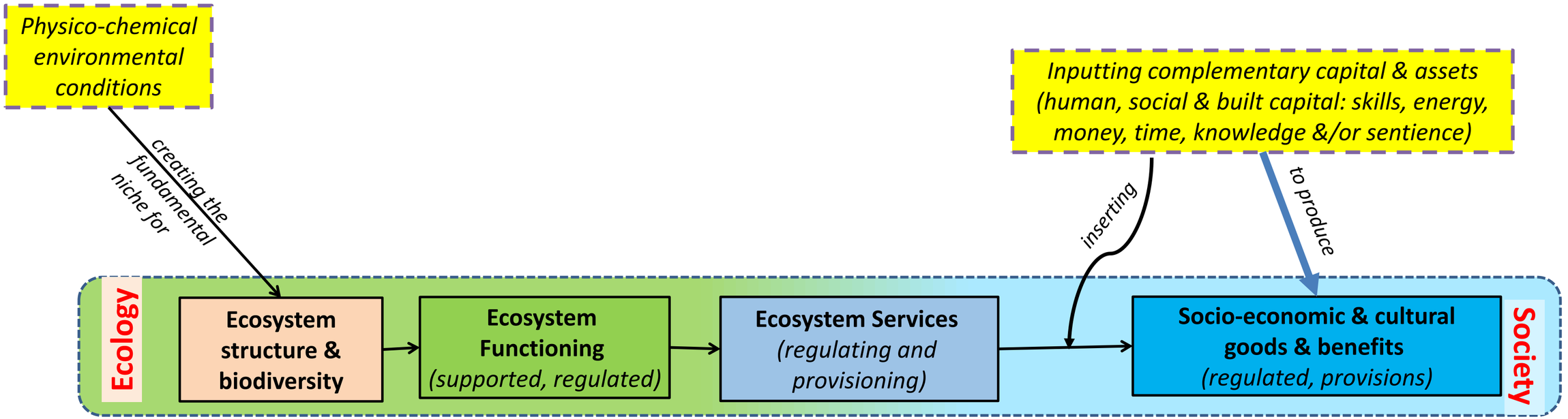
THE INTEGRATED SYSTEMS ANALYSIS



(Smith et al., 2025 Sustain. Futures)

(Elliott 2023 Mar Poll Bull)

