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International Estuarine and Coastal Specialists IECS

https://www.iecs.ltd

Unbounded boundaries and moving baselines: Estuaries and coastal seas in a rapidly changing world.

Michael Elliott[1,2]

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[2] Emeritus Professor, School of Environmental Sciences, University of Hull, Hull HU6 7RX, UK

GES4 SEAS

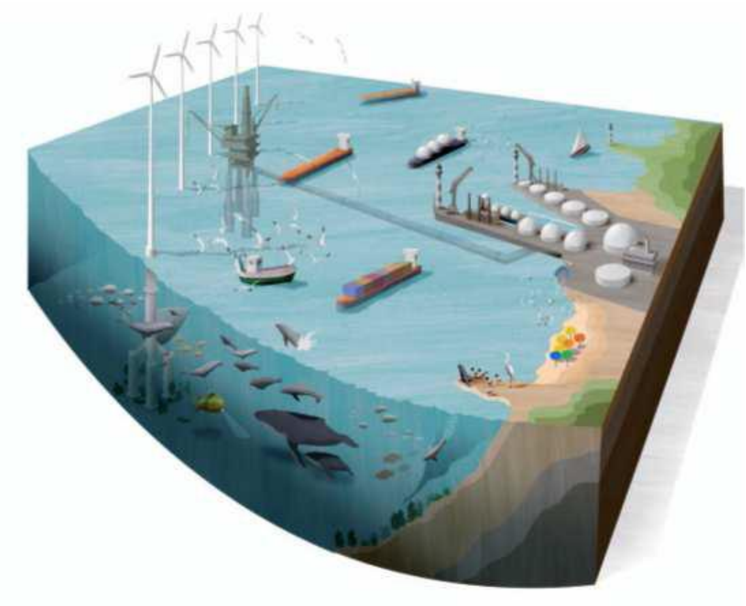
MARINE SABRES

MarinePlan

MARBEFES

UKRI

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:

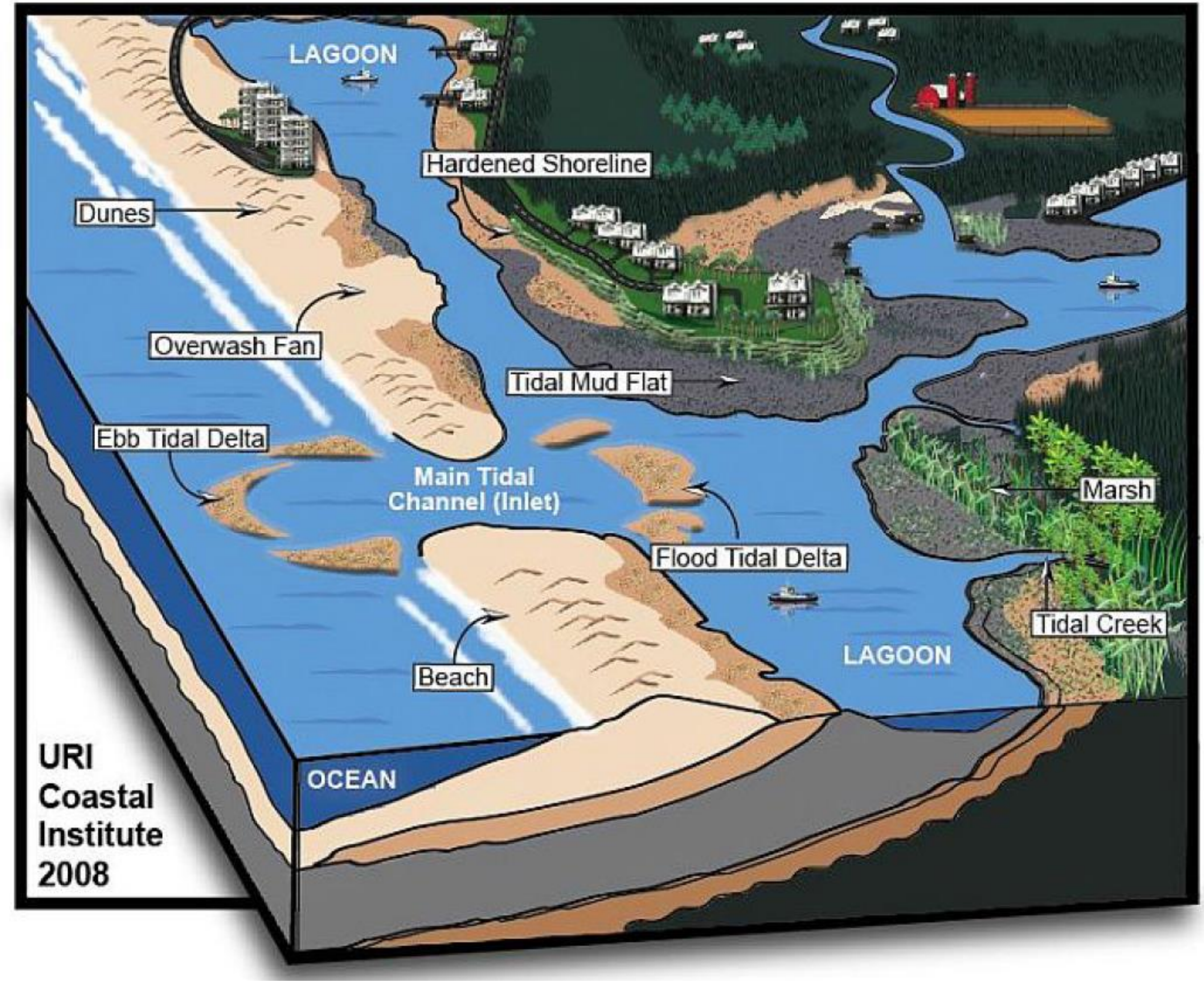
"to look after the natural stuff and deliver the human stuff"

Unbounded Boundaries:

- The concept of difficulties in defining the geographical (spatial and temporal) boundaries of the transitional waters and the definitions of structural and functional change due to external and internal influences.
- Many physico-chemical and ecological components in TraC waters are influenced by features inside the catchments and at sea.
- Areas may fail Directives through external factors beyond their control (force majeure).

Moving Baselines:

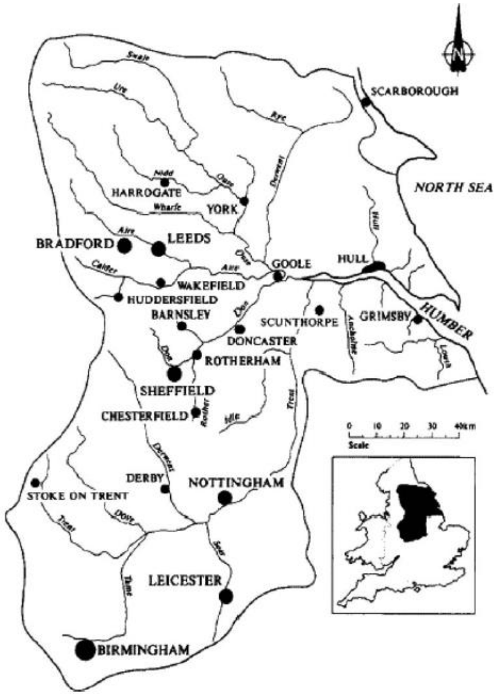
- Change has to be measured against agreed indicators, reference conditions, thresholds and trigger points.
- Change (a ‘signal’) has to be measured against the inherent spatial and temporal variability (‘noise’).
- Climate change is both increasing that ‘noise’ and moving those baselines.

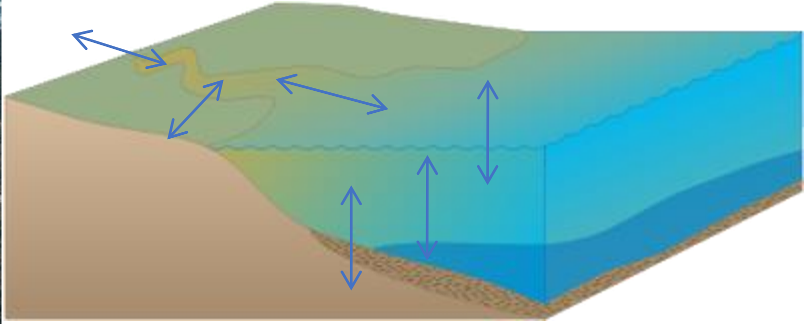


Antony et al., 2009, Ecol. & Society

Estuaries - Definitions, Scales, Ecotones and Linkages

- Paradigm 1: *An estuary is an ecosystem in its own right but cannot function indefinitely on its own in isolation and that it depends largely on other ecosystems, possibly more so than do other ecosystems.*
- Paradigm 2: *As ecosystems, estuaries are more influenced by scale than any other aquatic system; their essence is in the connectivity across the various scales and within the water body they are characterised by one or more ecotones (⟷).*





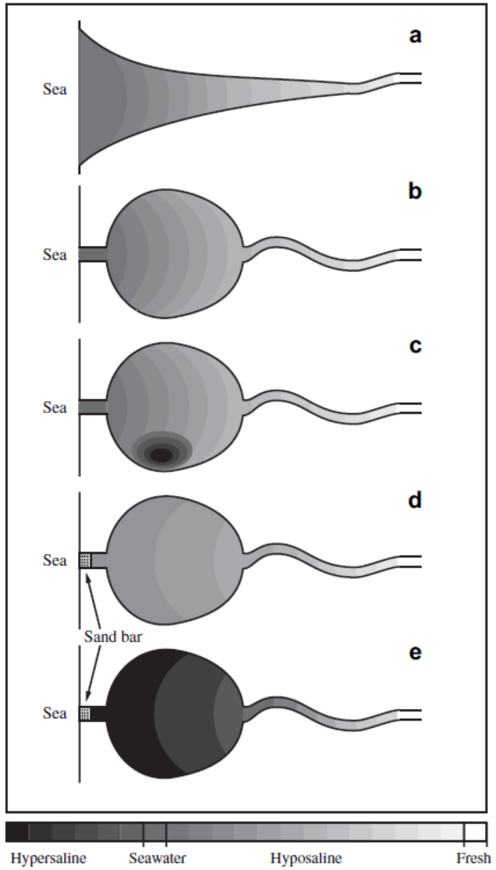
Estuarine, Coastal and Shelf Science 94 (2011) 306–314
Contents lists available at ScienceDirect
Estuarine, Coastal and Shelf Science
journal homepage: www.elsevier.com/locate/ecss

Challenging paradigms in estuarine ecology and management

M. Elliott [a,*], A.K. Whitfield [b]

Hydromorphological and Organic Functioning

- Paradigm 3: *Hydromorphology is the key to understanding estuarine functioning but these systems are always influenced by salinity (and the resulting density/buoyancy currents) as a primary environmental driver.*
- Paradigm 4: *Although estuaries behave as sources and sinks for nutrients and organic matter, in most systems allochthonous organic inputs dominate over autochthonous organic production.*



Nutrient loadings to the Humber Estuary (full calculations given in Elliott and Boyes, 2002)

Total inputs to the Humber Estuary	Total N—2001		Total P—2001	
	$t\ yr^{-1}$	%	$t\ yr^{-1}$	%
Industry	510	0.46	3	0.03
Sewage—STWs	36,562	33.31	6925	65.05
Sewage—CSOs	2871	2.62	767	7.21
Natural vegetation	96	0.09	24	0.23
Diffuse sources (runoff from agricultural land around the estuary) (based on 1988 data)	69,740	63.53	2926	27.49
	109,779	100	10,646	100

STW—sewage treatment works; CSO—combined sewer overflows.

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Available online at www.sciencedirect.com
SCIENCE DIRECT
Marine Pollution Bulletin 53 (2006) 136–143
MARINE POLLUTION BULLETIN
www.elsevier.com/locate/marpolbul

Organic matter and nutrient inputs to the Humber Estuary, England

Suzanne Boyes *, Michael Elliott

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Contents lists available at ScienceDirect
Estuarine, Coastal and Shelf Science
journal homepage: www.elsevier.com/locate/ecss

Short communication

The concept of an estuary: A definition that incorporates systems which can become closed to the ocean and hypersaline

Ian C. Potter [a,*], Benjamin M. Chuwen [a], Steeg D. Hoeksema [a], Michael Elliott [b]

Variability, Resilience and Redundancy

- Paradigm 5: *Estuaries are physico-chemically more variable than other aquatic systems but estuarine communities are less diverse taxonomically and the individuals are more physiologically adapted to environmental variability than equivalent organisms in other aquatic systems.*

Diversity, Tolerances, Stress, Productivity

- Paradigm 6: *Estuaries are systems with low diversity/high biomass/high abundance and their ecological components show a diversity minimum in the oligohaline region which can be explained by the stress-subsidy concept where tolerant organisms thrive but non-tolerant organisms are absent* (*cf*. Estuarine Quality Paradox)

Pressures, Valuing, Valuation and Management

- Paradigm 7: *Estuaries have more human-induced pressures than other systems and these include both exogenic unmanaged pressures and endogenic managed pressures. Consequently their management has to not only accommodate the causes and consequences of pressures within the system but, more than other ecosystems, they need to respond to the consequences of external natural and anthropogenic influences.*

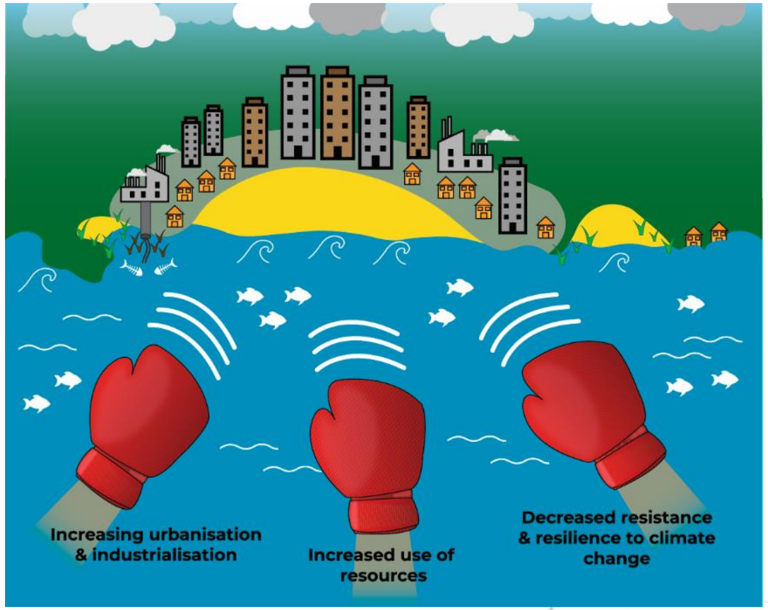
What are we managing? - Hazards, risks and their prevention, from single activities to whole areas

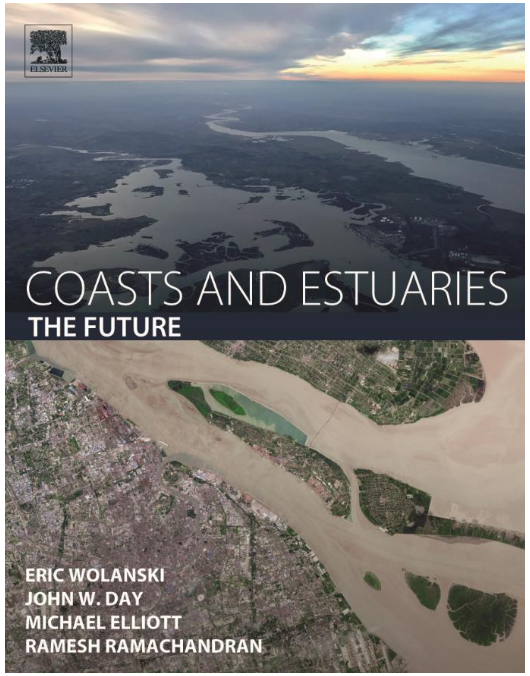
Exogenic unmanaged pressures ***(where the consequences are managed in the management area but the causes require global action)***	**Endogenic managed pressures** ***(where the causes and consequences are managed within the management area)***
Alien species Sea level rise (or loss?) Increased temperature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

Contents lists available at ScienceDirect

Marine Pollution Bulletin

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

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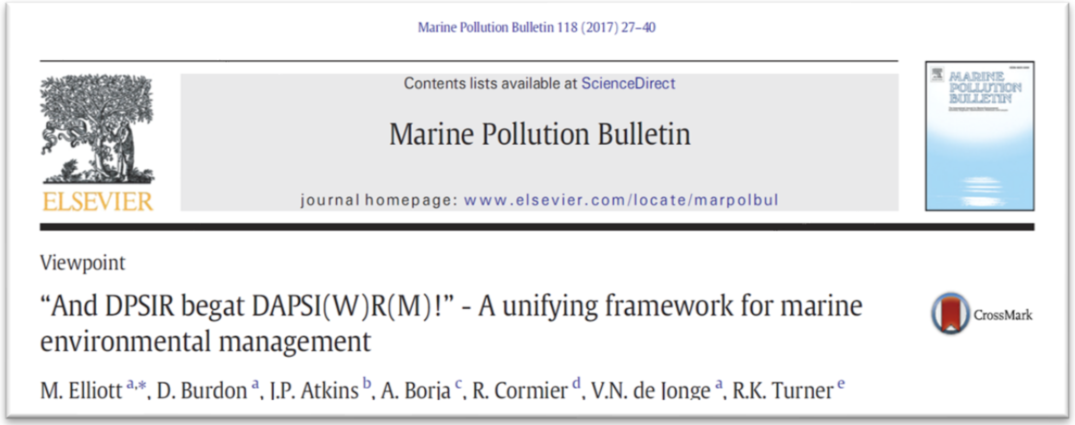
Editorial

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

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

DAPSI(W)R(M) framework


Marine Pollution Bulletin 118 (2017) 27–40

Contents lists available at ScienceDirect

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)

Pronounced “dapsiworm”!

(for each EnMP cf. Ex

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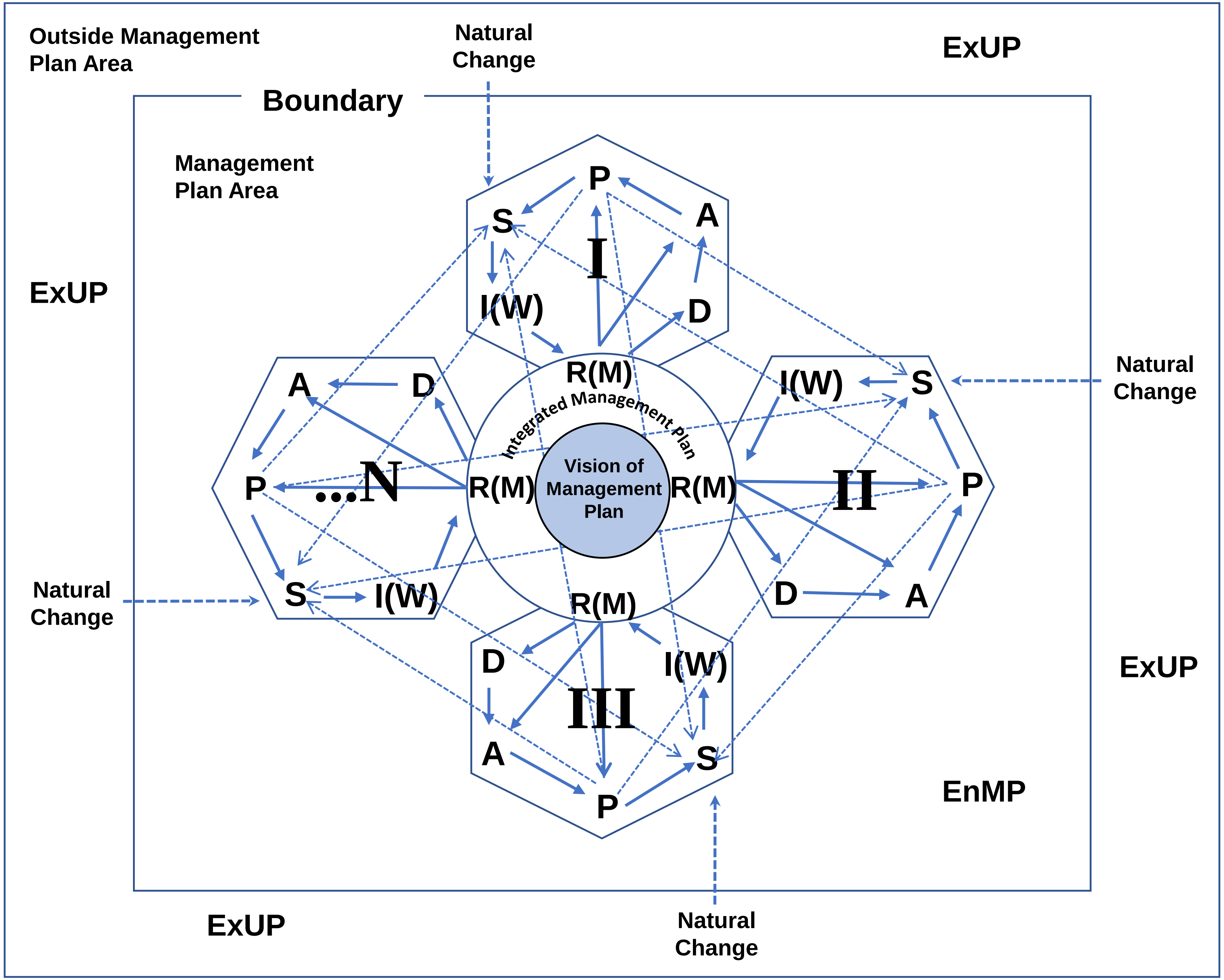
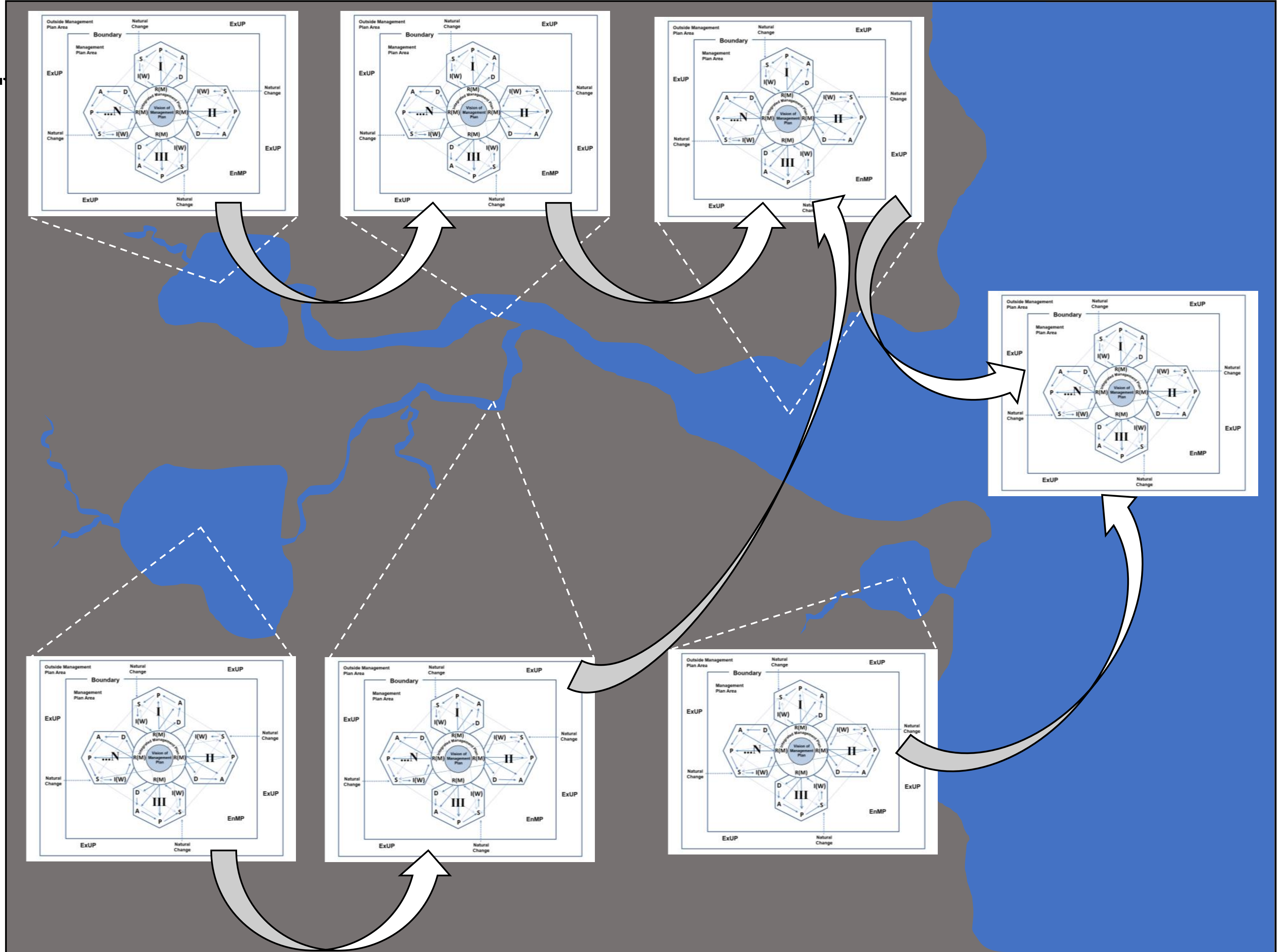
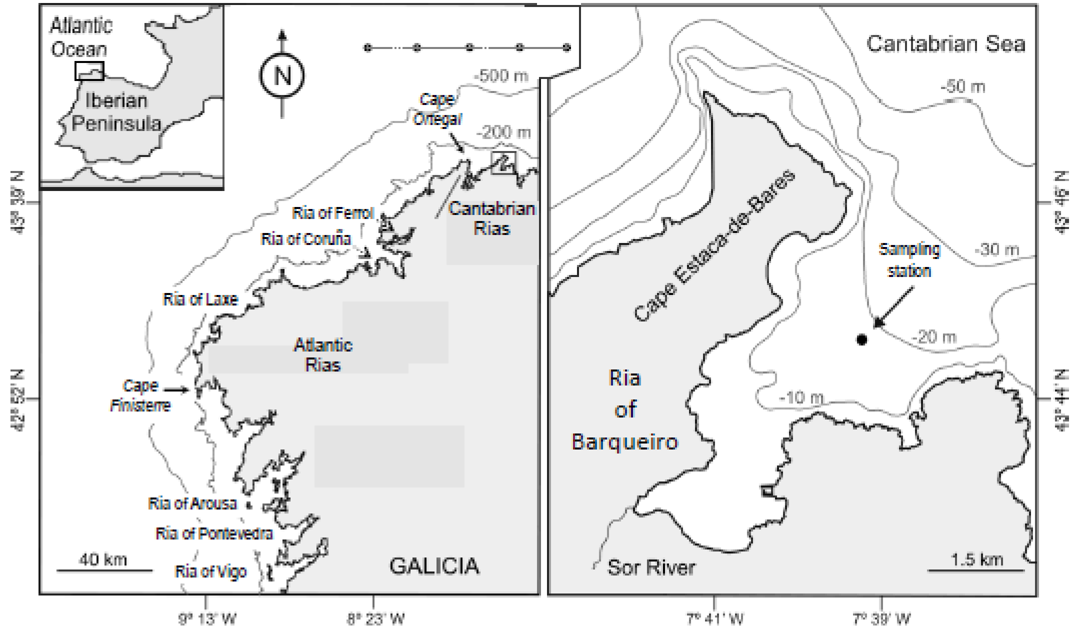


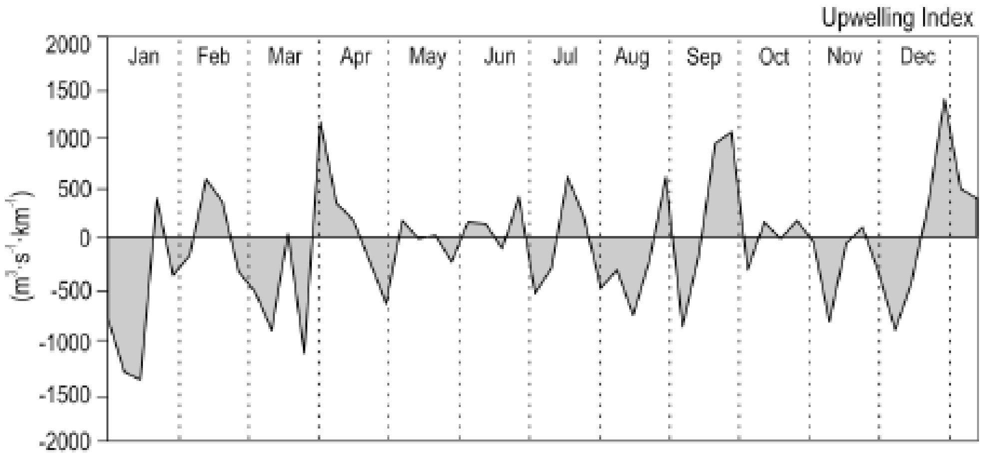

Outside Management Plan Area
Natural Change
ExUP
Boundary
Management Plan Area
EnMP
Vision of Management Plan
Integrated Management Plan
I
II
III
...N
R(M)
I(W)
P
A
D
S

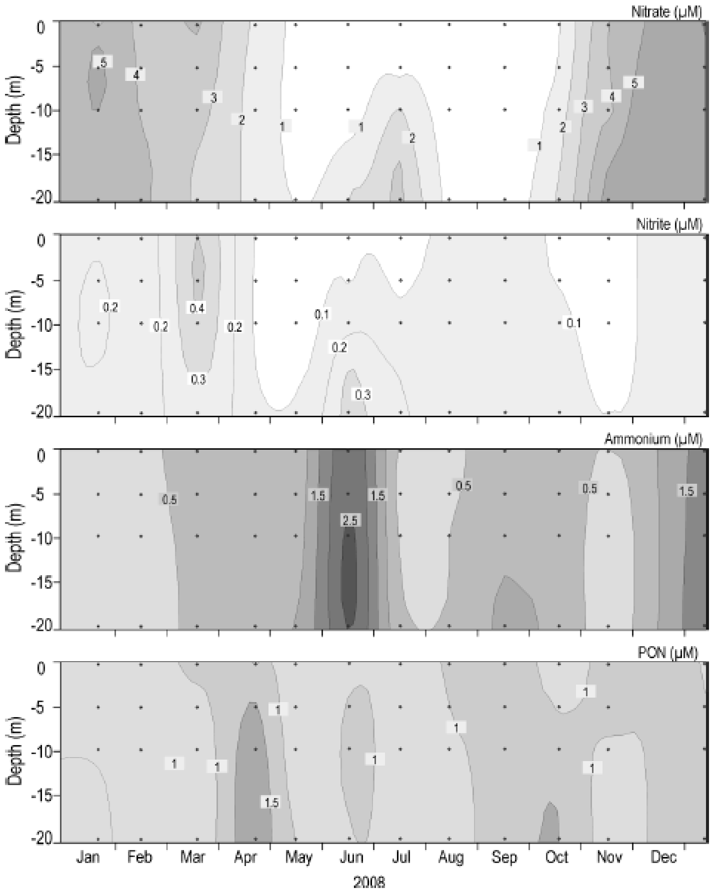
Unbounded boundaries - examples

- salinity regimes dependent on catchments,
- nutrient balances dependent on climatic forcing,
- hypernutrification dependent on upwelling events
- wading bird populations dependent on polar and tropical conditions
- diadromous fish populations dependent on the catchment
- catadromous fishes dependent on oceanic areas such as breeding in the Sargasso Sea
- anadromous fishes growing in the high Arctic
- species presence and ballast waters

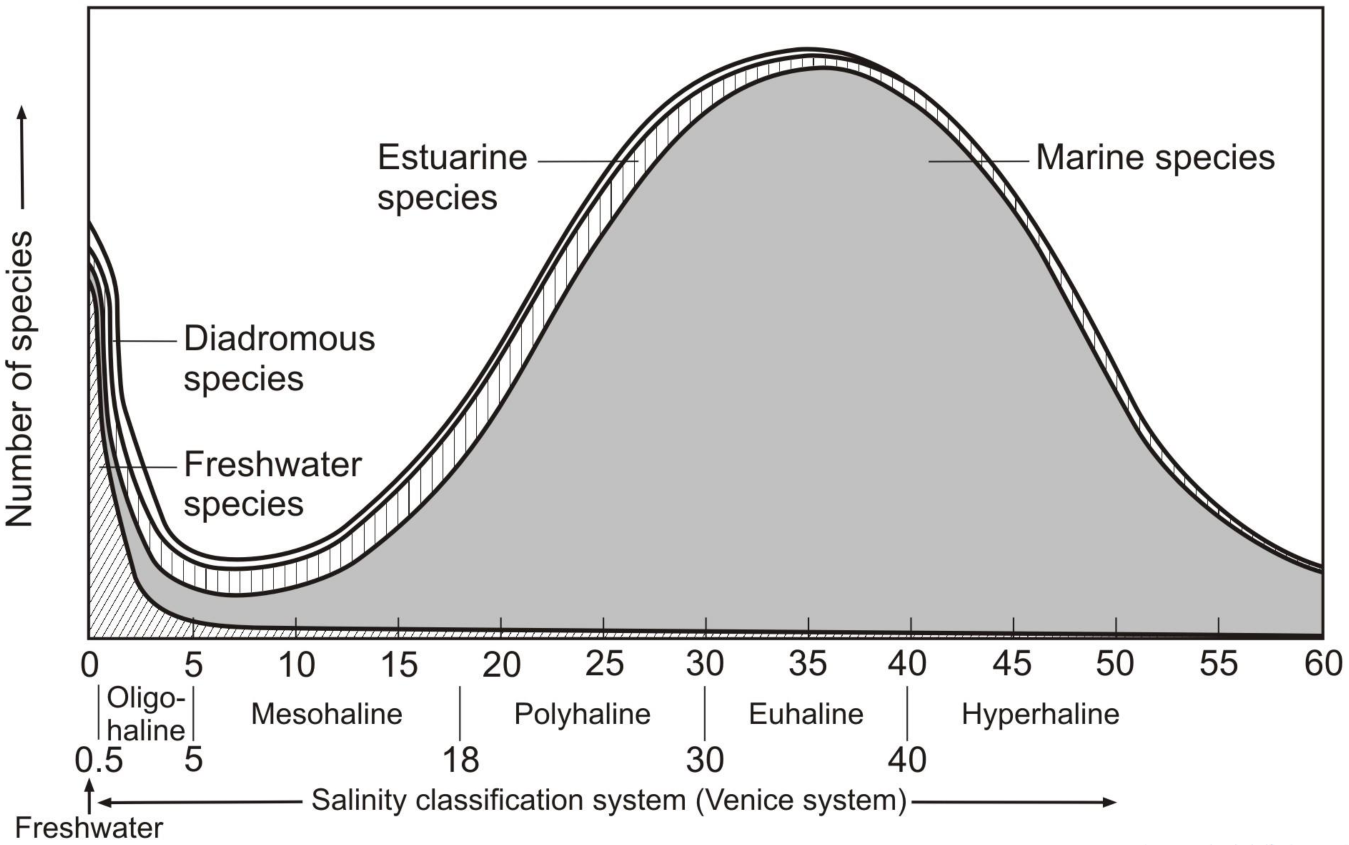
Exogenic unmanaged pressures – coastal upwelling events (e.g. Galician ria eutrophication – effects of external nutrient inputs)



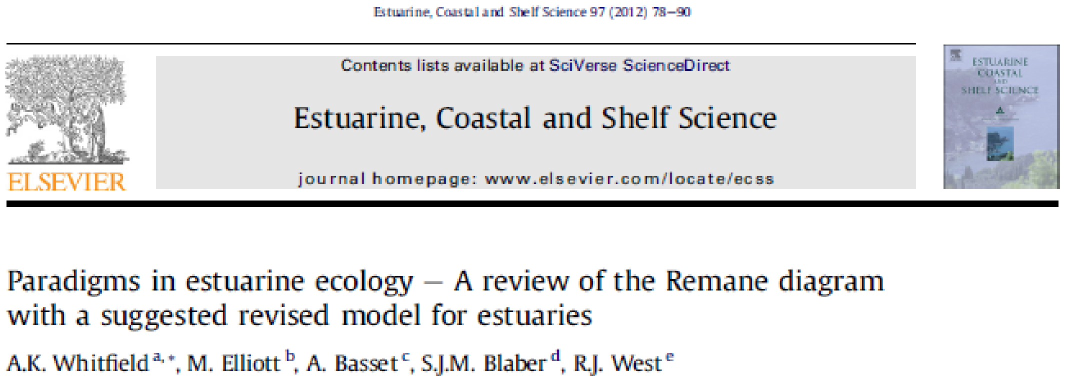




(Ospina-Alvarez et al ECSS in press)



Invertebrates – components from freshwater, estuarine and marine areas

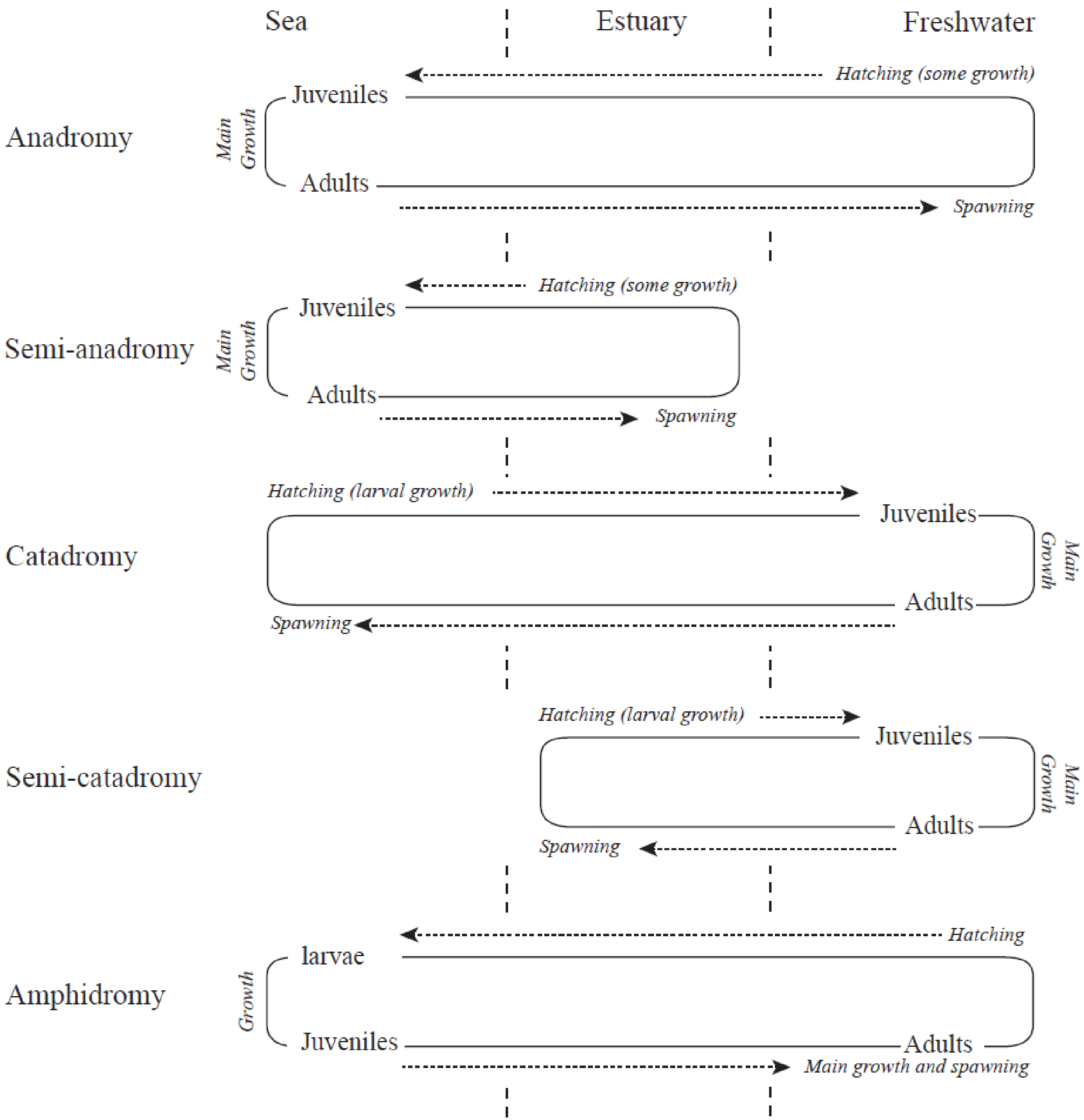


Important Marine Orders of Teleosts

Pleuronectiformes - marine, demersal flatfish; larvae with metamorphosis, important commercially, plaice, turbot, sole, *etc*.; (estuarine residents, estuarine nursery)

Anguilliformes - true eels, mostly marine but with catadromous common eel, *Anguilla*; (estuarine migration)

Salmoniformes - including fam. Salmonidae, fw and diadromous spp., all carnivores but may be planktivores, including Salmon (anadromous); (estuarine migrations);



Migratory movements of the main diadromous guilds of fishes using TW emphasising where growth and spawning take place

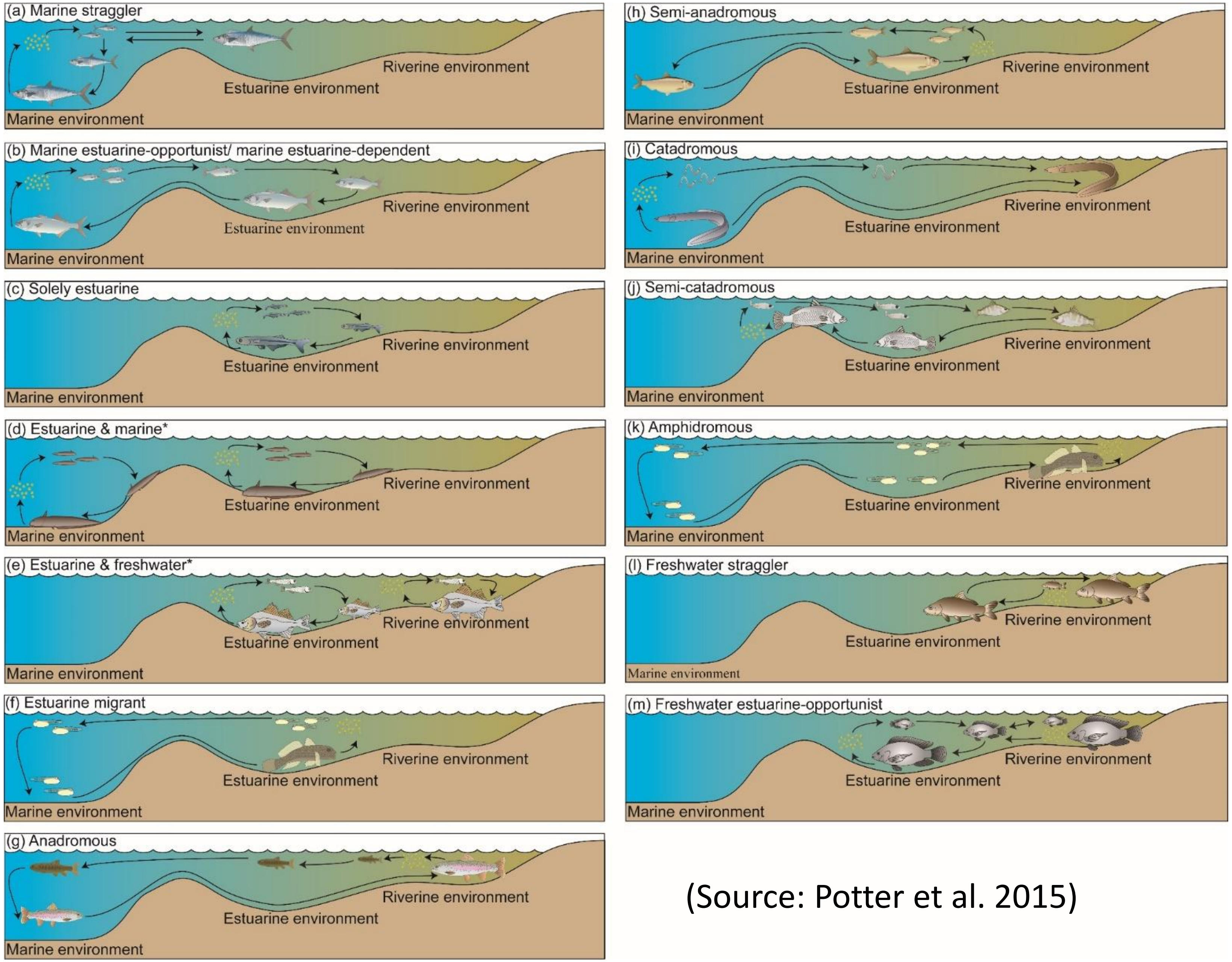
FISH and FISHERIES

FISH and FISHERIES

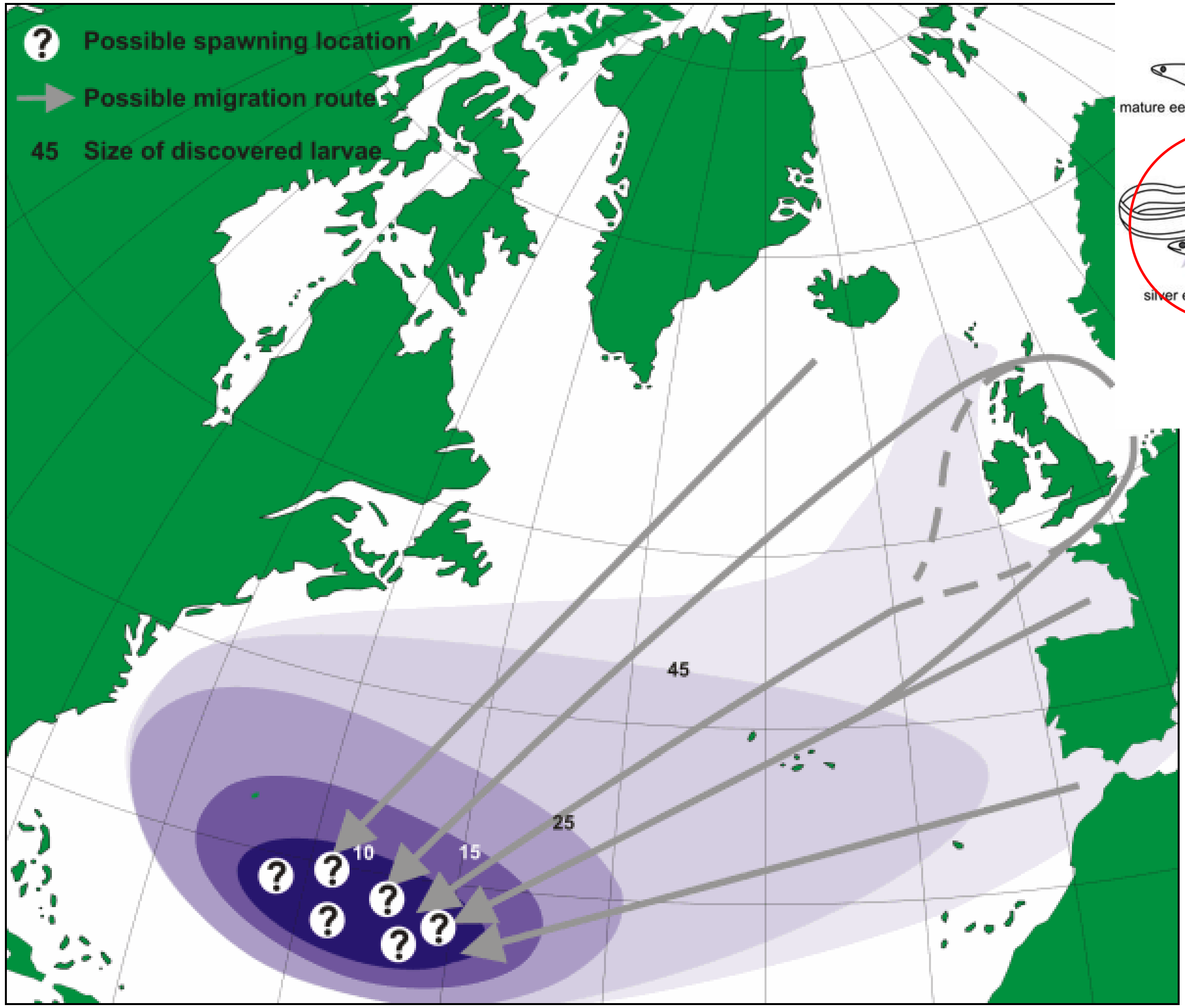
The ways in which fish use estuaries: a refinement and expansion of the guild approach