Elliott, M. (2023). https://doi.org/10.1016/j.marpolbul.2023.115177



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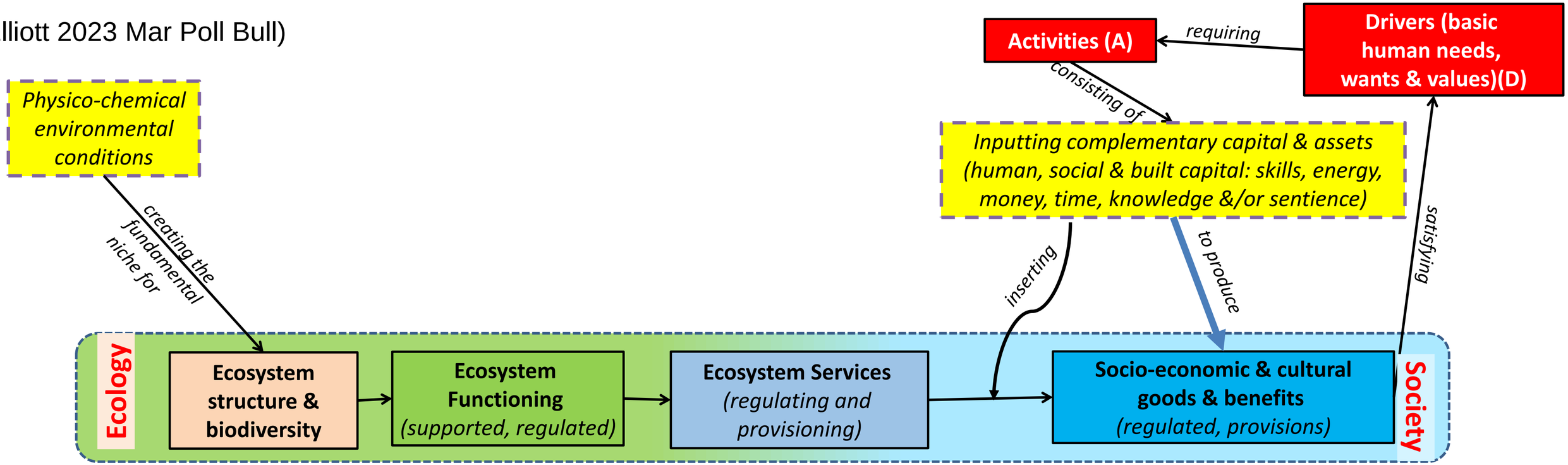
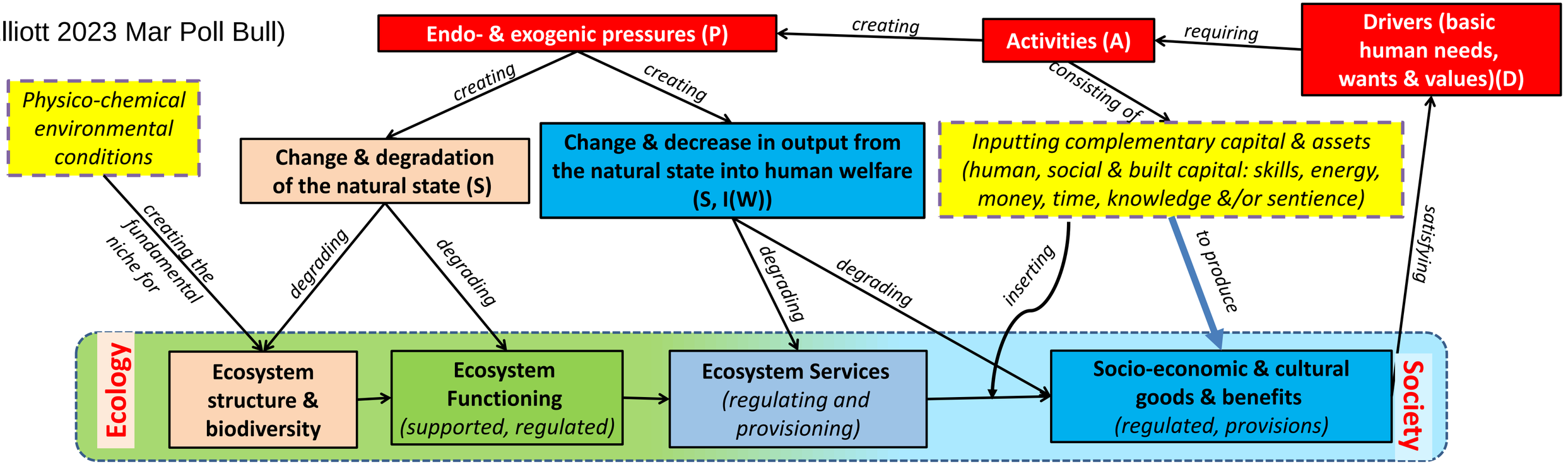
Editorial

Marine Ecosystem Services and Integrated Management: "*There's a crack, a crack in everything, that's how the light gets in*"!