Ian C Potter[1], James R Tweedley[1], Michael Elliott[2] & Alan K Whitfield[3]

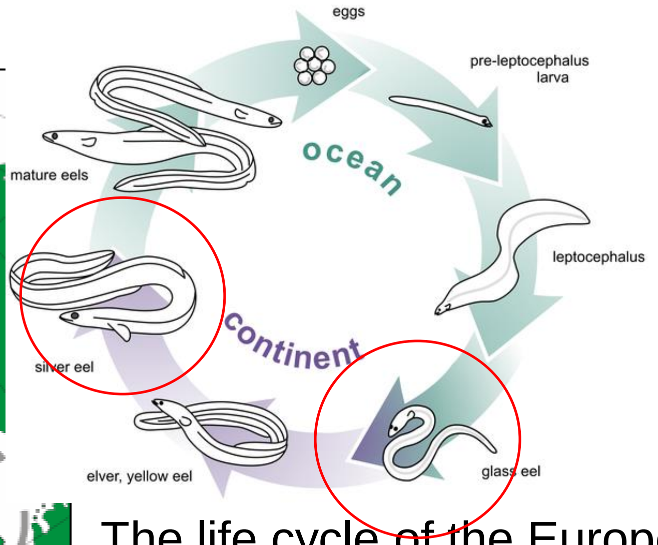
Life-history styles of fishes in estuaries – connectivity is obvious



(Source: Potter et al. 2015)

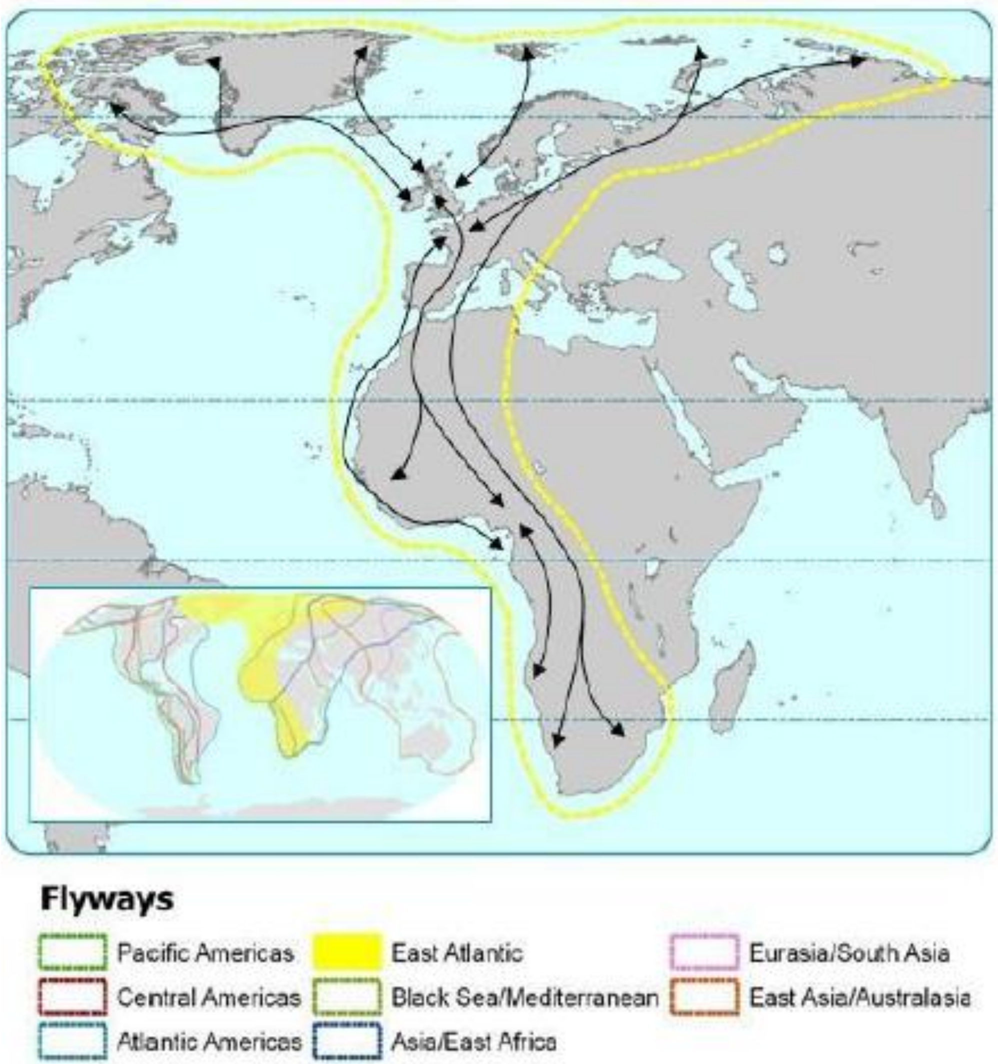


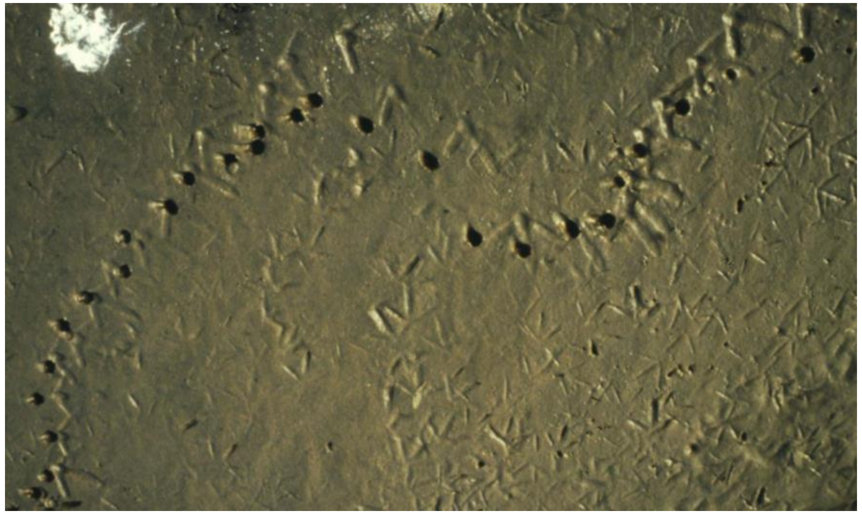
Possible routes of the spawning migration of European eels
(EU ***eeliad*** project, 2008 to 2012)



The life cycle of the European eel
(Henkel et al., 2012. Primitive Duplicate Hox Clusters in the European Eel's Genome. *PloS one, 7* (2)
PMID: 22384188)

(Circled in red - stages in transitional waters)





East Atlantic Flyway – breeding and overwintering areas

Conservation Goals for Waterfowl

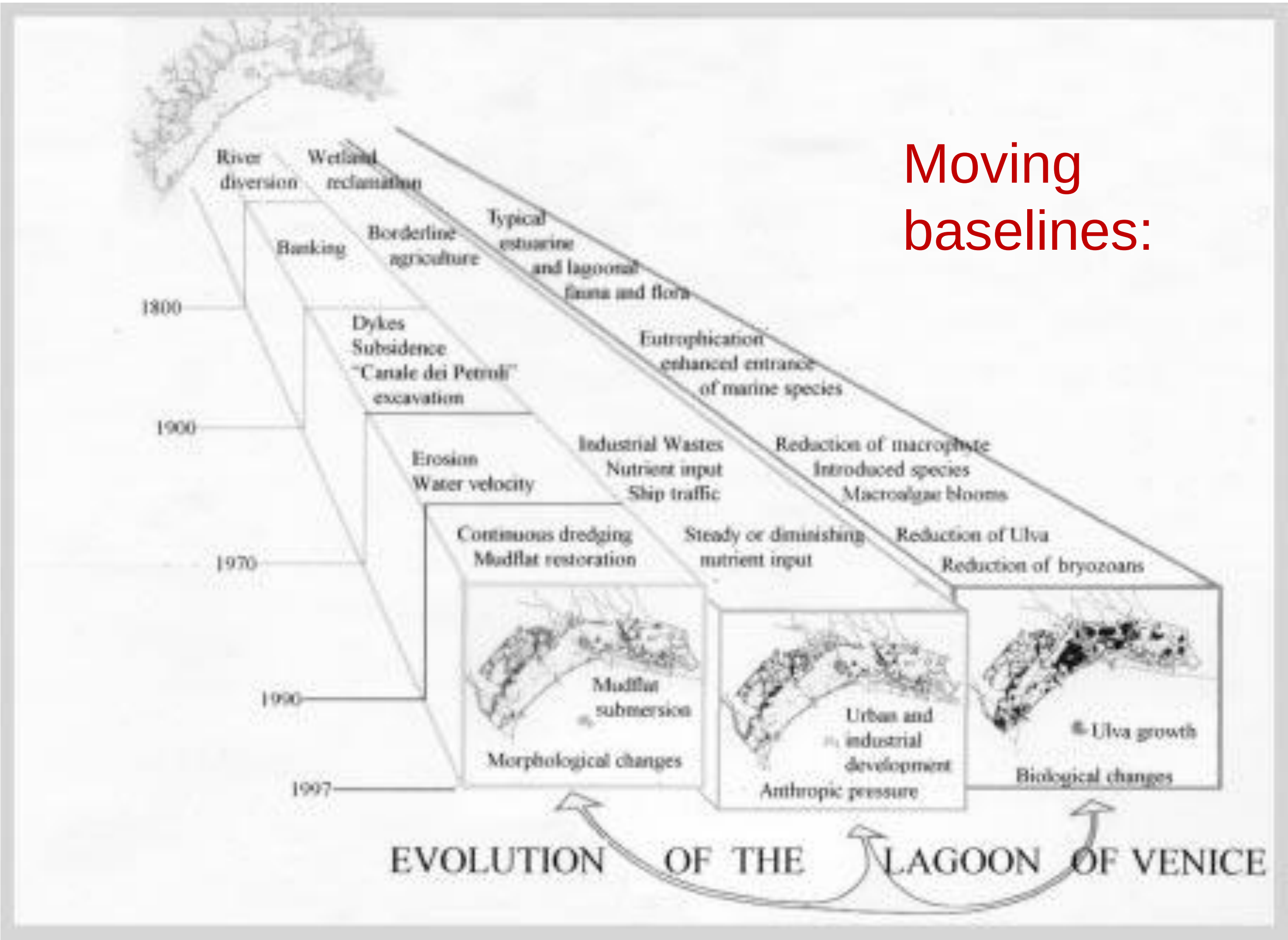
- Measurements of waterfowl status to address Favourable Condition for EU estuarine sites tend to be simplistic, based on maxima and an arbitrary threshold (+/- 50%).
- Conservation Goals need to be set to allow the key aspects of site function to be measured, these measurements based on indices of Habitat Needs.
- The HNs and their associated metrics need to reflect functional requirements (feeding, roosting and breeding use) as well as potential anthropogenic impacts.
- Indices are required in a decision support system context in order to ascertain whether specific components of the assemblage and associated estuarine function were in an 'unhealthy' state.
- This would then allow for a prescribed management response at an early intervention time, potentially addressing a situation before it created unfavourable conditions.




Moving Baselines - difficult to detect anthropogenic change against background variability

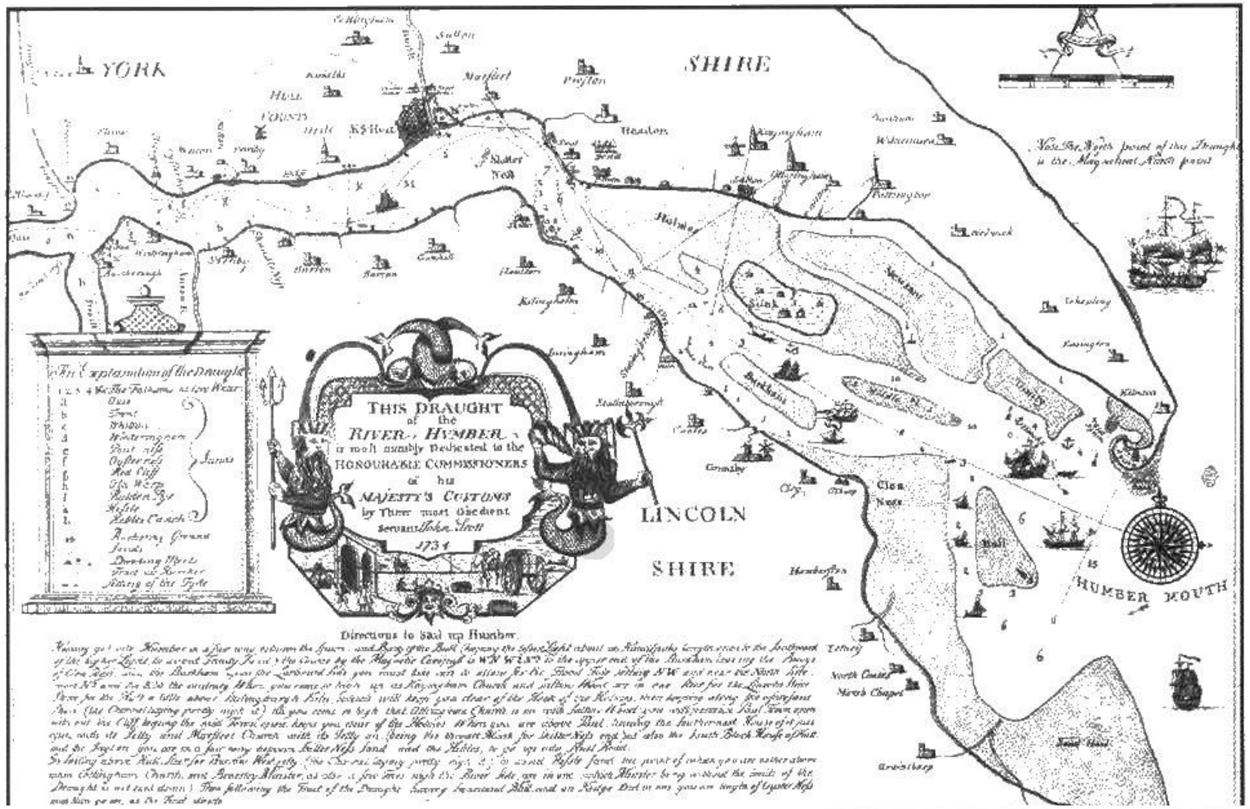
- Historic modification – new, accepted system,
- Climate change - temperature regimes,
- Climate change - relative sea level,
- Climate change - Species presence – alien species
- Population dynamics and species abundance,
- Isostatic rebound vs sea level rise.

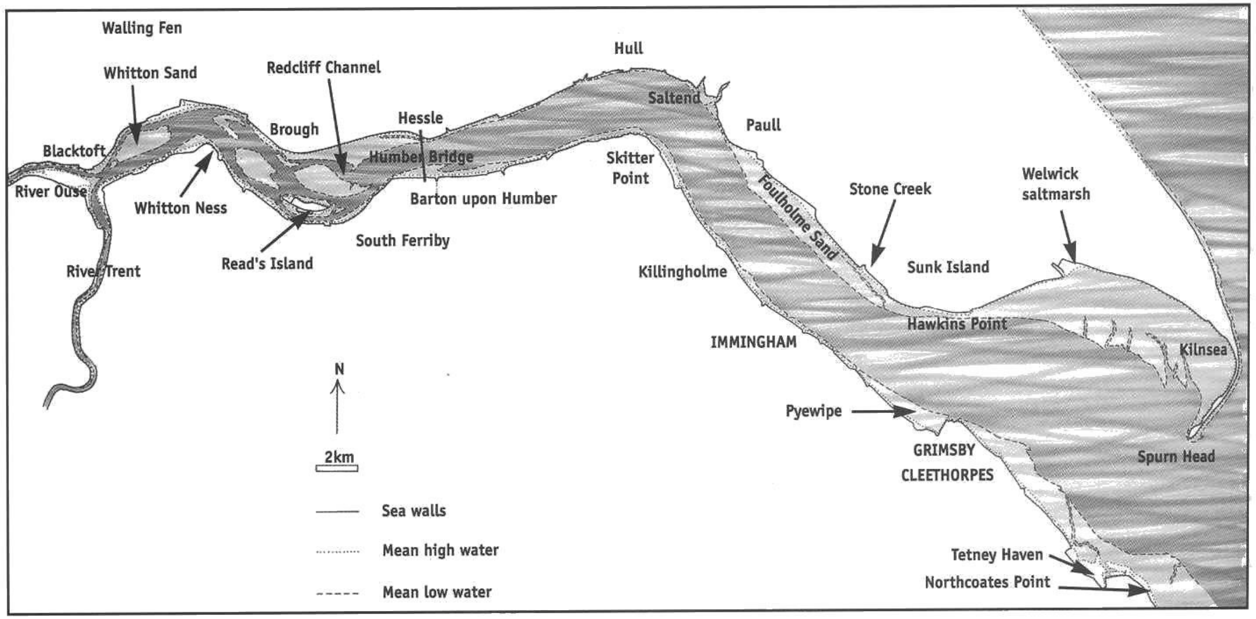
Moving baselines:



Major environmental changes in the Venice Lagoon since industrial times. (Modified from Technital-CVN 'Project for the Environmental Restoration of the Lagoon of Venice' Ministry of Public Works, 1994.)

(Occhipinti Ambrogi, 2000, Biol. Invasions, 2: 165-176)





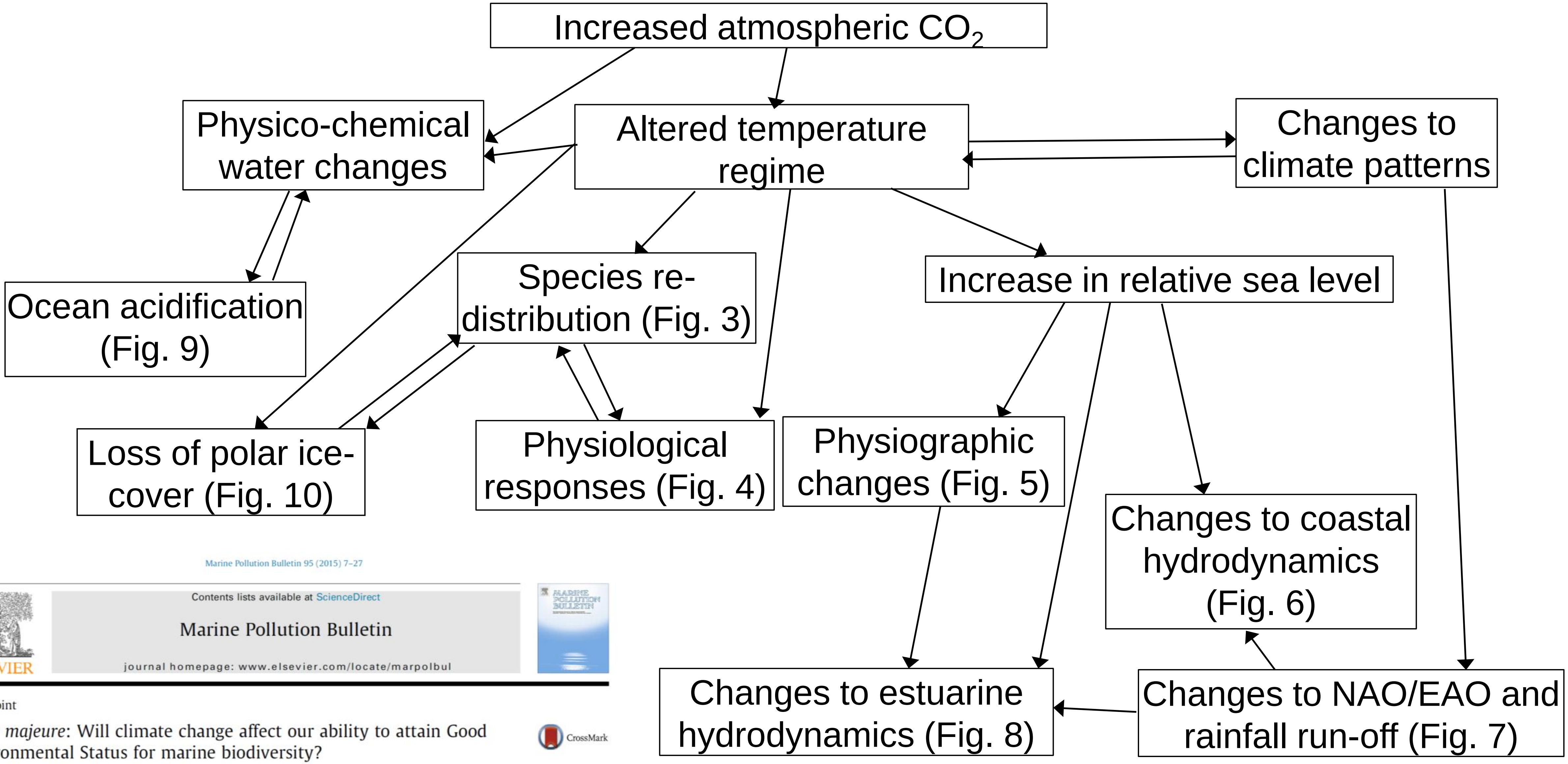
Land claim in the Humber (since the Scott chart, 1794)

Coastal squeeze – anthropogenic and exogenic

IECS 1993; Murby 2001; http://www.hull.ac.uk/iecs

Climate change - Basic Premise:

- Exogenic (outside the management area) and endogenic (inside the management area) pressures produce individual, in-combination and cumulative effects.
- Global climate change is an *exogenic unmanaged pressure* where management has to respond to the consequences rather than the causes of that change.
- We can summarise our understanding as conceptual models ('*horrendograms*') to inform future natural and social science research and management.
- This presents managers with the sequence of responses by the natural and human systems, and hence indicate impediments to the implementation of legislation such as European Directives.



Marine Pollution Bulletin 95 (2015) 7–27

Contents lists available at ScienceDirect

Marine Pollution Bulletin

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

Viewpoint

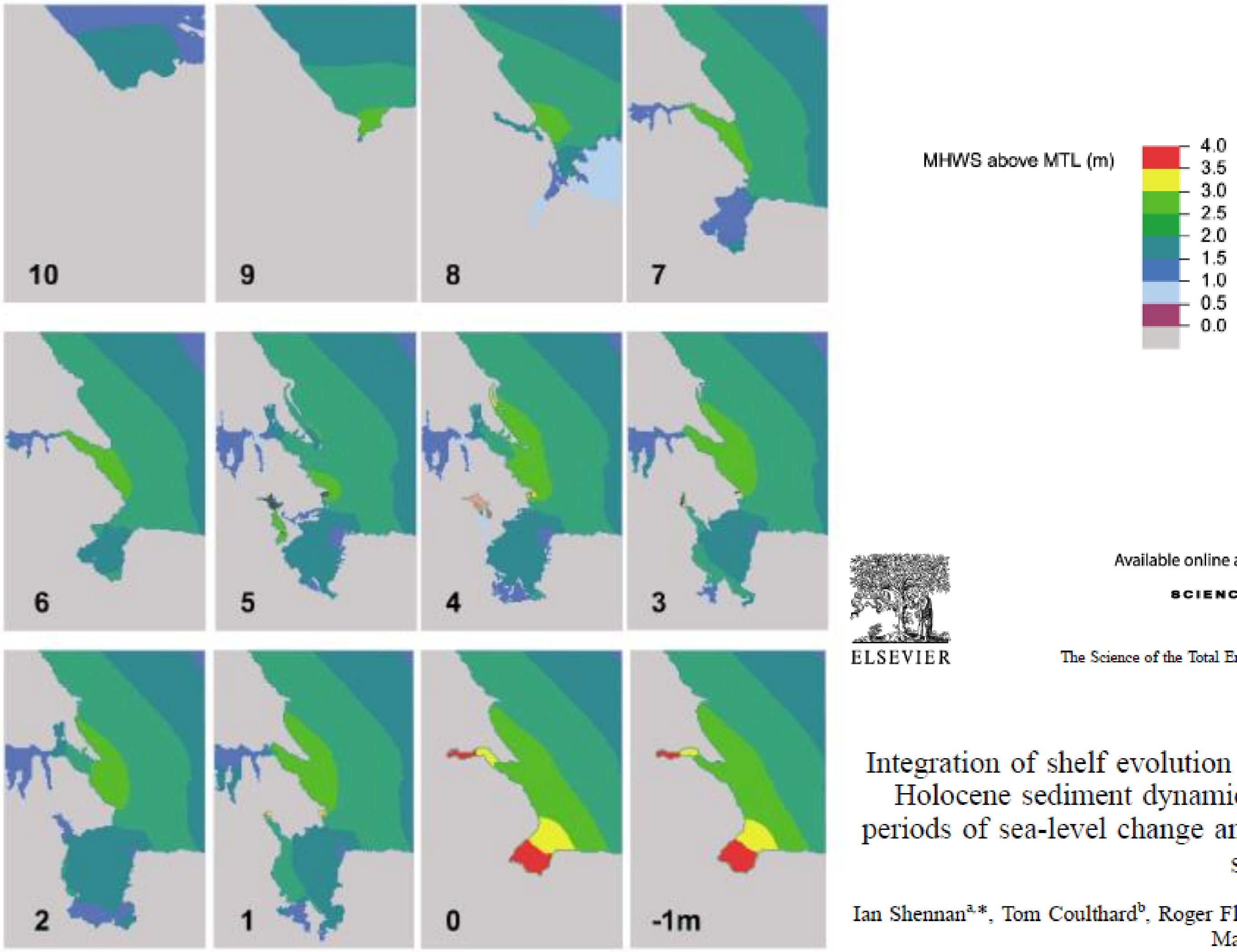
Force majeure: Will climate change affect our ability to attain Good Environmental Status for marine biodiversity?

Michael Elliott[a,*], Ángel Borja[b], Abigail McQuatters-Gollop[c], Krysia Mazik[a], Silvana Birchenough[d], Jesper H. Andersen[e], Suzanne Painting[d], Myron Peck[f]

Primary drivers and consequences of marine global climate change (cross-referring to other figures in Elliott et al., 2015)

Climate Change Environmental Summary

Causes	Consequences	Solution examples
Hotter, drier summers	More droughts, water supply problems	Permanent inland water storage systems; water use reduction education, water transfer schemes
Greater frequency of rainstorms	More fluvial/pluvial flooding	Temporary inland water storage systems, ecoengineering of wetlands, increased water run-off mechanisms
Increased Sea Level Rise	Increase in tidal flooding/erosion	Greater defences in urban/industrial areas, roll-back policies,
Greater storminess/ surges	Increase in tidal flooding/erosion	Marine and estuarine defences, estuarine storage areas
Increase in non-indigenous species	Ecological repercussions	Greater biosecurity, marine controls

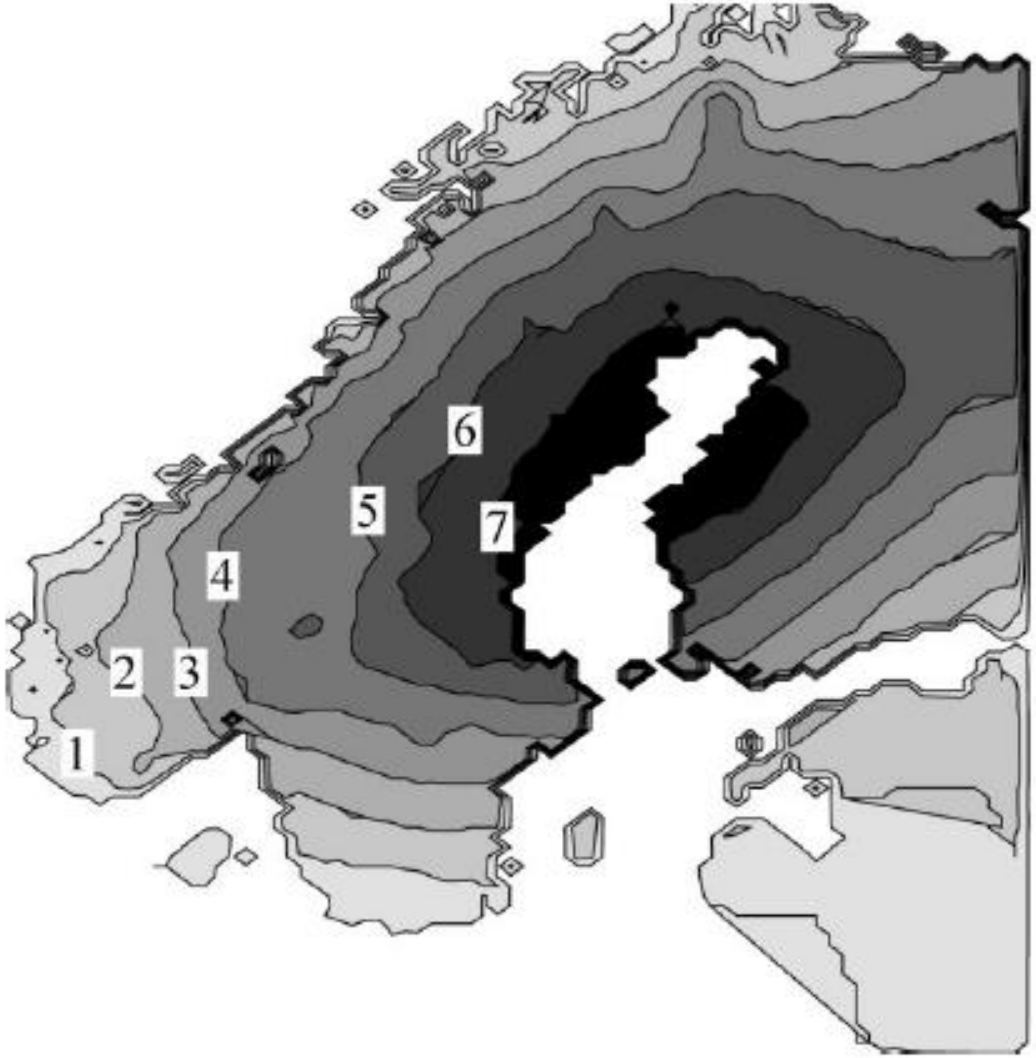


Palaeographic reconstructions and elevations of MHWST (m above MSL) for SW North Sea

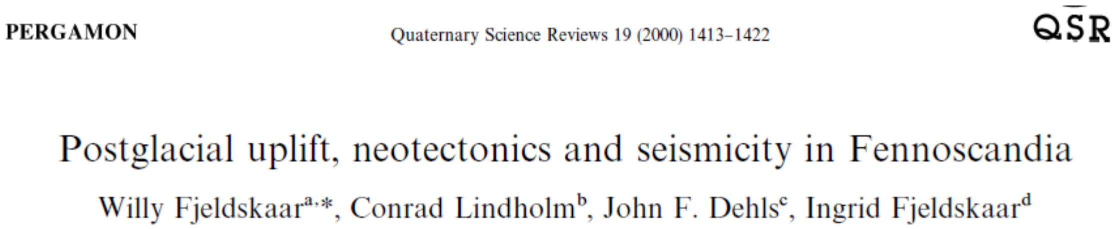
Available online at www.sciencedirect.com
SCIENCE DIRECT®
The Science of the Total Environment 314–316 (2003) 737–754
the Science of the Total Environment
www.elsevier.com/locate/scitotenv

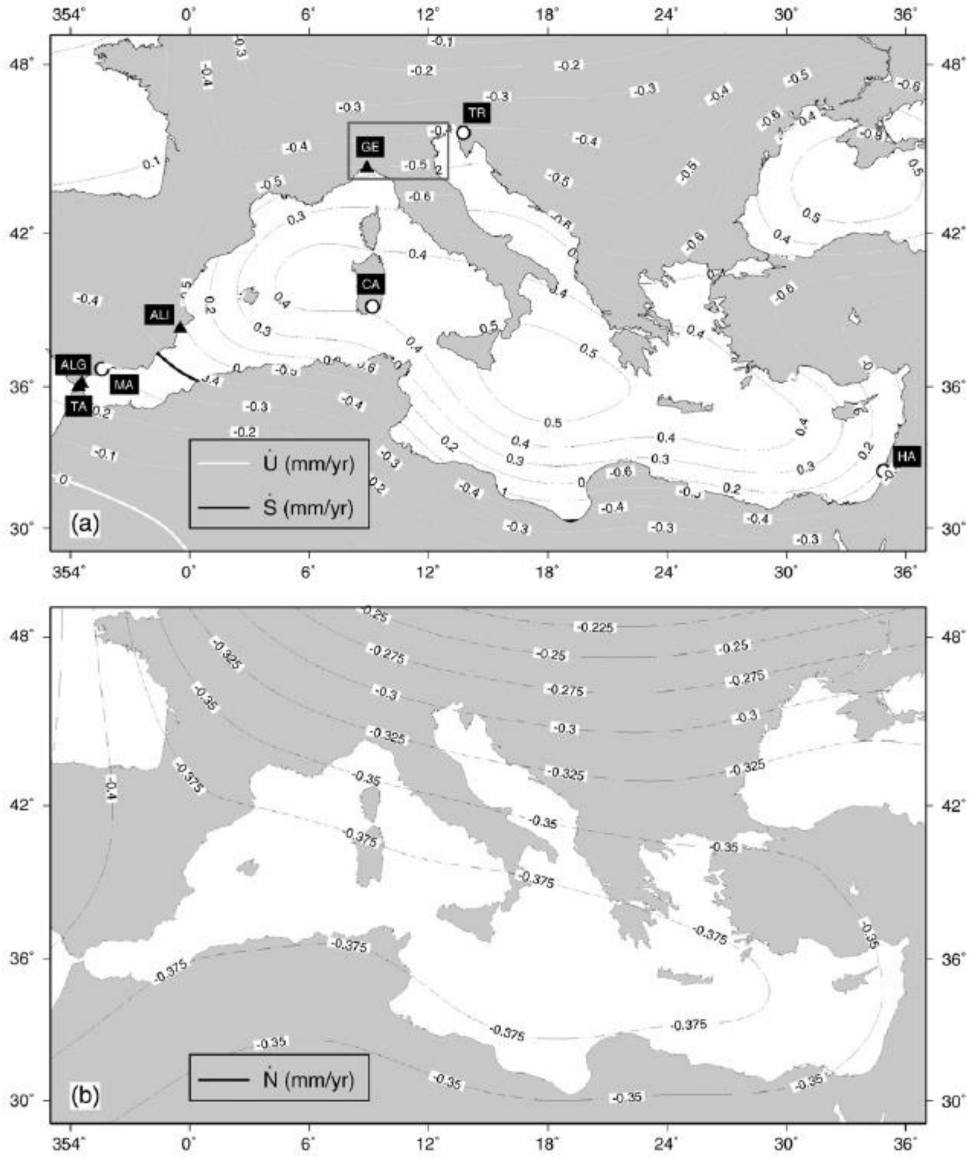
Integration of shelf evolution and river basin models to simulate Holocene sediment dynamics of the Humber Estuary during periods of sea-level change and variations in catchment sediment supply

Ian Shennan[a,*], Tom Coulthard[b], Roger Flather[c], Ben Horton[d], Mark Macklin[b], John Rees[d], Matt Wright[a]



Scandinavia – Observed present rate of uplift (contour interval 1mm/yr)





Mediterranean Sea -

(a) Predicted rates of present day sea-level change S and vertical deformation of the solid surface U

(b) Present day rates of geoid height change $\dot{N}$(absolute rate of sea level change)

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Tectonophysics
journal homepage: www.elsevier.com/locate/tecto
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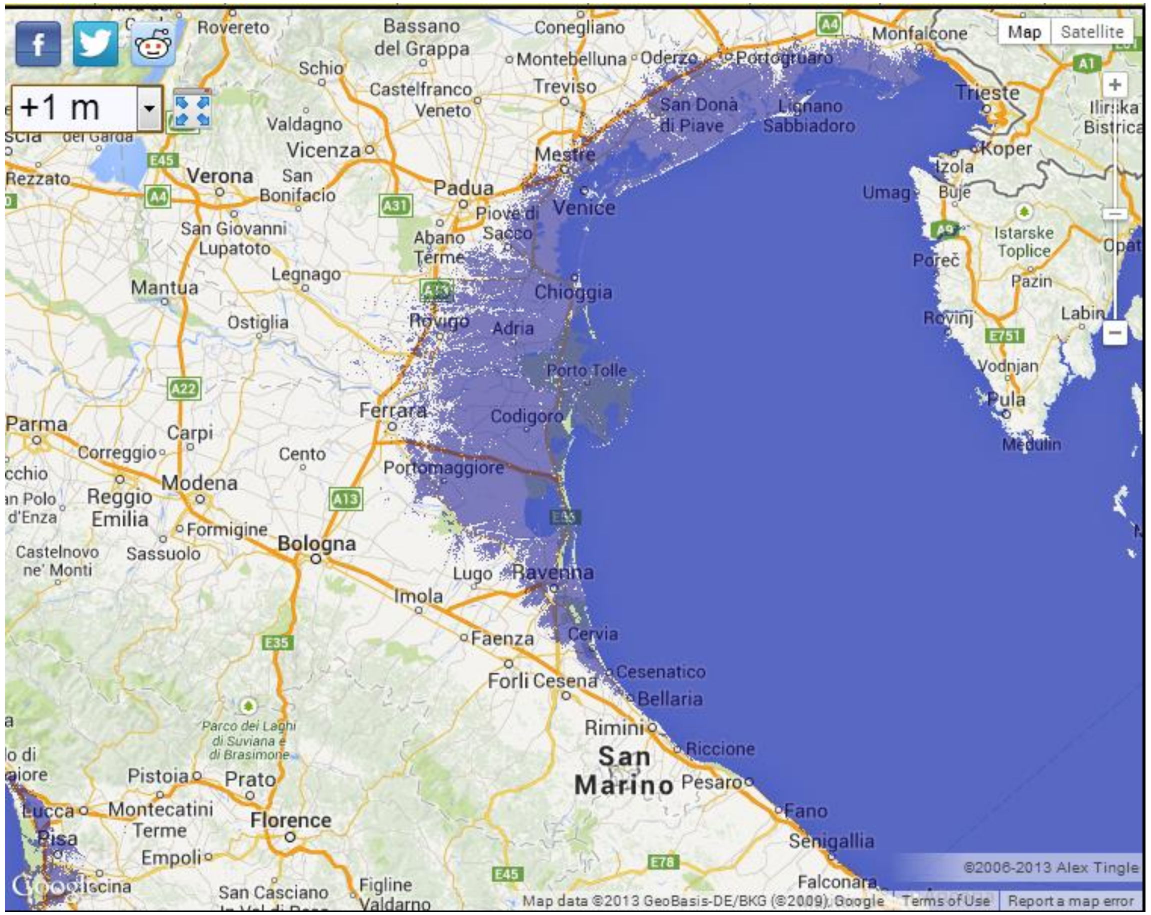
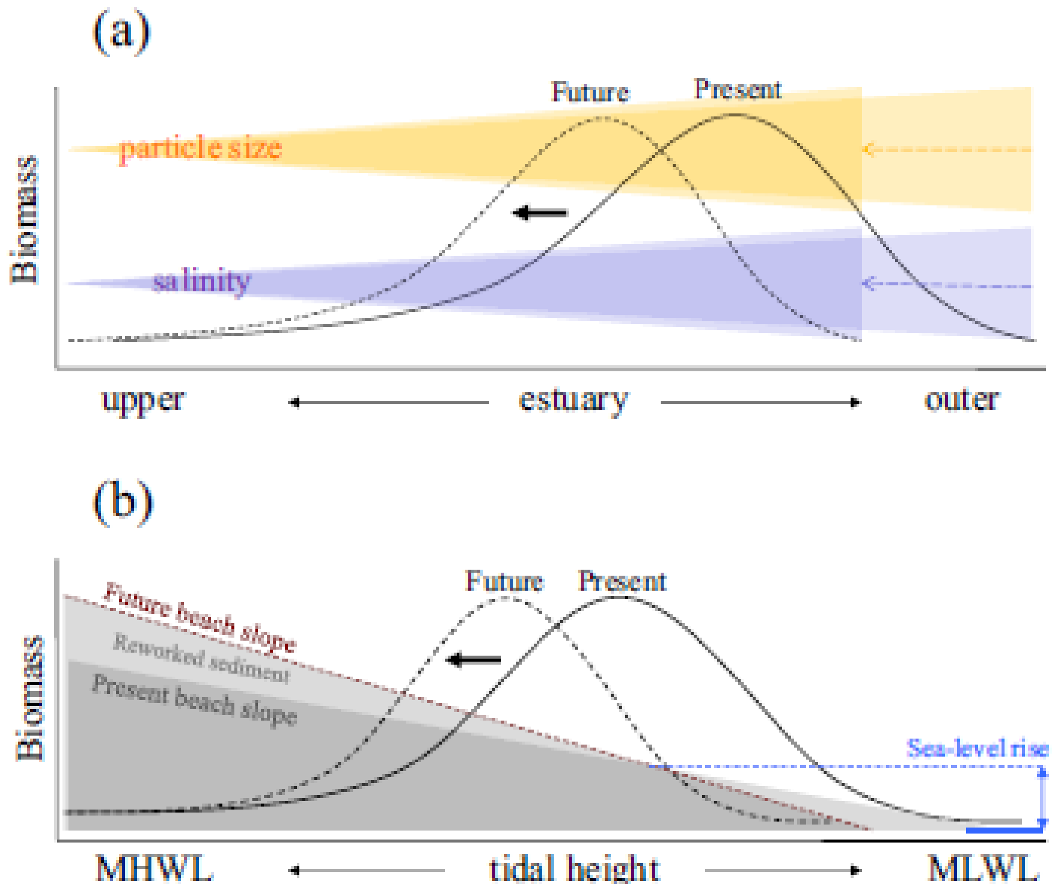
Influence of glacial isostatic adjustment upon current sea level variations in the Mediterranean

P. Stocchi [a], G. Spada [b,*]

Areas of Venice that would be flooded at various stages of sea level rise; (this gives a visual impression of which geographic areas might be flooded if global warming and climate change continue unabated).



http://geology.com/sea-level-rise/venice.shtml



Conceptual models of possible shifts in estuarine intertidal macrobenthic biomass wrt SLR:

(a) along estuarine axial gradient due to salinity intrusion and sediment change;

(b) along estuarine vertical gradient due to change in beach profile.