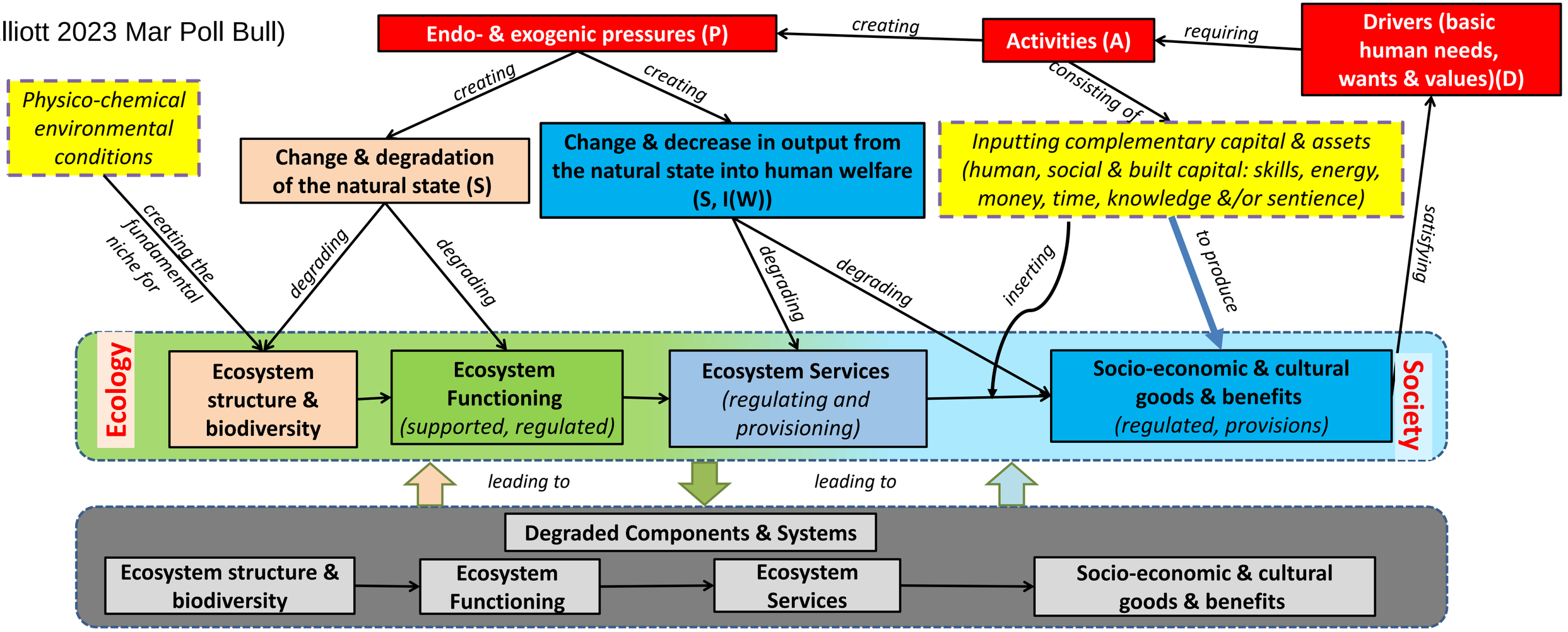
(Elliott 2023 Mar Poll Bull)