Biology 2012, *1*, 597-616; doi:10.3390/biology1030597

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biology

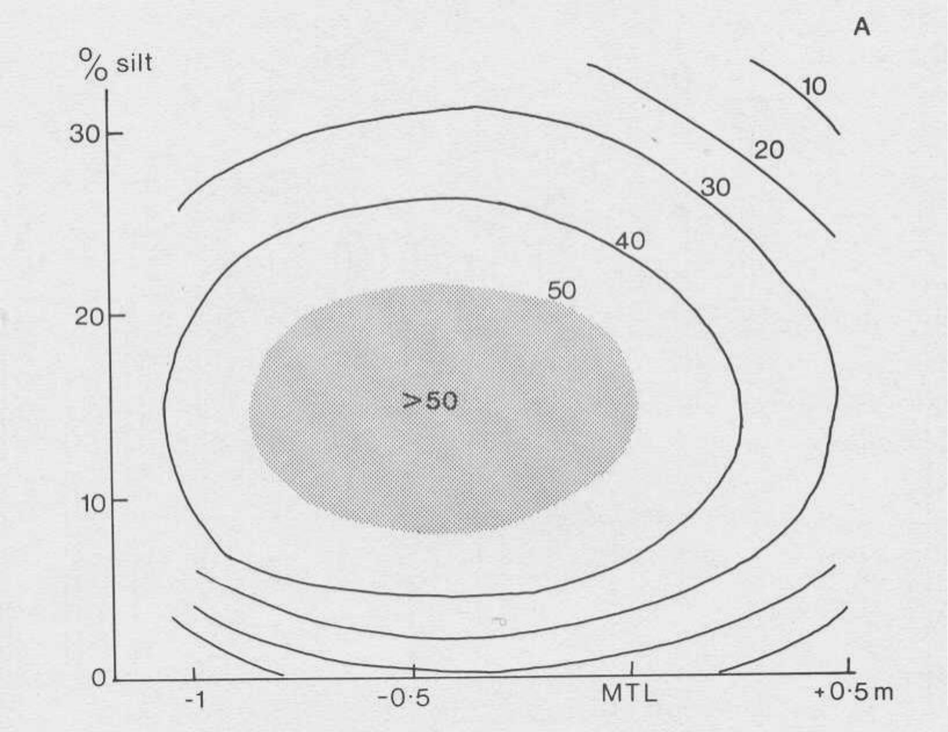
ISSN 2079-7737

www.mdpi.com/journal/biology

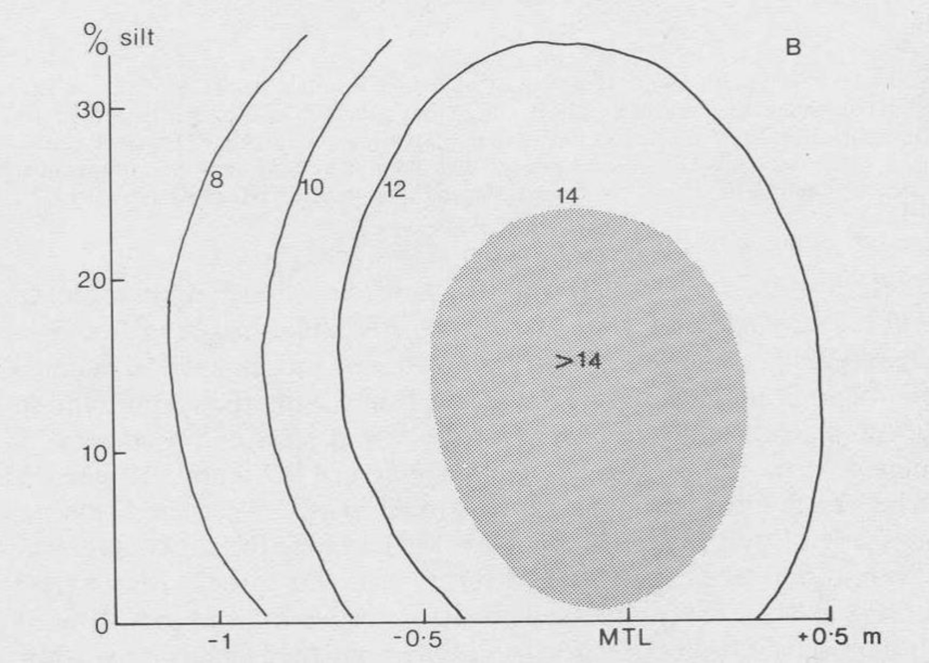
Review

Climate Change, Sea-Level Rise and Implications for Coastal and Estuarine Shoreline Management with Particular Reference to the Ecology of Intertidal Benthic Macrofauna in NW Europe

Toyonobu Fujii †



Intertidal macrofaunal biomass (A, g m^{-2} afdw) & species richness vs. silt and tidal height (Beukema 1976)



Change in availability of preferred prey areas

Alien species in the Venice lagoon

Introduction of non-indigenous algae by attachment to ship hulls or via imported cultivated molluscs

Invertebrate species introduced accidentally, e.g., *Scapharca inaequivalvis*

Crassostrea gigas and Tapes philippinarum - bivalves introduced for aquaculture

But:
NIS species in Mediterranean waters as the result of the Suez Canal causing a failure of GES in the MSFD?

(Occhipinti Ambrogi, 2000. Biotic invasions in a Mediterranean Lagoon. Biol. Inv.)

Table 1. Alien species introduced into the benthic communities of the Lagoon of Venice. Species marked with an asterisk (*) were described in the Lagoon of Venice as the first record for the Mediterranean Sea.

Species	First record	Known from	Reference
Algae			
Sargassum muticum	1992	Japan	Gargiulo et al. 1992
Undaria pinnatifida	1992	Japan	Rismondo et al. 1993
Grateloupia doryphora	1992	Atlantic Pacific	Gargiulo et al. 1992
Radicilingua thysanorhizans	1993	Boreal-Atlantic	Curiel et al. 1994
Antithamnion pectinatum	1994	Japan	Curiel et al. 1996
Sorocarpus sp. *	1996	N Atlantic, Japan, Australia	Curiel et al. 1999b
Ectocarpus siliculosus var. *hiemalis*	1998	Black Sea	Bellemo et al. 1999
Punctaria tenuissima	1998	Boreal-Atlantic	Bellemo et al. 1999
Cnidaria			
Garveia franciscana *	1978	Indopacific	Morri 1982
Diadumene cincta *	1993	Atlantic	Birkemeyer 1996
Annelida Polychaeta			
Ficopomatus enigmaticus	1934	Australia	Fauvel 1938
Hydroides dianthus	1934	NW Atlantic	Fauvel 1938
Hydroides elegans	1934	Australia?	Fauvel 1938
Crustacea			
Paracerceis sculpta	1983	N Africa	Forniz and Sconfietti 1985
Elasmopus pectenicrus *	1983	Red Sea	Sconfietti 1983
Callinectes danae *	1981	NW Atlantic	Mizzan 1993
Callinectes sapidus	1950	NW Atlantic	Mizzan 1993
Dyspanopeus sayi *	1992	NW Atlantic	Froglia and Speranza 1993
Caprella scaura *	1994	Indopacific	Sconfietti and Danesi 1996
Arthropoda Chelicerata			
Ammothea hilgendorfi *	1979–1981	Pacific	Krapp and Sconfietti 1983
Bryozoa			
Tricellaria inopinata *	1982	Indopacific	d'Hondt and Occhipinti 1985
Celleporella carolinensis *	1994	W Atlantic	Occhipinti and d'Hondt 1996
Mollusca			
Crassostrea gigas	1966	Japan	Cesari and Pellizzato 1985a
Anadara (Scapharca) inaequivalvis	1976	Indopacific	Cesari and Pellizzato 1985a
Saccostrea commercialis	1984	NW Pacific	Cesari and Pellizzato 1985a
Rapana venosa	1981	Japan, China	Cesari and Pellizzato 1985b
Bursatella leachi	1985	Red Sea	Cesari et al. 1986
Xenostrobus securis *	1992	Australia, New Zealand	Sabelli and Speranza 1993
Tapes philippinarum	1983	Japan	Cesari and Pellizzato 1985a
Tunicata			
Botrylloides violaceus *	1993	Indopacific	Zaniolo et al. 1998

Basis - TraC Footprints and Trajectories

- H_{A1} The footprint of an impact due to an anthropogenic stressor has an extent and magnitude proportional to the intensity of the stressors and the sensitivity of the receiving environment.
- H_{A2} The determination of effect is dependent on the complexity and variability of the component or habitat being influenced by the stressor such that environmentally or ecologically variable systems require a greater stressor in order to manifest a change.
- H_{A3} The speed of recovery from the effects of the stressor is dependent on the turnover rate of the ecological components being affected by the stressors and the timing of the removal of the action of the stressor.

- In the European context Article 1(3) of the Marine Strategy Framework Directive (MSFD) (EC 2008) states that:

  ‘Marine strategies shall apply an ecosystem-based approach to the management of human activities, ensuring that the collective pressure of such activities is kept within levels compatible with the achievement of good environmental status and that the capacity of marine ecosystems to respond to human-induced changes is not compromised, while enabling the sustainable use of marine goods and services by present and future generations’.

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

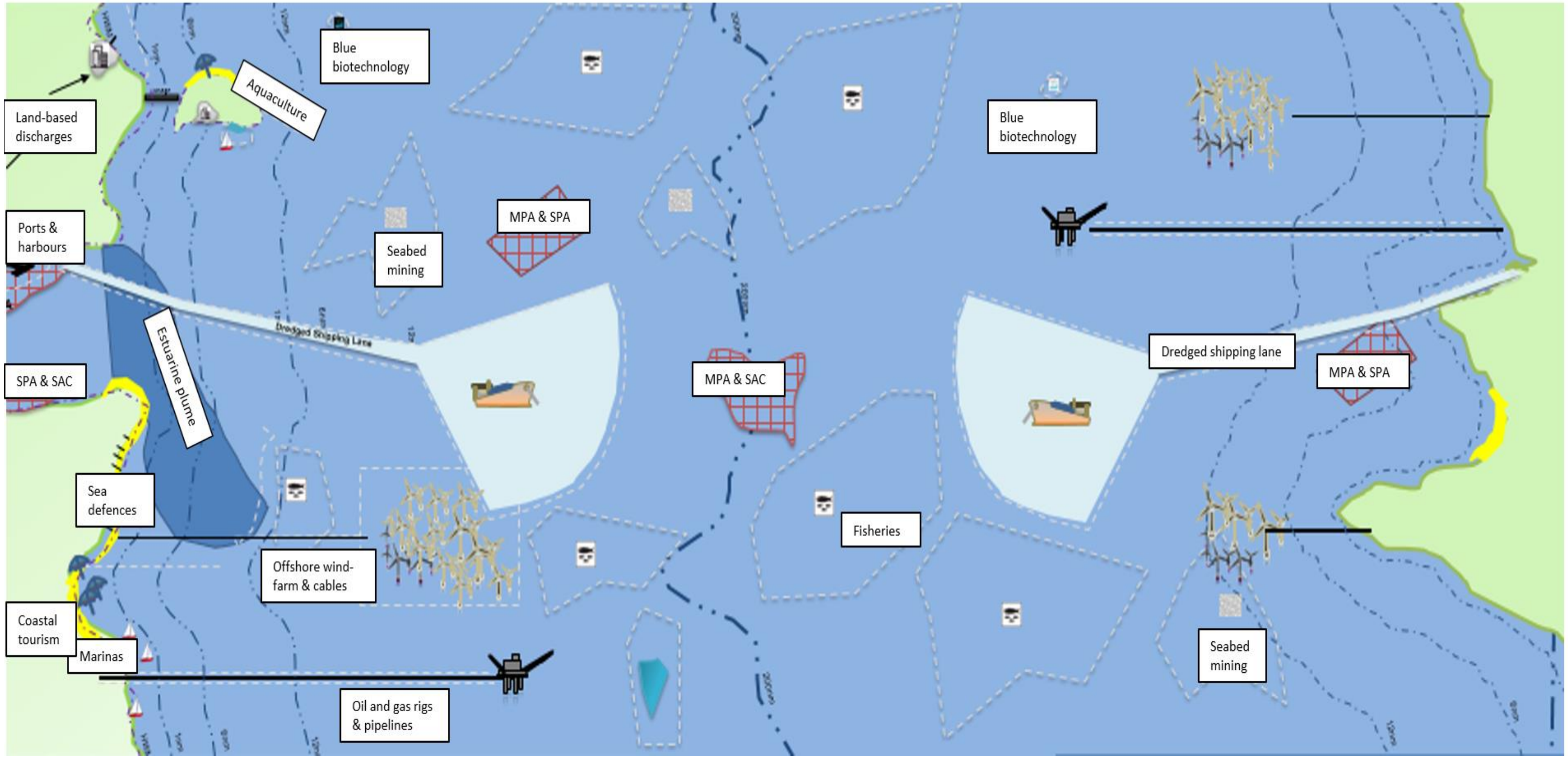
The area and/or time covered by the marine management action and measures (or programme of measures), including the distribution range of a species.

Determine activity-footprints → Determine pressures-footprints → Determine effects-footprints → Determine management response-footprints

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

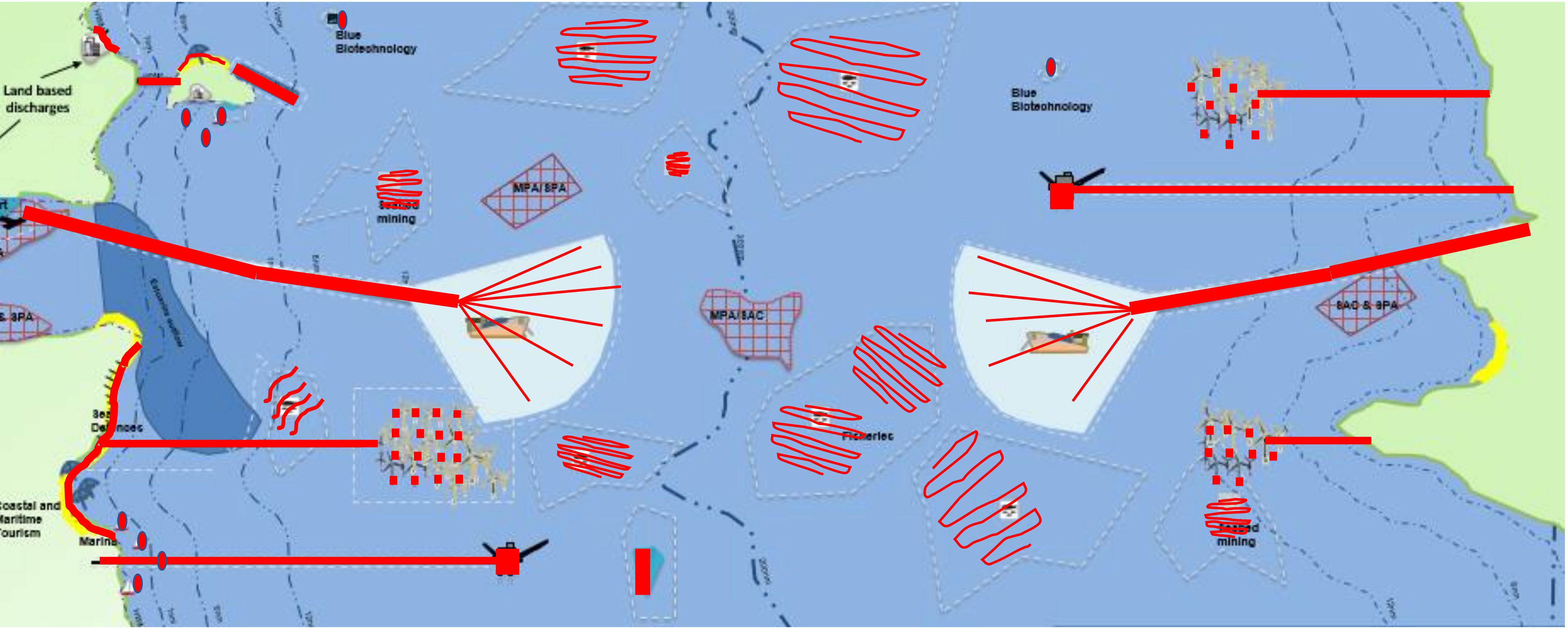
Michael Elliott, International Estuarine & Coastal Specialists (IECS) Ltd., Leven, United Kingdom and School of Environmental Sciences, University of Hull, Hull, United Kingdom
Michael J Kennish, Department of Marine and Coastal Sciences, School of Environmental and Biological Sciences, Rutgers University,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

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



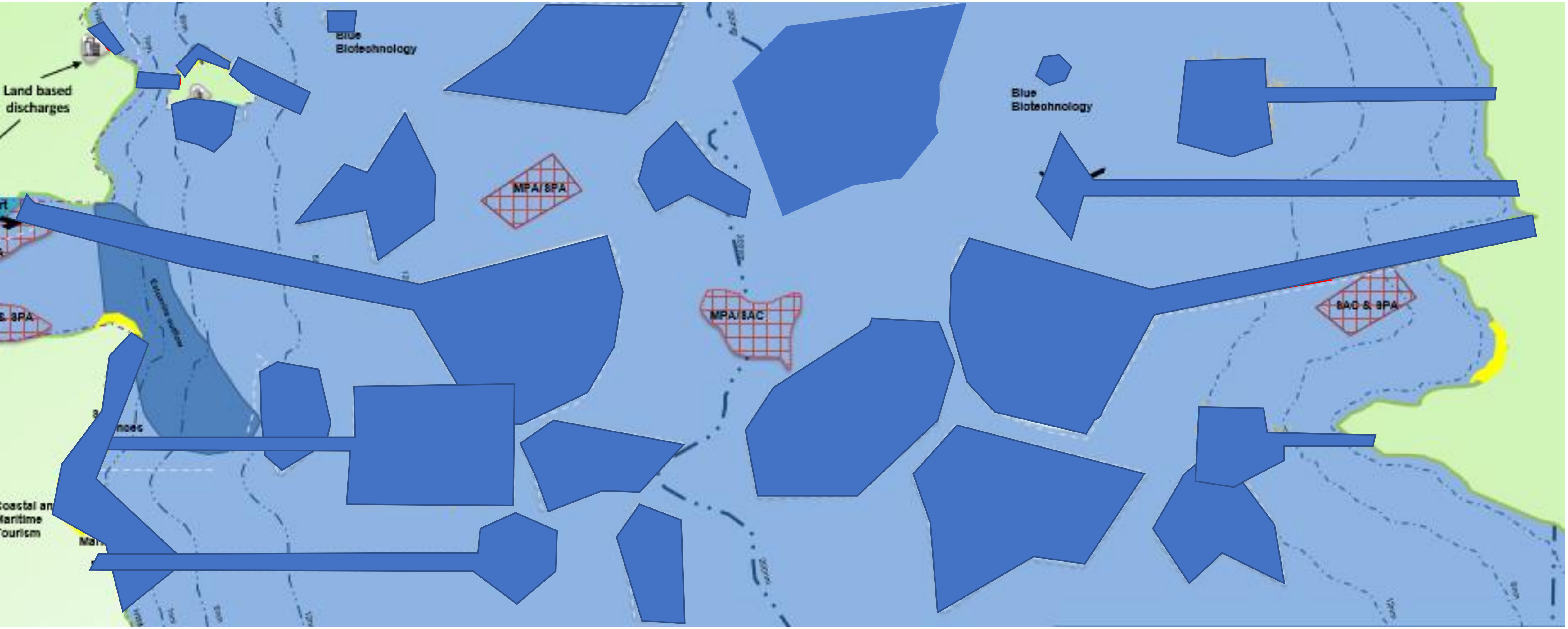
Challenge of multi-use international seas: Stylised transnational sea area showing activity footprints and transboundary Marine Protected Areas and fishing grounds – to reflect the challenges of complex marine management

Management of a complex transboundary area



Activity-footprint

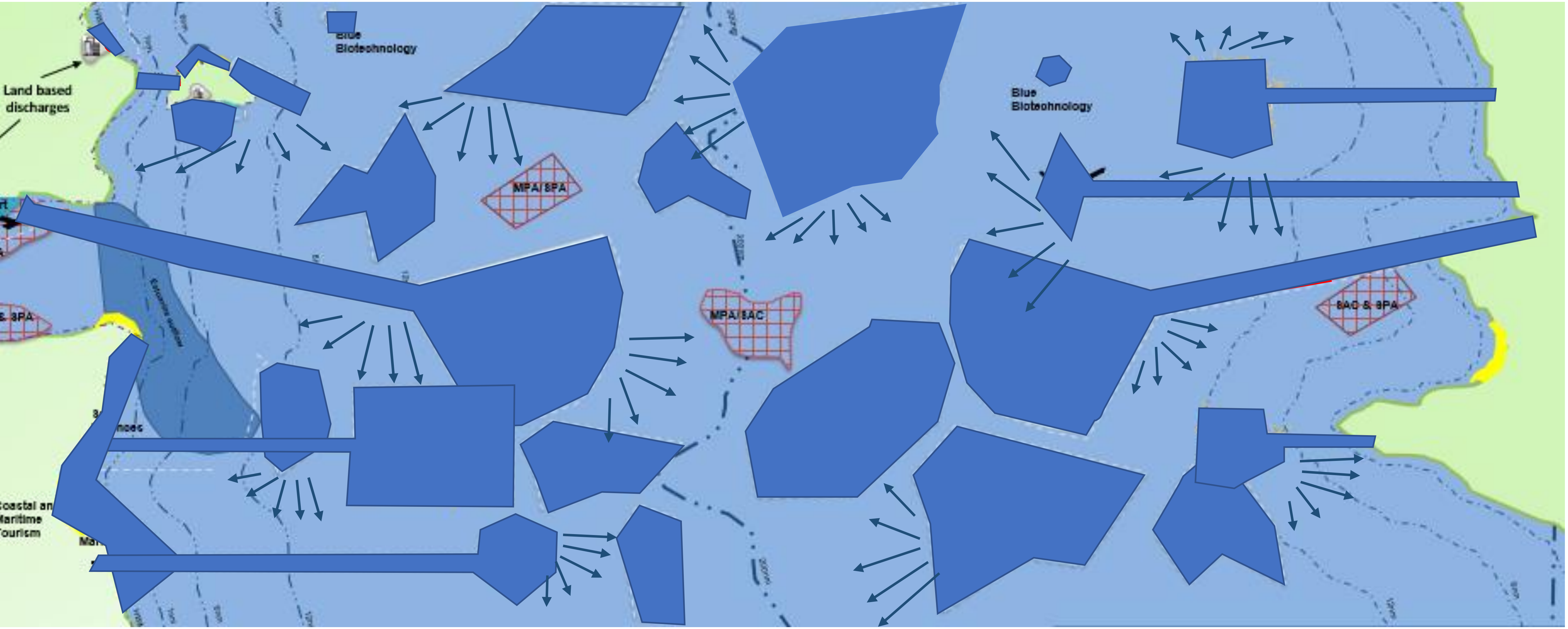
Management of a complex transboundary area



Activity-footprint

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

Management of a complex transboundary area



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

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
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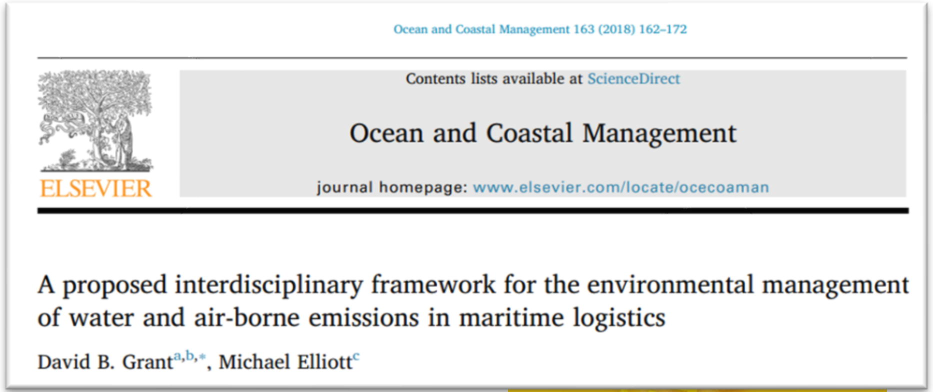
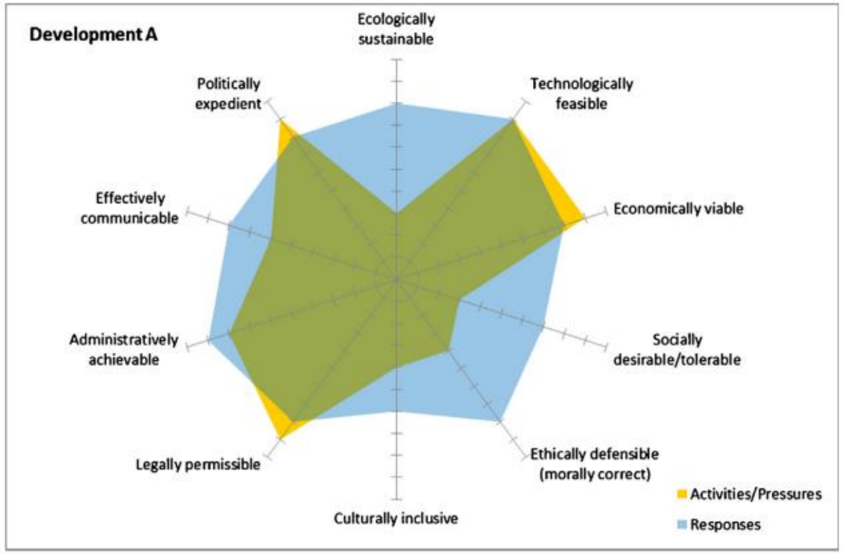
journal homepage: www.elsevier.com/locate/marpolbul
ELSEVIER
Editorial
The *10-tenets* for integrated, successful and sustainable marine management


ENVIRONMENTAL SCIENCE & POLICY 51 (2015) 181–191
Available online at www.sciencedirect.com
ScienceDirect
journal homepage: www.elsevier.com/locate/envsci
ELSEVIER
The 10-tenets of adaptive management and sustainability: An holistic framework for understanding and managing the socio-ecological system
CrossMark
*Steve Barnard *, Michael Elliott*

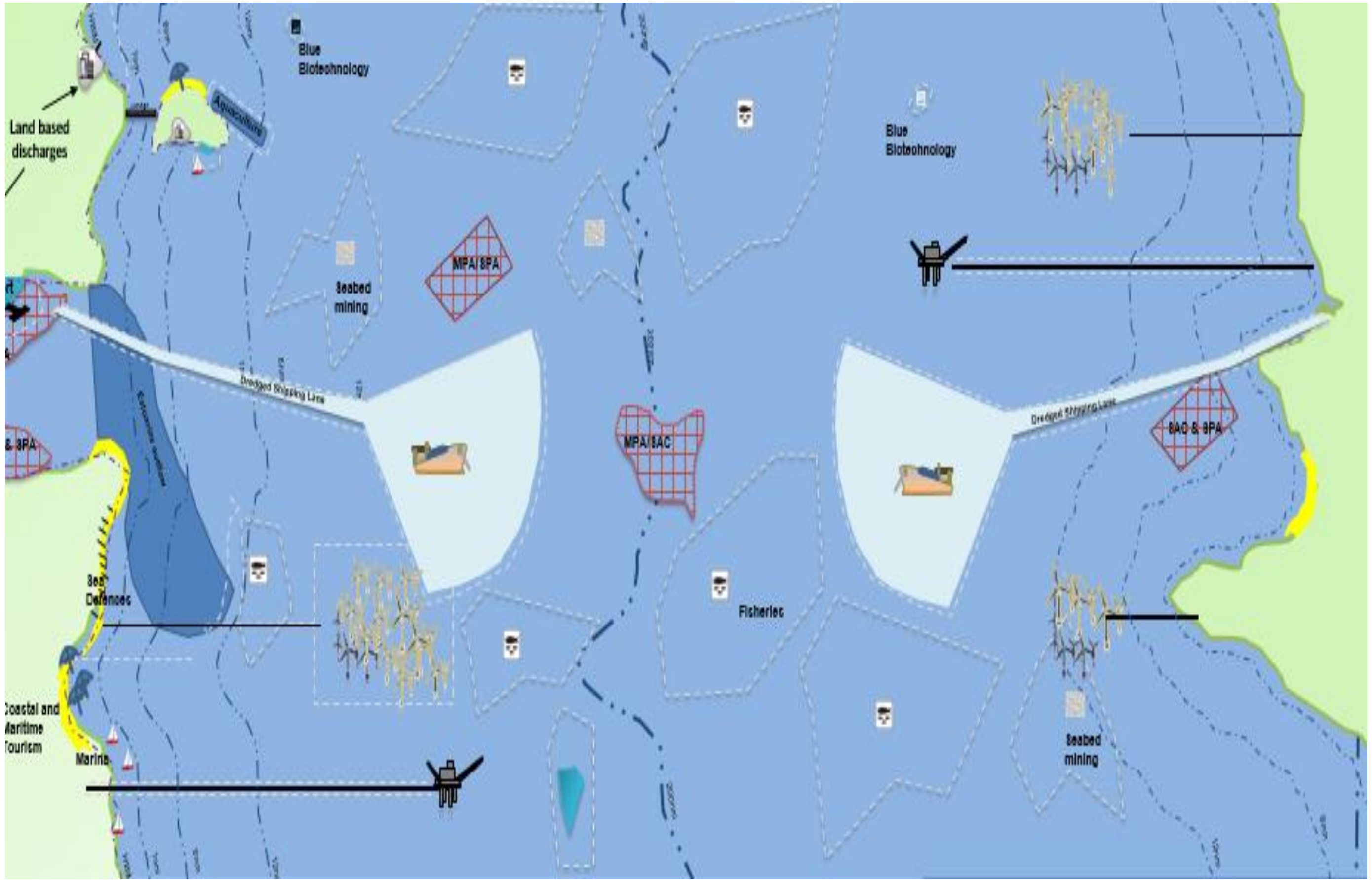

Ocean and Coastal Management 163 (2018) 162–172
Contents lists available at ScienceDirect
Ocean and Coastal Management
journal homepage: www.elsevier.com/locate/ocecoaman
ELSEVIER
A proposed interdisciplinary framework for the environmental management of water and air-borne emissions in maritime logistics
David B. Grant[a,b,*], Michael Elliott[c]



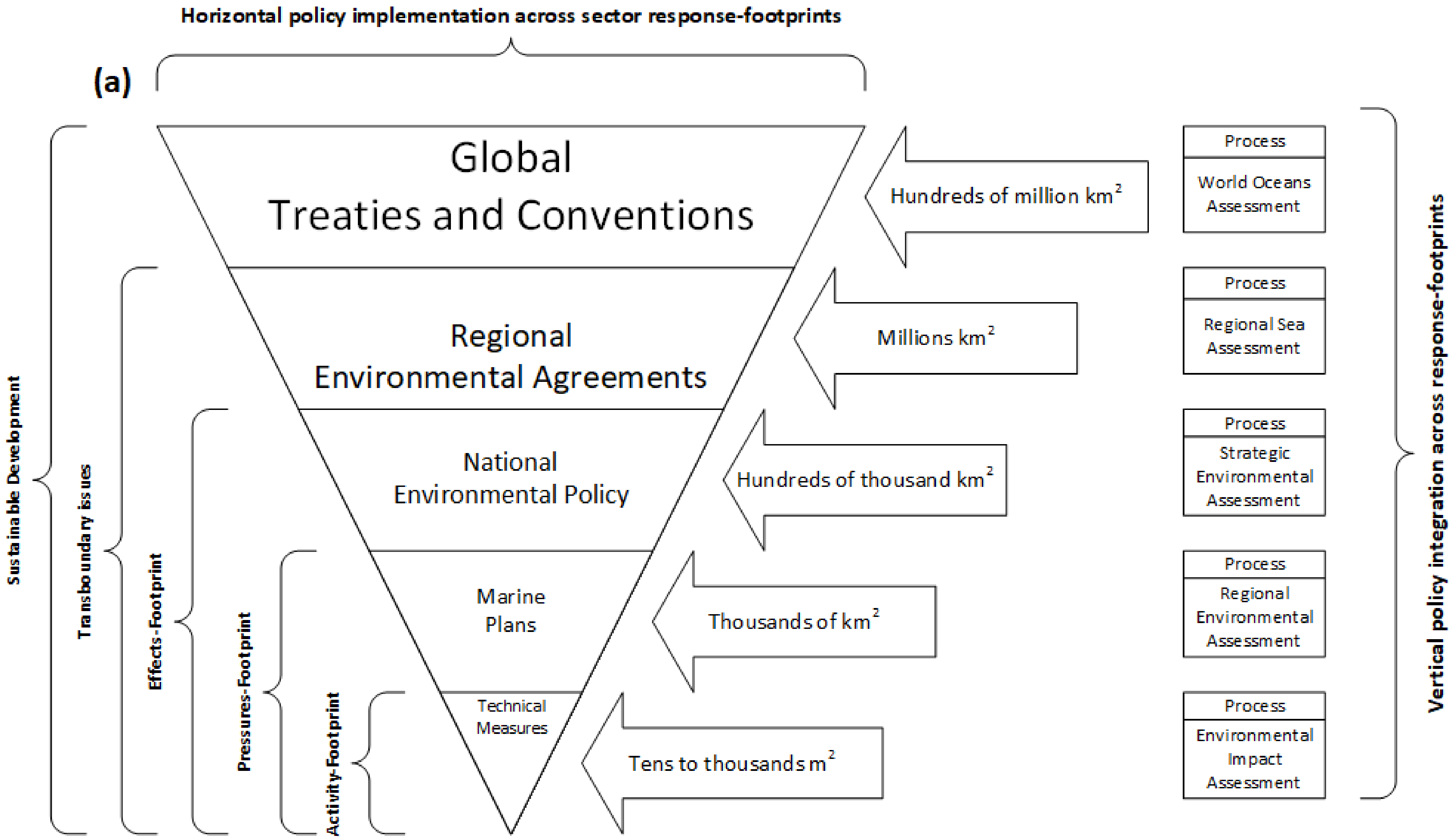
(NB spellcheck - not "10 Tennents – that's a good night in Scotland"!)

Where are we managing?

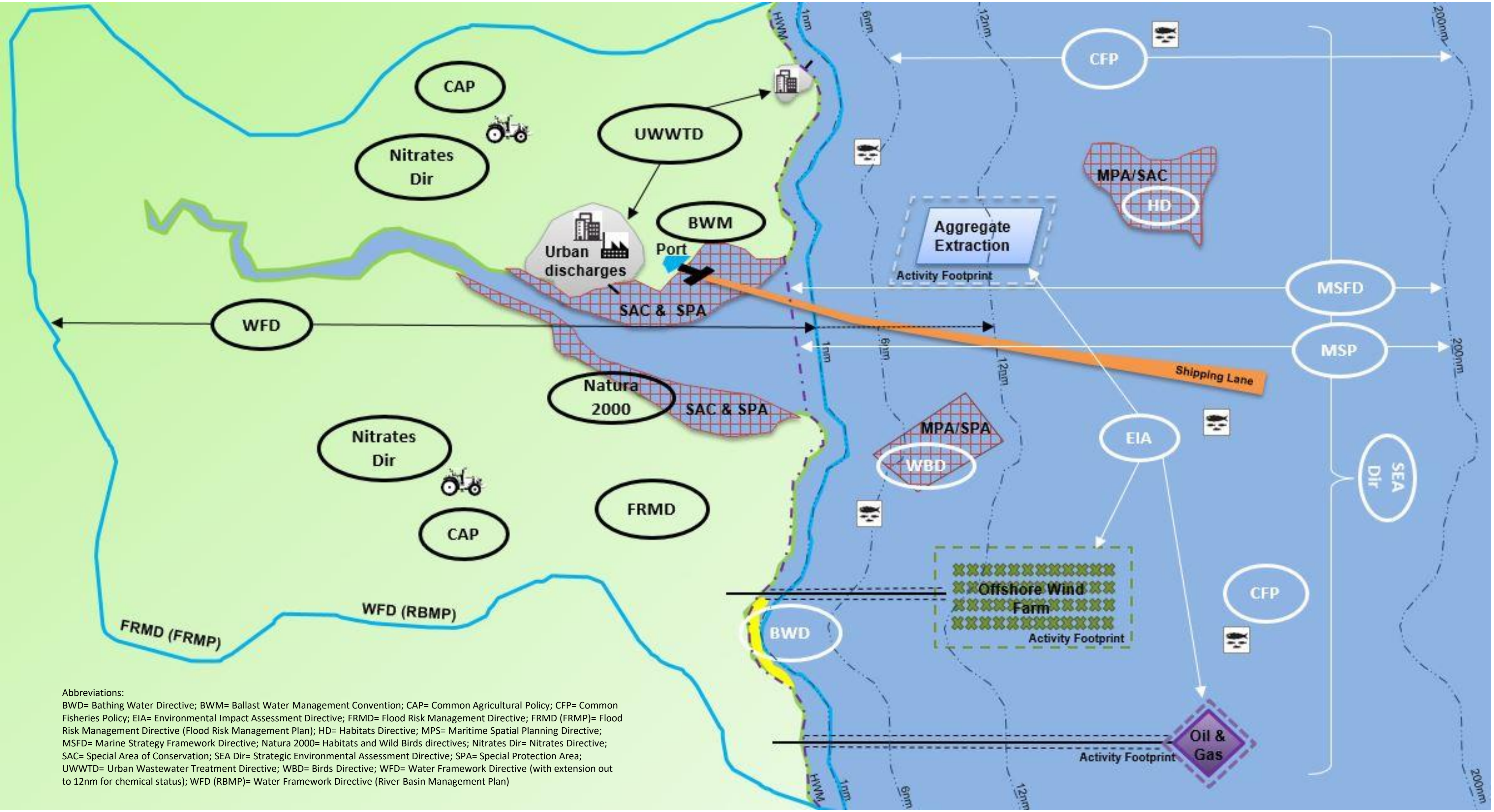
- A small area (the activity footprint)
- A middle sized area (pressures footprints)
- Middle to large areas (effects footprints)
- Whole estuaries
- Whole catchments/river basins
- Catchment-estuary-coastal areas
- Seas and sea regions
- Regional seas
- Areas Beyond National Jurisdictions
- The globe



The ‘*management response-footprint pyramid*’



(From Cormier, Elliott & Borja – 2022, Frontiers in Marine Science)



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

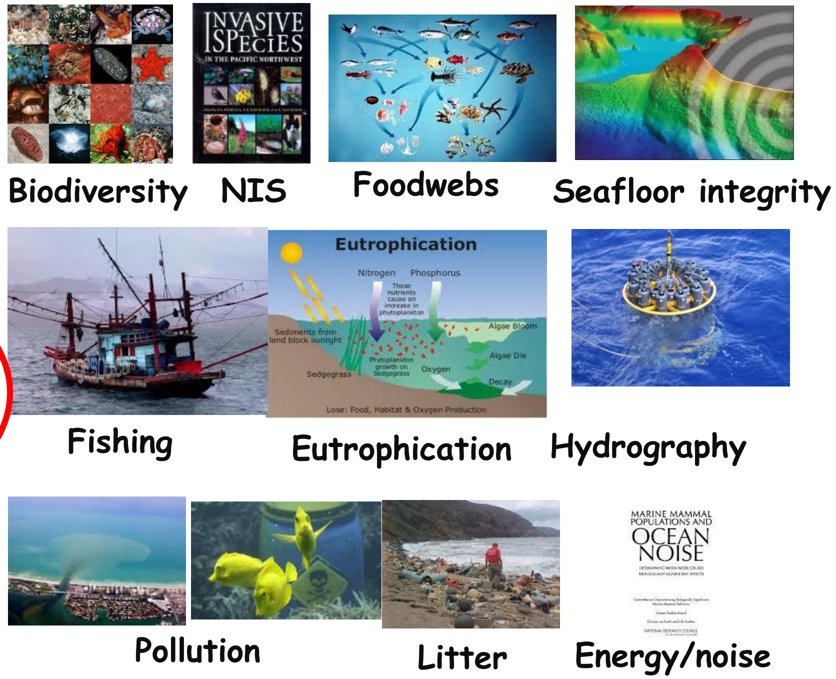
How are we managing it/them? - Responses (using management Measures) (R(M)) (Programmes of Measures in WFD/MSFD/UKMS)

- 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

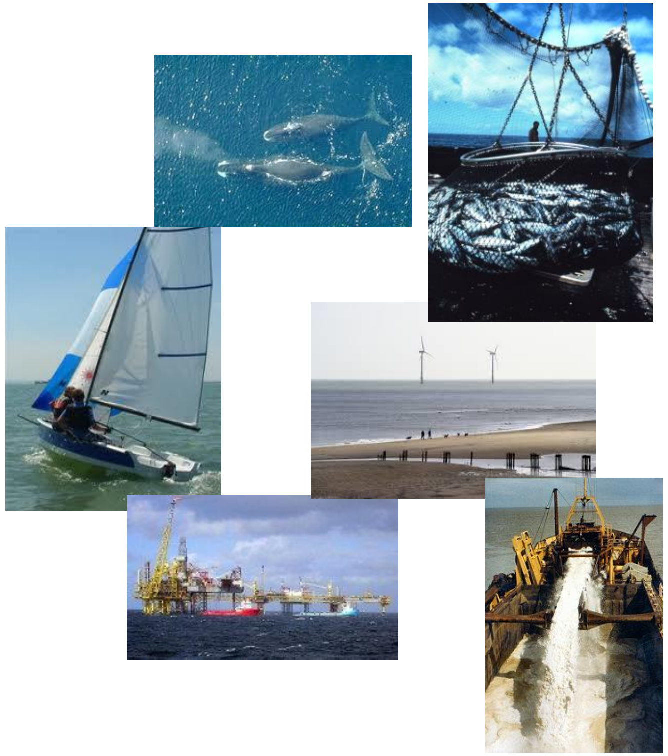
Cf.

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

Qualitative Descriptors



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.*

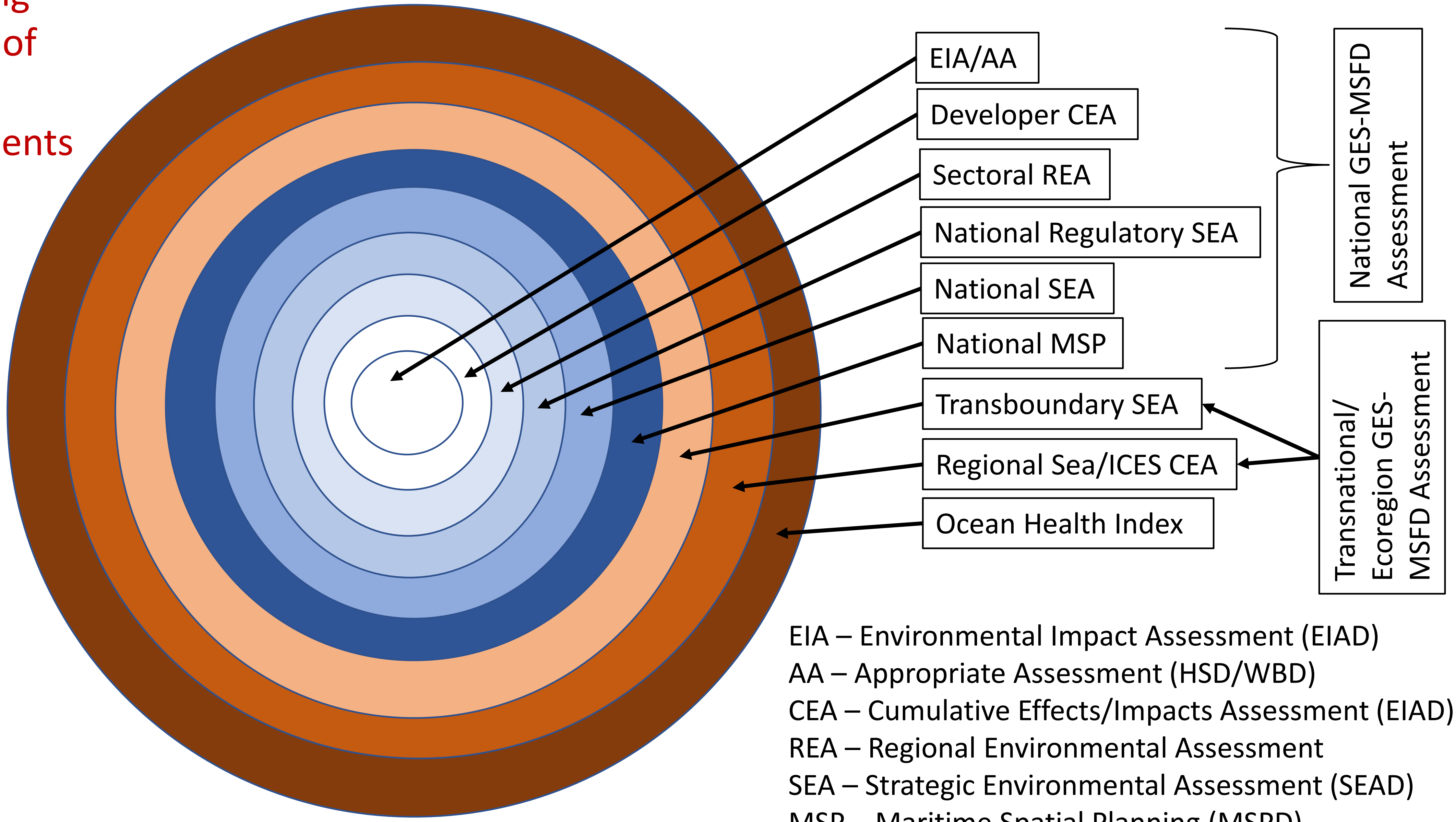


Framework Directive on Maritime Spatial Planning (MSP, 2014/89/EU)
(the marine blue growth directive!)