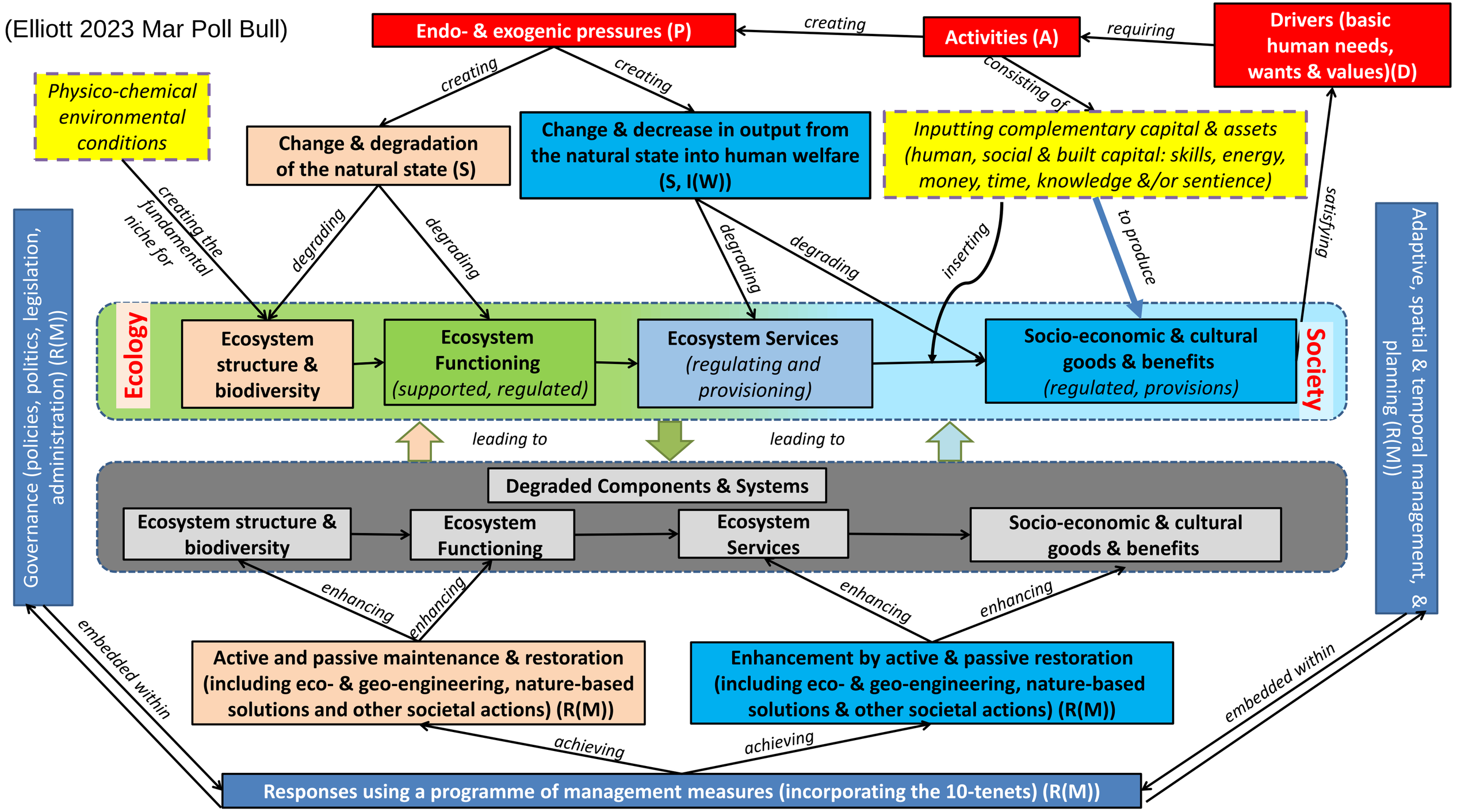


(Elliott 2023 Mar Poll Bull)



(Elliott 2023 Mar Poll Bull)




(Elliott 2023 Mar Poll Bull)
Endo- & exogenic pressures (P)
creating
Activities (A)
requiring
Drivers (basic human needs, wants & values)(D)
creating
creating
consisting of
Physico-chemical environmental conditions
Change & degradation of the natural state (S)
Change & decrease in output from the natural state into human welfare (S, I(W))
Inputting complementary capital & assets (human, social & built capital: skills, energy, money, time, knowledge &/or sentience)
creating the fundamental niche for
degrading
degrading
degrading
degrading
inserting
to produce
satisfying
Governance (policies, politics, legislation, administration) (R(M))
Ecology
Ecosystem structure & biodiversity
Ecosystem Functioning (supported, regulated)
Ecosystem Services (regulating and provisioning)
Socio-economic & cultural goods & benefits (regulated, provisions)
Society
Adaptive, spatial & temporal management, & planning (R(M))
leading to
leading to
Degraded Components & Systems
Ecosystem structure & biodiversity
Ecosystem Functioning
Ecosystem Services
Socio-economic & cultural goods & benefits
enhancing
enhancing
enhancing
enhancing
embedded within
Active and passive maintenance & restoration (including eco- & geo-engineering, nature-based solutions and other societal actions) (R(M))
Enhancement by active & passive restoration (including eco- & geo-engineering, nature-based solutions & other societal actions) (R(M))
embedded within
achieving
achieving
Responses using a programme of management measures (incorporating the 10-tenets) (R(M))

Lessons for measuring success in marine management (I):

- Need long-term monitoring networks, covering multiple ecosystem components, provide adequate knowledge to take informed management decisions to restore marine systems;
- Monitoring is not a management measure *per se* but is needed to show *a priori* what management is required and *a posteriori* whether the management actions were successful.
- Success of management may take many years to show given the lag-time between management actions, inertia in the system & the resulting change in structure and function;
- Management success can be measured in the creation or restoration of ecosystem services and societal benefits but there needs to be more cost-benefit assessments of the latter;

(From Elliott, Borja & Cormier, OCMA 2025)

Lessons for measuring success in marine management (II):

- Resorting to legal proceedings as the result of an activity not meeting an issued licence, authorisation or permit (i.e. non-compliance by a company) can be regarded as a failure of management; the success of management is based on the effectiveness and efficiency of the management led by the person that is delegated as the competent authority;
- Finance-based environmental and operational management may deliver economic benefits/sustainability for an industry or developer and, in economically-difficult times, may be allowed by regulators to the exclusion of environmental sustainability;
- Success in management should be measured against a well- and clearly-defined outcome, e.g. the achieving of a vision, aims and objectives, rather than outputs (amount of reports, samples, data);
- Satisfying the wishes of all stakeholders, including the public, will be the sign of successful management but perhaps it is not possible to satisfy all stakeholders so may require a political decision to allow an activity to proceed despite potential adverse environmental effects (i.e. IROPI);