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

Increasing Spheres of Marine Assessments

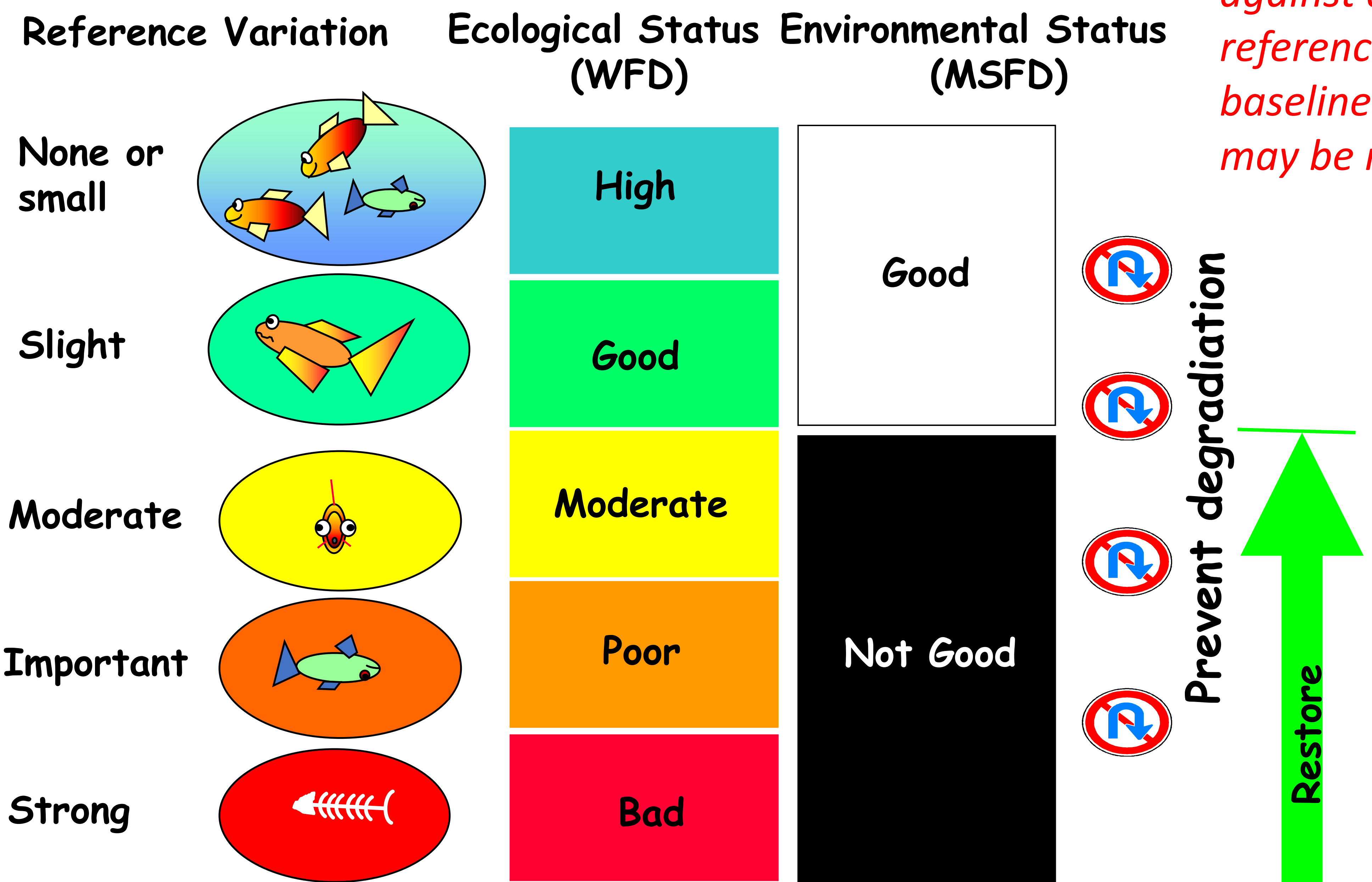


EIA – Environmental Impact Assessment (EIAD)
AA – Appropriate Assessment (HSD/WBD)
CEA – Cumulative Effects/Impacts Assessment (EIAD)
REA – Regional Environmental Assessment
SEA – Strategic Environmental Assessment (SEAD)
MSP – Maritime Spatial Planning (MSPD)
GES – Good Environmental Status (MSFD)

MarinePlan

GES4 SEAS

Comparison of the WFD and MSFD



N.B. Comparison against a reference or baseline which may be moving!

Definitions for Transboundary Analysis in Estuarine & 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***.

(Elliott, Borja & Cormier, 2023 OCMA)

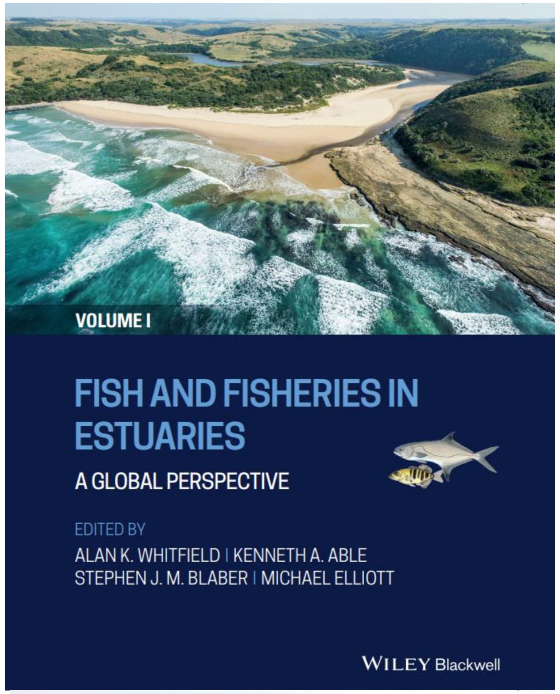
Challenge – how do we ensure the connectivity, coherence and/or equivalence between transboundary areas?

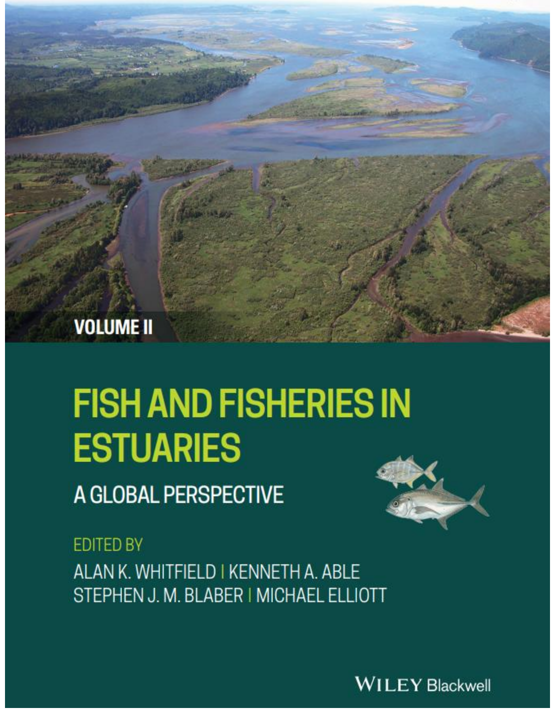
Typology of Marine Connectivity, Coherence and Equivalence
A. In natural sciences - Physico-chemical connectivity; Ecological connectivity; nature conservation coherence, equivalence and connectivity. ***B. In socio-economy*** - societal connectivity and equivalence; cultural connectivity and equivalence; 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)

Example of Estuarine Fishes

- The essence of an appropriate and expected structure and function of healthy and sustainable estuarine fish communities lies in achieving and maintaining ecological connectivity between adjacent ecosystems.
- This connectivity includes a knowledge of the associated components of, and links with, both the marine and catchment areas.
- Using estuary-associated fish species as examples, this presentation illustrates these concepts and shows the natural and social sciences aspects required to achieve healthy and sustainable estuarine fish populations and communities.
- **But management requires coherence and equivalence as well as connectivity.**



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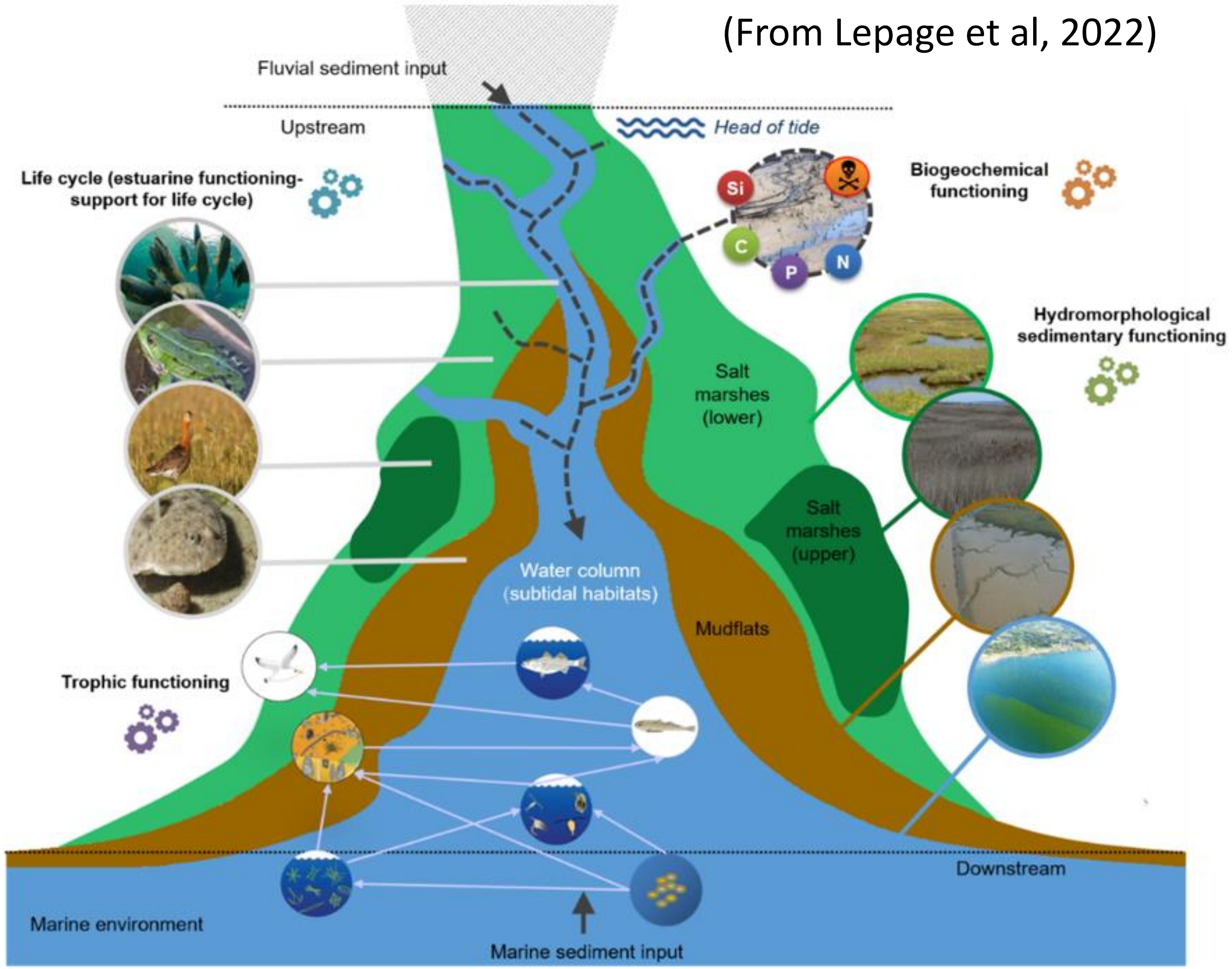
ELSEVIER

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]

	Meaning and relevance in an estuarine ecotone boundary* context
A. Connectivity, equivalence or coherence in natural sciences ***(i) Physico-chemical connectivity***	That the water characteristics and hydrographic patterns either side of the ecotone boundaries and between the areas on both sides of the boundaries are known and not distorted by temporary or permanent natural or human-created barriers occurring in one or both areas across the boundary.

(From Lepage et al, 2022)

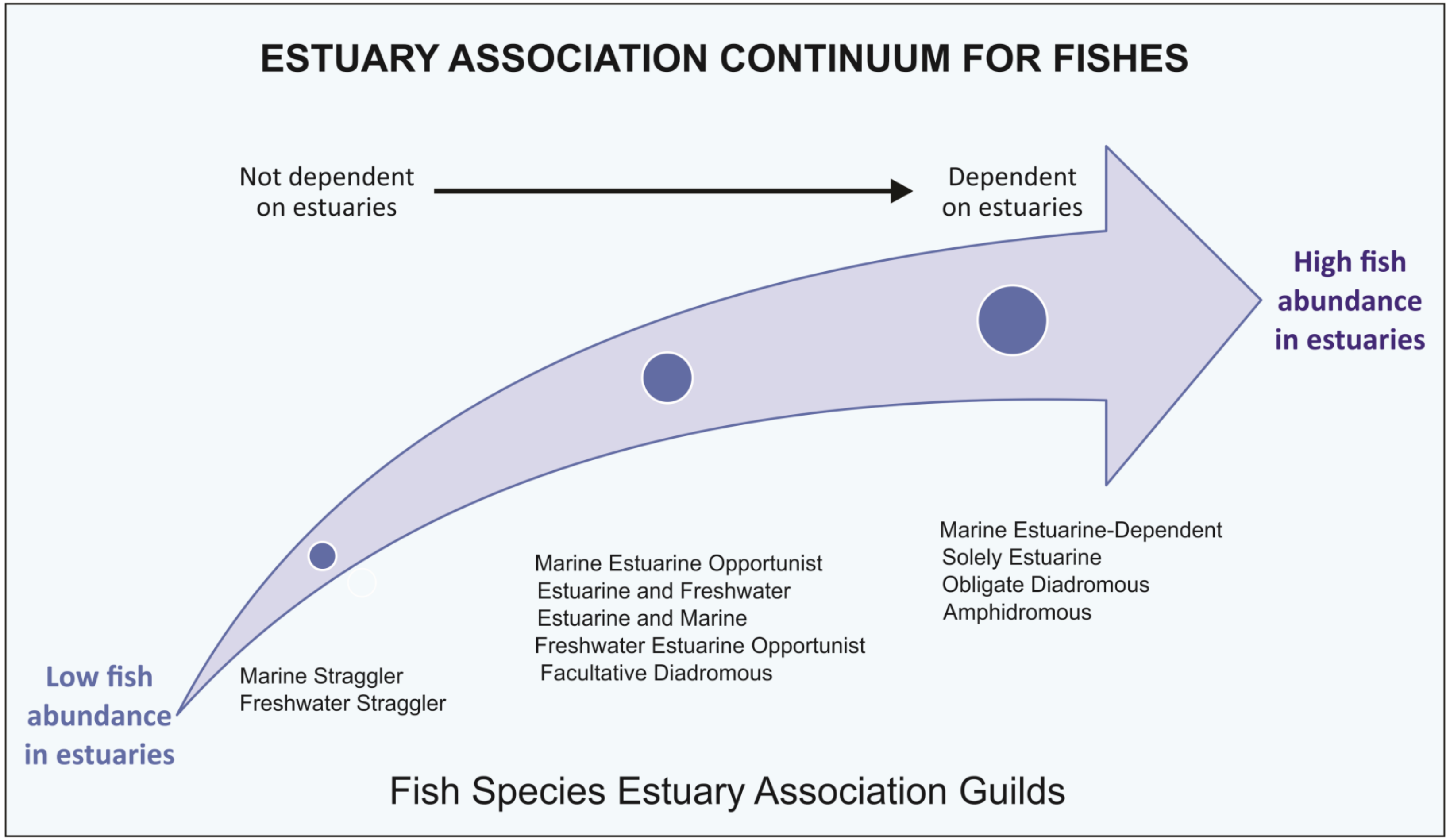


(*In this case, a boundary is regarded as any of the ecotones in the continuum from sea to estuary to catchment; where relevant a transboundary also refers to international borders as in international rivers, estuaries or catchments)

(Modified from Elliott, Borja & Cormier, 2023; Elliott and Whitfield, in prep.)

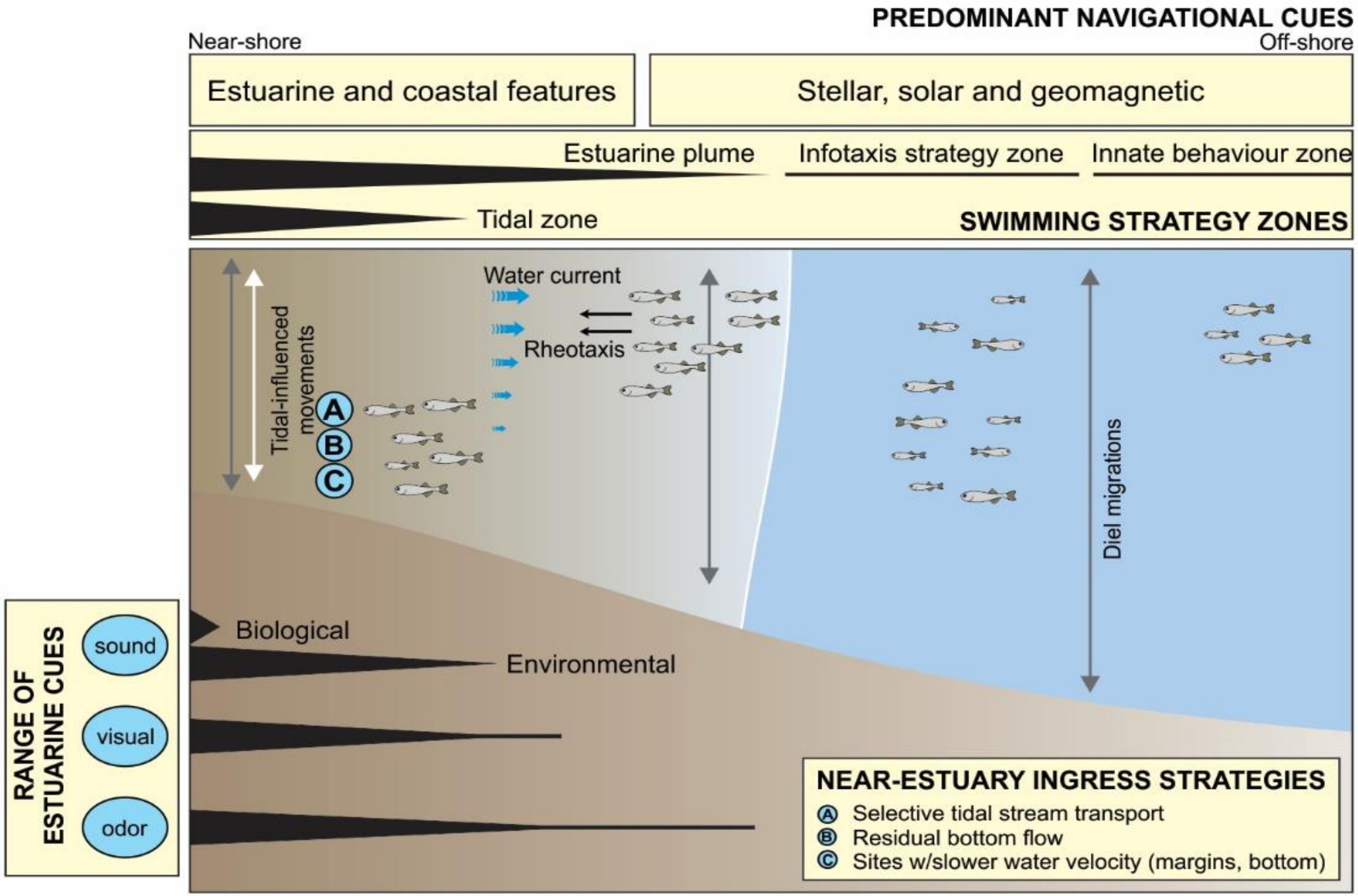
	Meaning and relevance in an estuarine ecotone boundary* context
(ii) Ecological connectivity	That the populations either side of the ecotones are connected either by migration patterns or by the larval and juvenile dispersal and settlement patterns, and that there are no temporary or permanent interferences created by natural or human structures or barriers preventing that connectivity.

(Modified from Elliott, Borja & Cormier, 2023)



(Source: Whitfield 2023)

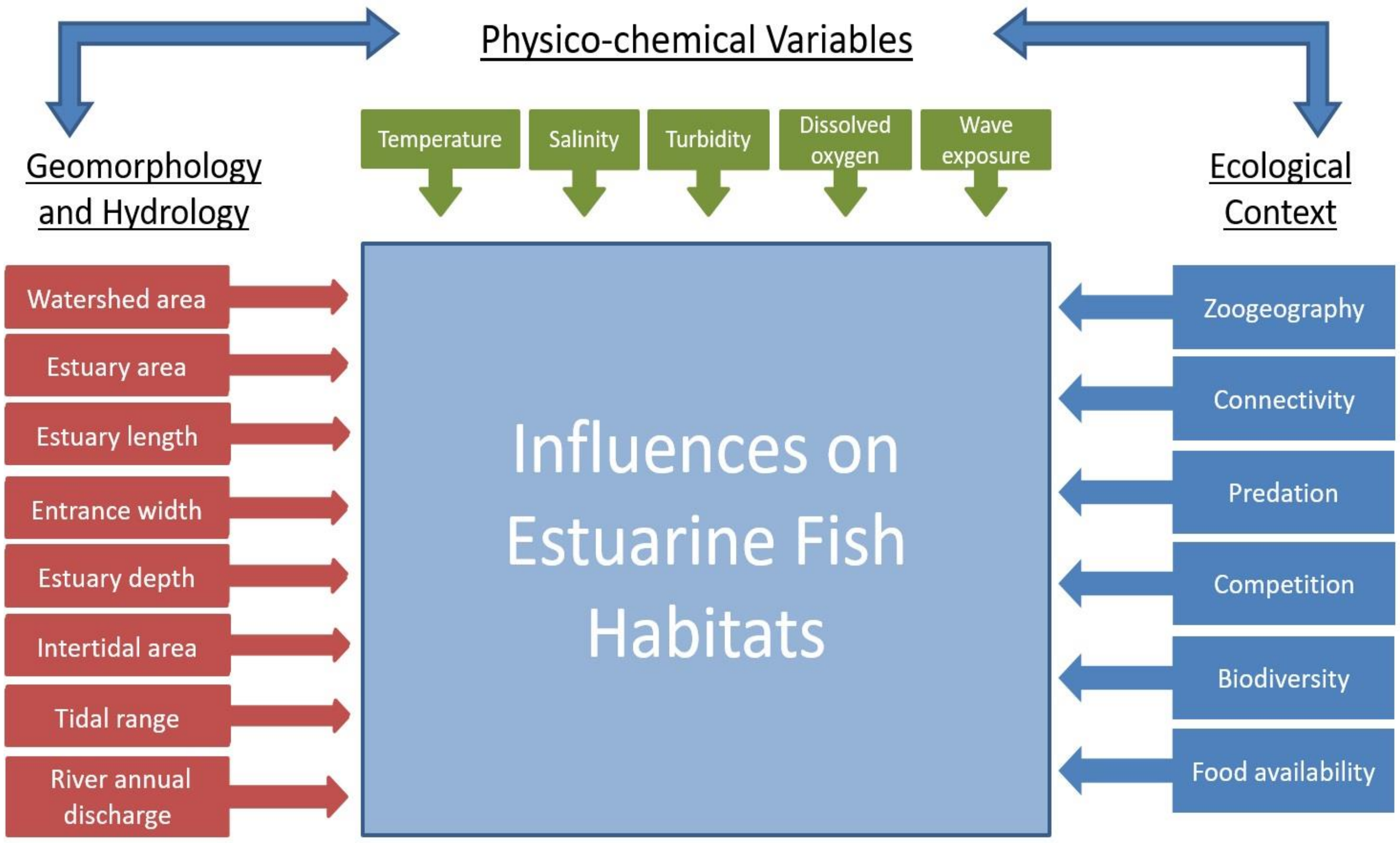
Recruitment of marine estuary-associated larvae – connectivity is key



(Source: Houde et al. 2022)

	Meaning and relevance in an estuarine ecotone boundary* context
(iii) Nature conservation coherence, equivalence and connectivity	That there are the same practices of nature conservation on each side of the ecotone boundaries in relation to species and habitats, that habitat units are treated equally, and that species are given the same protection, especially for highly mobile species.