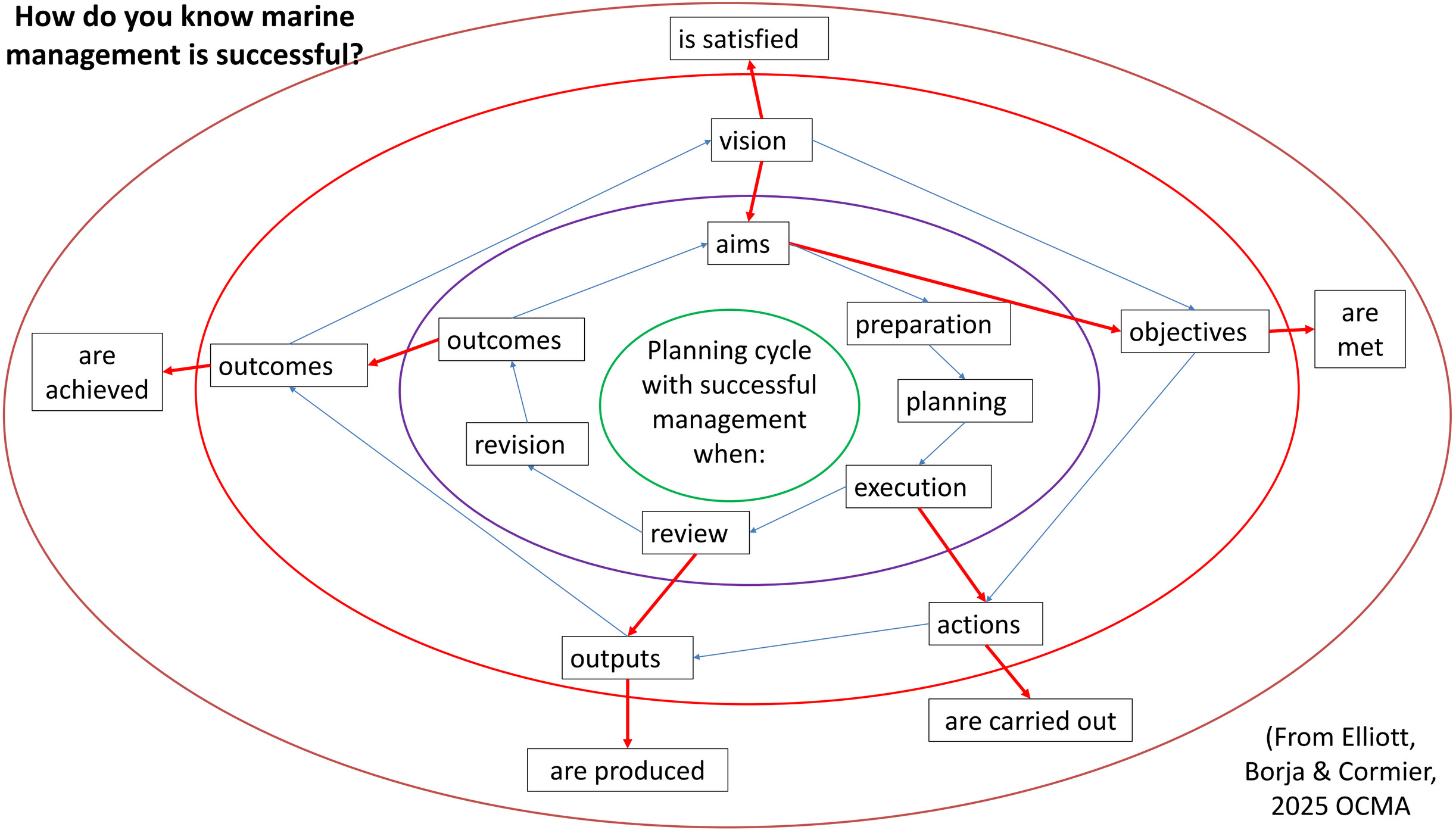
(From Elliott, Borja & Cormier, OCMA 2025)

Lessons for measuring success in marine management (III):

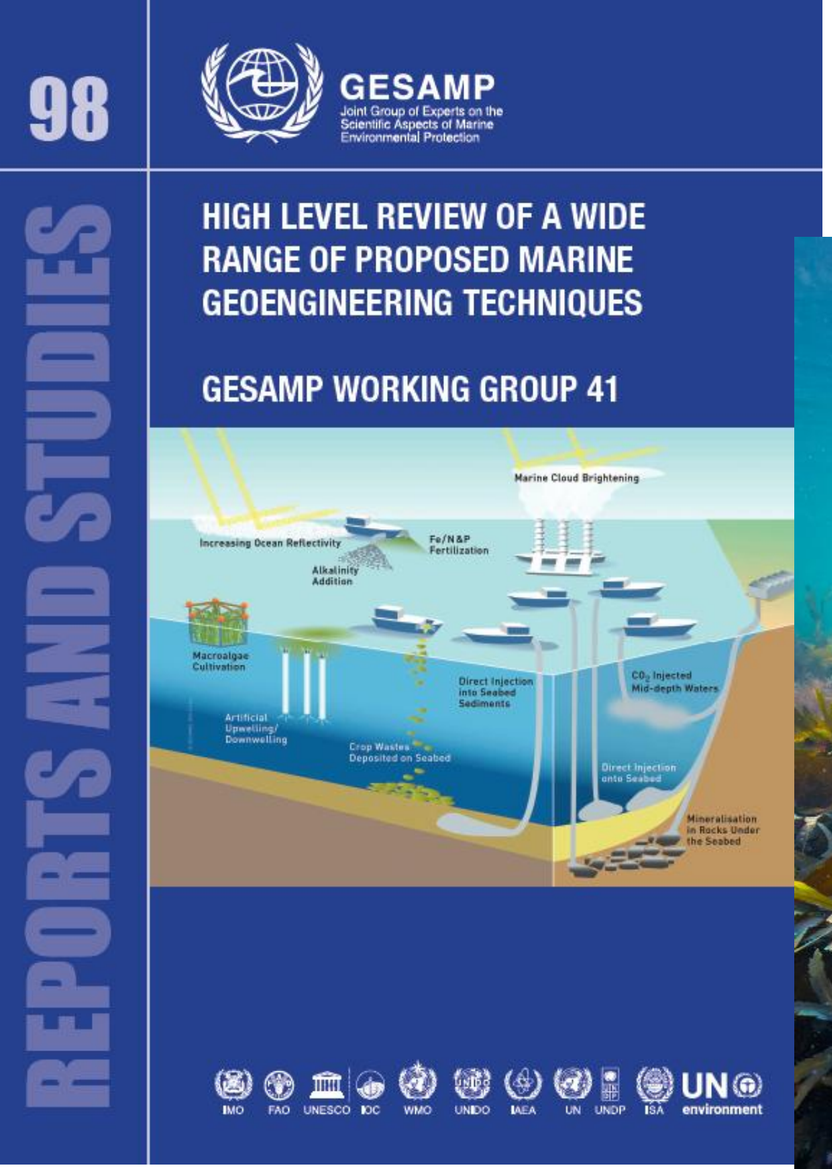
- Success in management can be summarised as a well-defined planning cycle with a vision achieved *leading to* objectives met *leading to* actions carried out *leading to* outputs produced *leading to* outcomes achieved;
- Success in management needs to take a holistic view of sustainability and governance including interdisciplinary and transdisciplinary approaches and views, the use of the 10-tenets/PESTLE, the promotion of ocean literacy, to make citizens aware of the problems and the possibility of solutions, as well as to take management informed decisions;
- Marine management can encompass the marine environment as an organisation requiring a systems approach and the same methods of risk and opportunity assessment and management as any other organisation.
- The success of effective marine management will require that ocean literacy and the large number of national, regional and global marine initiatives should be shown to have an impact.

(From Elliott, Borja & Cormier, OCMA 2025)

How do you know marine management is successful?