(Modified from Elliott, Borja & Cormier, 2023)



(Source: Able et al. 2022)

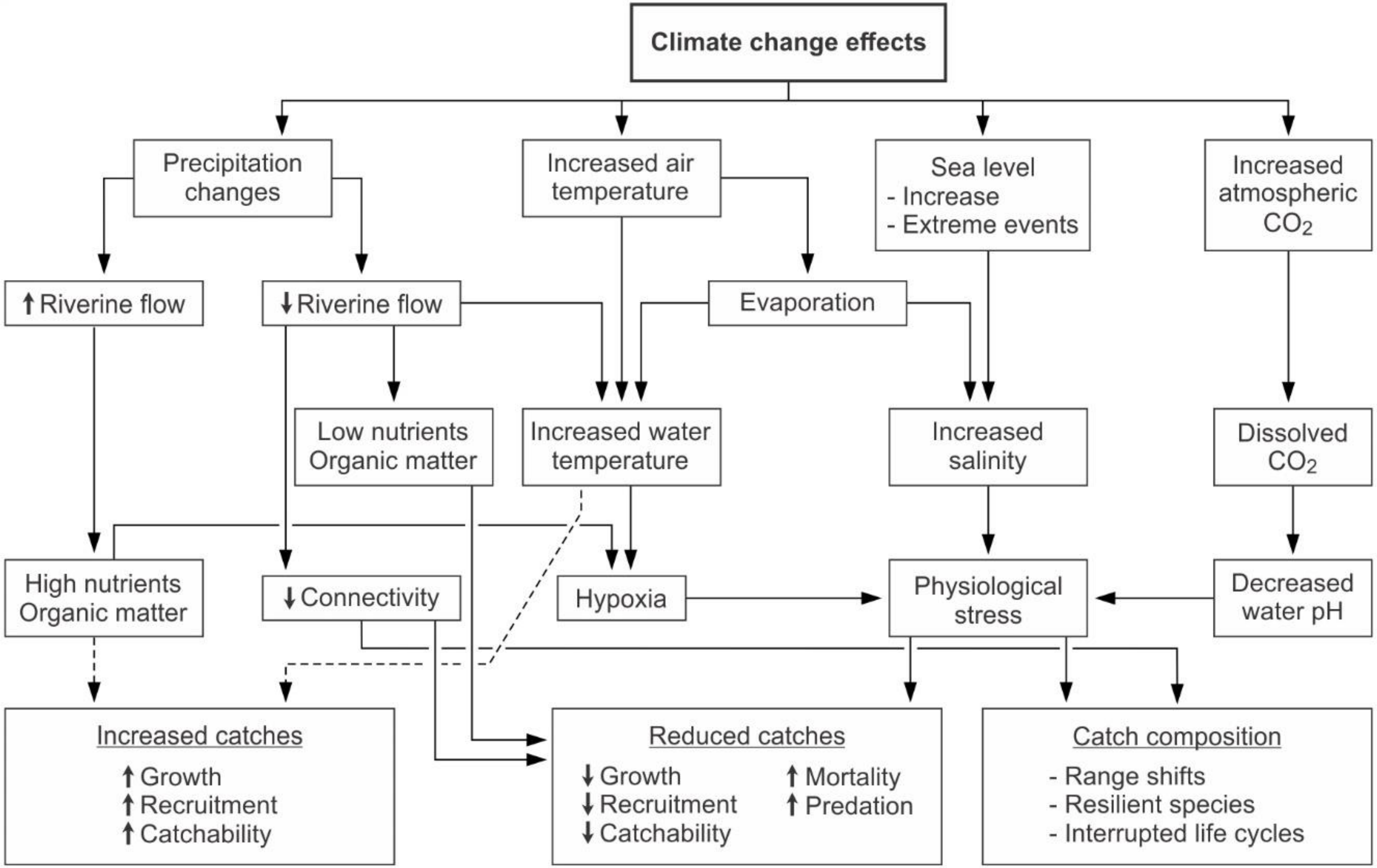
Connectivity, coherence and equivalence in management - Why are we managing?

- To stop adverse causes and consequences of change;
- To maintain and protect biodiversity, ecosystem structure and function;
- To support ecosystem services and societal goods and benefits;
- To allow activities and stop their consequences;
- To look for opportunities;
- To make up for the past environmental mistakes/abuse and to restore/recreate;
- To ensure adaptation to wider pressures such as climate change;
- Because the law tells us to;
- Because we are nice people and want to ('duty of care').

Barriers to connectivity – anthropogenic and climate change induced

- Ensuring such a connectivity involves removing, preventing or overcoming pressures, barriers and impediments to the ecological functional connectivity along the continuum between riverine, estuarine and marine systems.
- Those barriers may be physical structures (permanent barriers) or related to adverse water quality (temporary seasonal and/or spatial barriers).
- It also involves an understanding of how climate change may impact on current connectivity between estuaries and adjacent marine and freshwater aquatic ecosystems.

Climate change and estuarine fishes – connectivity will change

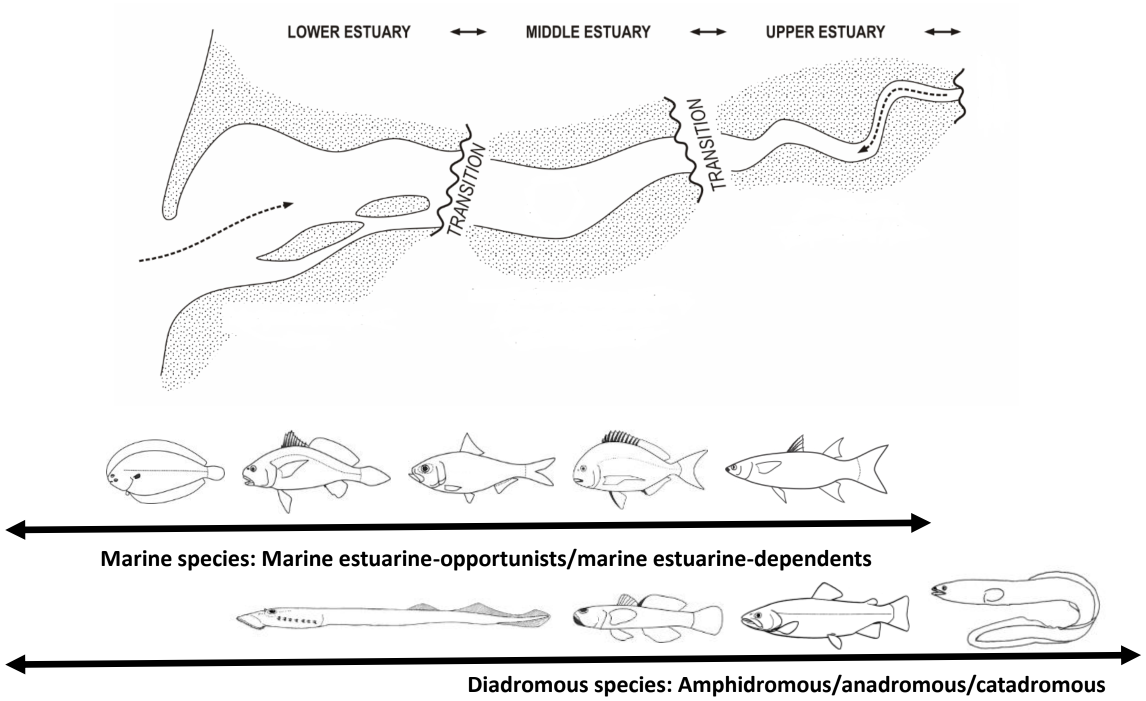


(Source: Gillanders et al. 2022)

Connectivity conclusions for fishes in estuaries

- Connectivity requires maintaining ecotones and determining the links across ecotone barriers;
- Physical barriers in rivers is a major issue but consider temporary (e.g. WQ) and permanent (e.g. structures) barriers;
- Ecological connectivity relies on physico-chemical connectivity;
- Catchment water quality and quantity very important;
- Estuarine pollution and habitat alteration impacts fish connectivity;
- Mouth configuration and closure important in some regions;
- Climate change will impact estuarine connectivity.

(Elliott and Whitfield, in prep.)



(Source: Whitfield et al. 2023)

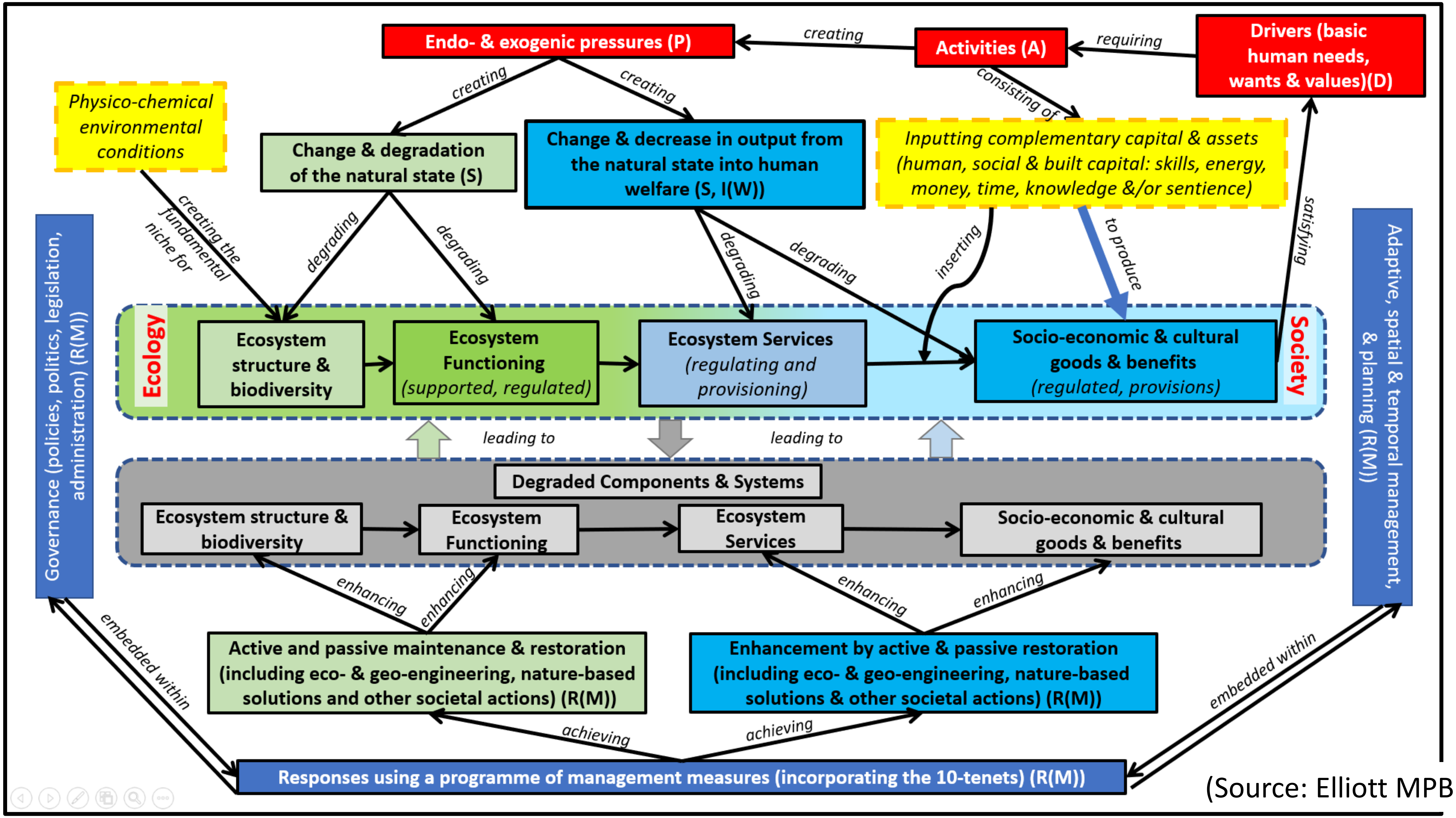
Connectivity, coherence and equivalence conclusions for estuarine policy and management

- Need increased understanding of estuarine ecosystem functioning and dependence to drive appropriate policy;
- Improved understanding of how policy can mitigate negative impacts of climate change on estuarine connectivity;
- Co-ordinate national and international efforts to improve estuarine policy on a global basis;
- Facilitate policy requirements for long-term monitoring of changing connectivity between aquatic ecosystems;
- Need to create policy that restores estuarine connectivity;
- Need for consistent management informed by consistent monitoring, assessment and reporting;
- Ensure there is coherence and/or equivalence across ecotone boundaries and between national and international water bodies;
- But: also consider and accommodate divergence.

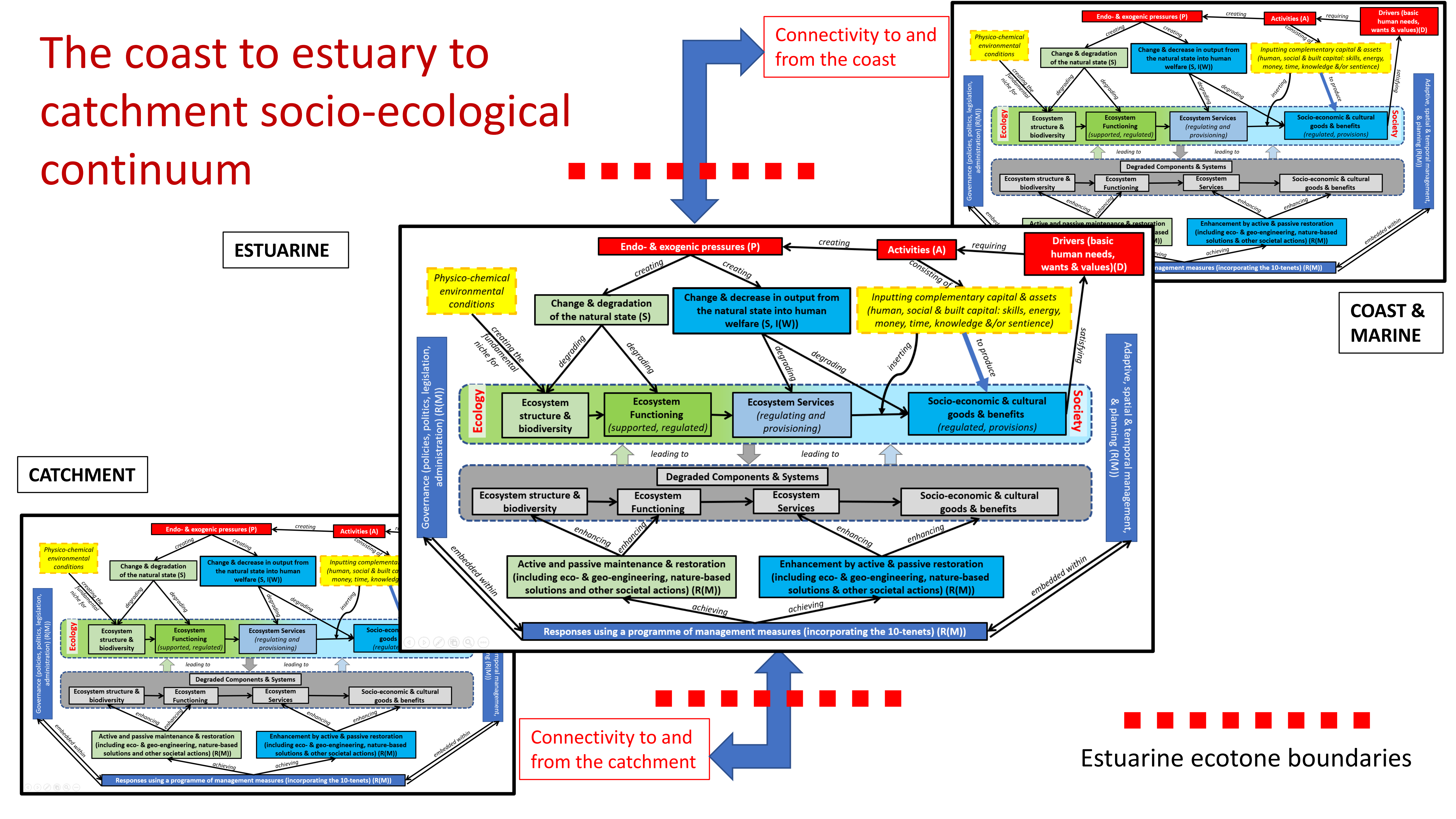
Challenges for Estuarine and Coastal Management:

- Where are the problems?
- What changes do they cause?
- What is the impact of these 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?
- What governance framework is there, what do stakeholders need?
- What can we do about the problems?
- Where are the risks and how to address them now and in the future?
- What are the governance successes, failures and implications?
- How ‘good’ is the decision-making?

Integrating ecology and society



(Source: Elliott MPB 2023)


The coast to estuary to catchment socio-ecological continuum
Connectivity to and from the coast
ESTUARINE
COAST & MARINE
CATCHMENT
Connectivity to and from the catchment
Estuarine ecotone boundaries
Endo- & exogenic pressures (P)
creating
Activities (A)
requiring
Drivers (basic human needs, wants & values)(D)
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
inserting
to produce
satisfying
Governance (policies, politics, legislation, administration) (R(M))
Adaptive, spatial & temporal management, & planning (R(M))
Ecology
Ecosystem structure & biodiversity
Ecosystem Functioning (supported, regulated)
Ecosystem Services (regulating and provisioning)
Socio-economic & cultural goods & benefits (regulated, provisions)
Society
leading to
Degraded Components & Systems
Ecosystem structure & biodiversity
Ecosystem Functioning
Ecosystem Services
Socio-economic & cultural goods & benefits
enhancing
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))
achieving
embedded within
Responses using a programme of management measures (incorporating the 10-tenets) (R(M))

Unbounded Boundaries:

- The concept of difficulties in defining the geographical (spatial and temporal) boundaries of the transitional waters and the definitions of structural and functional change due to external and internal influences.
- Many physico-chemical and ecological components in TraC waters are influenced by features inside the catchments and at sea.
- Areas may fail Directives through external factors beyond their control (force majeure).

Moving Baselines:

- Change has to be measured against agreed indicators, reference conditions, thresholds and trigger points.
- Change (a ‘signal’) has to be measured against the inherent spatial and temporal variability (‘noise’).
- Climate change is both increasing that ‘noise’ and moving those baselines.

Summary

- Importance of paradigms which synthesise our knowledge of the structure and functioning of transitional and coastal waters and their management.
- TraC waters have two overriding features operating in space and time: firstly, the waters are inherently and highly variable and, secondly, they function solely because of their connectivity.
- The variability is on spatial and temporal (daily, lunar, seasonal and annual) scales and occurs both in their natural (physical, chemical and biological) features and in their anthropogenic features.
- Superimposed on these shorter timescales are the long-term climatic and geological scale changes. Inherent to the spatial scales are the geographical links which will include whole catchments and may cross global hemispheres such as major migrations of estuarine fishes and wading birds.

Summary (cont.)

- The management of the estuaries and coastal waters relies on detecting and preventing adverse changes due to human influences along or as the result of these temporal and spatial scales.
- Hence that detection has to be performed against the high variability (the confounding signal to noise ratio), the wide boundaries (in which natural or anthropogenic factors operate far outside the estuary or coast in question), and the need to accommodate changes to baselines or targets (against which change is judged and which need to be altered to accommodate climate change).
- Importantly there are several important governance instruments which require such changes to be detected and managed but have to accommodate the ‘moving baselines’ and ‘unbounded boundaries’.

A premise –

“changing systems are not a problem for the ecology as it will adjust to any new situation and create a new equilibrium, they are only a problem for society, i.e. we might not be able to obtain the societal benefits from ecosystem services that we wish to and we may not like the new ecology but eventually we will have to accept it”

The challenge -

“for management to deal with especially unpredictable exogenic unmanaged pressures when it cannot manage the causes but can only respond to the consequences; it has to realise what is manageable and what is not” https://www.iecs.ltd

Thanks for listening!

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HorizonEurope Projects:

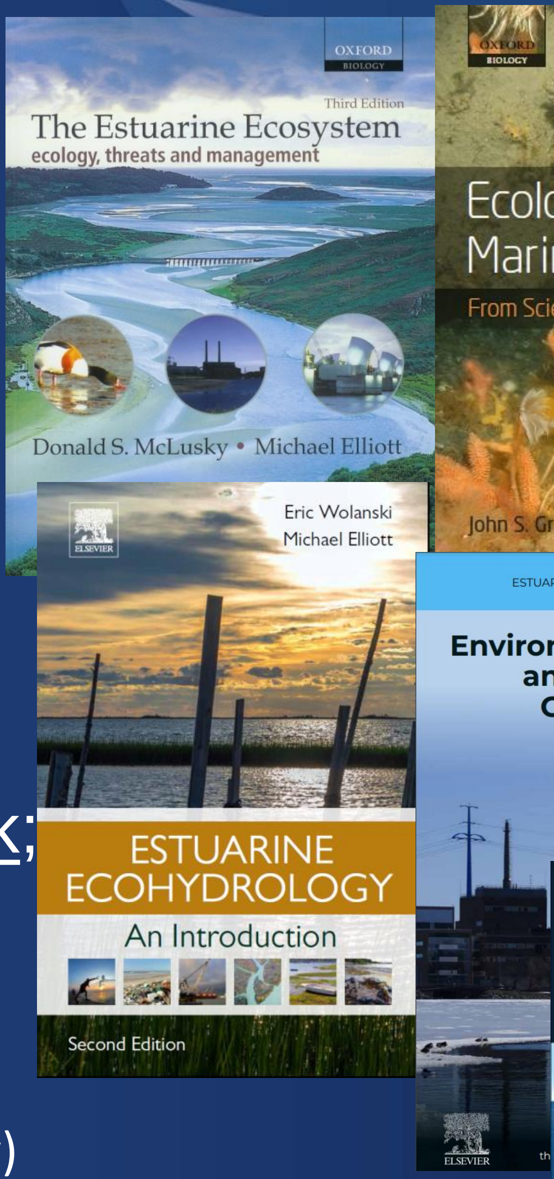
GES4SEAS (led by AZTI, Spain)

MarinePlan (led by TI, Germany)

MarineSABRES (led by UCC, Ireland)

MARBEFES (led by IOPAN, Poland)

GuardIAS (led by UAegean, Greece)



7 volumes – March 2024)