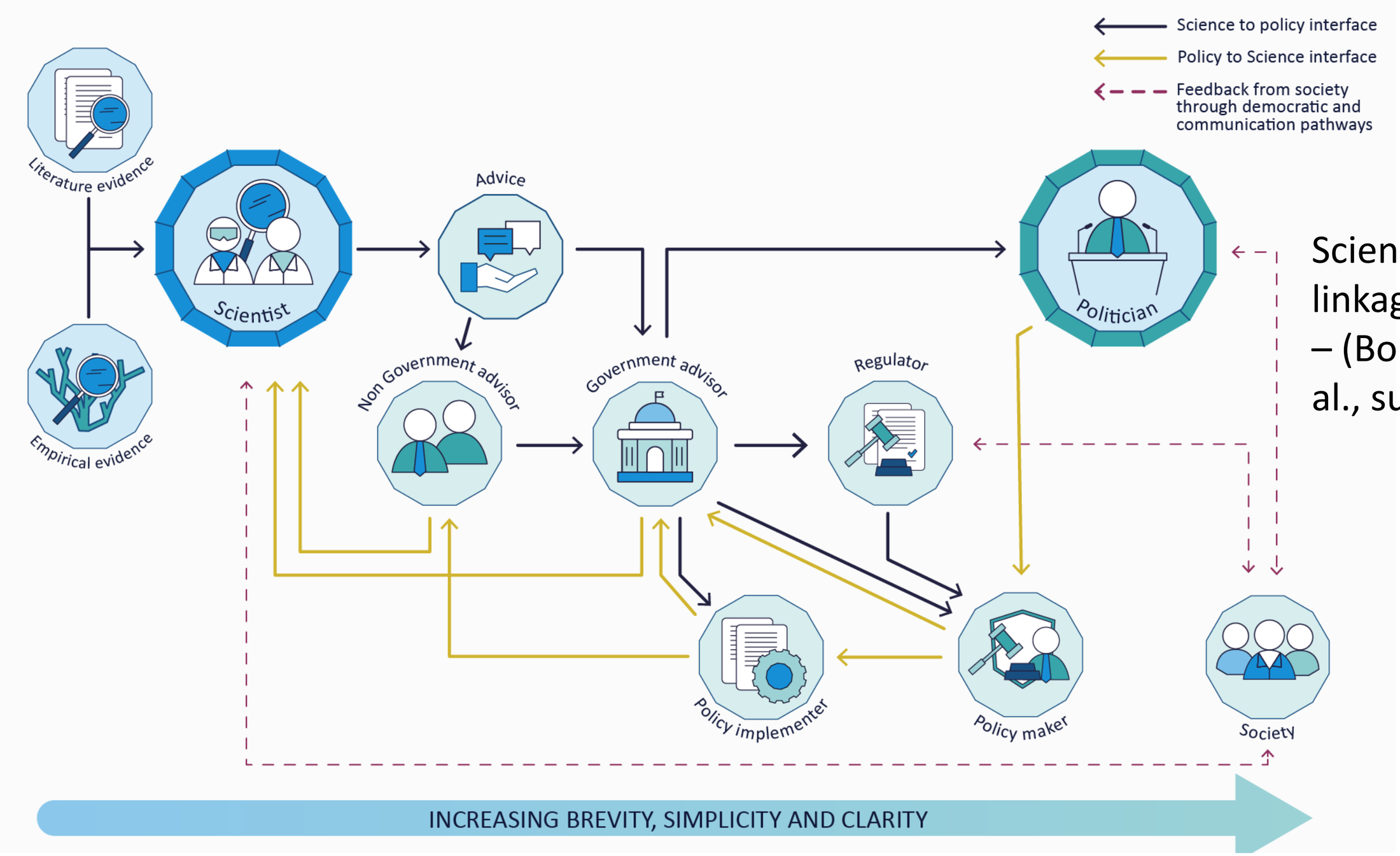
(From Elliott, Borja & Cormier, 2025 OCMA



- A question of scale – geoengineering techniques for ocean climate change adaptation – an example of globally-relevant restoration?

- GESAMP WG41

GESAMP. 2025. *The State of the Science for Marine Carbon Dioxide Removal (mCDR) – A Scientific Summary for Policy-Makers*. Paris, UNESCO-IOC. (IOC Technical Series, 209) https://doi.org/10.5281/zenodo.15490407



Science-policy linkages and roles – (Borja, Elliott et al., submitted)

Tackling the challenges – needs for measuring and managing change:

- Start off with SMART objectives (EBA-EBM-EBMT)
- Base management on good science
- Quantify the four footprints and ROAM framework
- Emphasise that the system functions because of connect across all fields
- Collect data to use and use data collected
- Determine if management is working
- Have solid underpinning concepts and tools
- Use ecological, socio-ecological and socio-economic valuation
- Harmonise the governance (policies, politics, administration and legislation
- Use systems analysis and SES and know measure of success

"I suppose I'll be the one to mention the elephant in the room."

"How come it's always the old, bald-headed guy with glasses in cartoons?"

- ***Focus on the global primary activity footprint for causes to climate change and the response activity footprint for the consequences***

Thank you!

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HorizonEurope Projects:

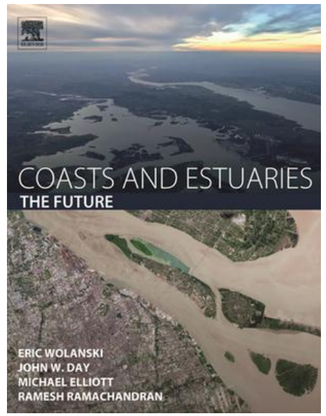
GES4SEAS (led by AZTI, Spain)

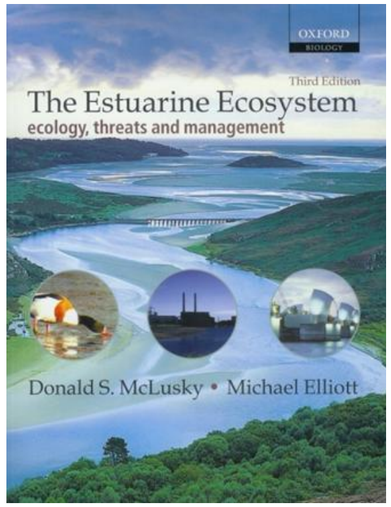
MarinePlan (led by TI, Germany)

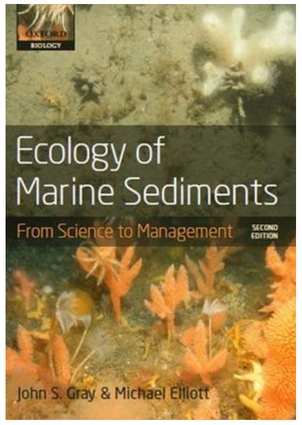
MarineSABRES (led by UCC, Ireland)

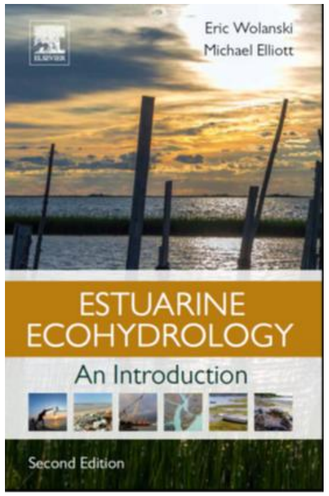
MARBEFES (led by IOPAN, Poland)

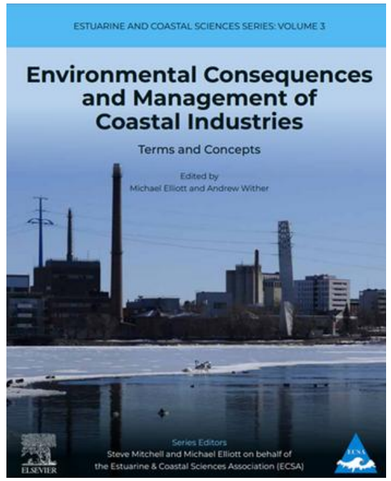
GuardIAS (led by UAegean, Greece)

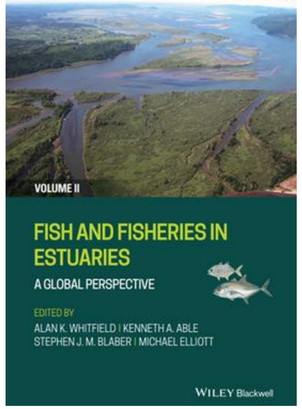


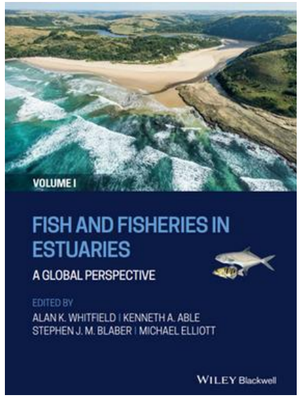


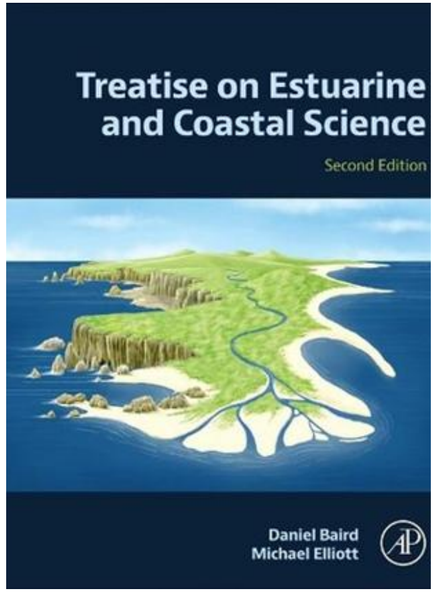












7 volumes – (March 2024)