The value of biodiversity – natural and social science perspectives

Professor Mike Elliott[1,2], Dr Daryl Burdon[1,3], Dr Anita Franco[1,4] and Professor Jonathan Atkins[1,5]

[1] International Estuarine & Coastal Specialists (IECS) Ltd, Leven HU17 5LQ, UK

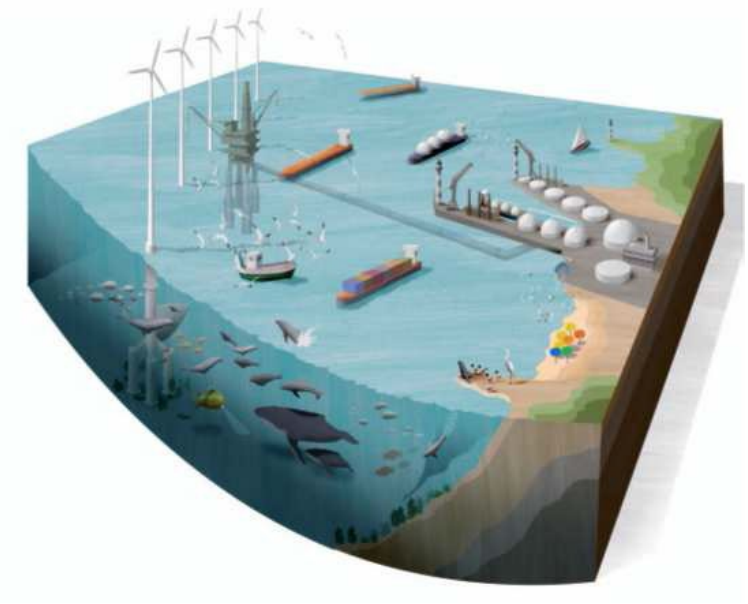
[2]Department of Environmental Sciences, University of Hull, Hull HU6 7RX, UK

[3]Daryl Burdon Ltd, Marine Research, Teaching & Consultancy, Willerby, Hull, UK

[4]Anita Franco, Estuarine & Marine Ecological Consultant, Hull, UK

[5]Hull University Business School, University of Hull, Hull, UK

Challenges for estuarine/marine science & management:

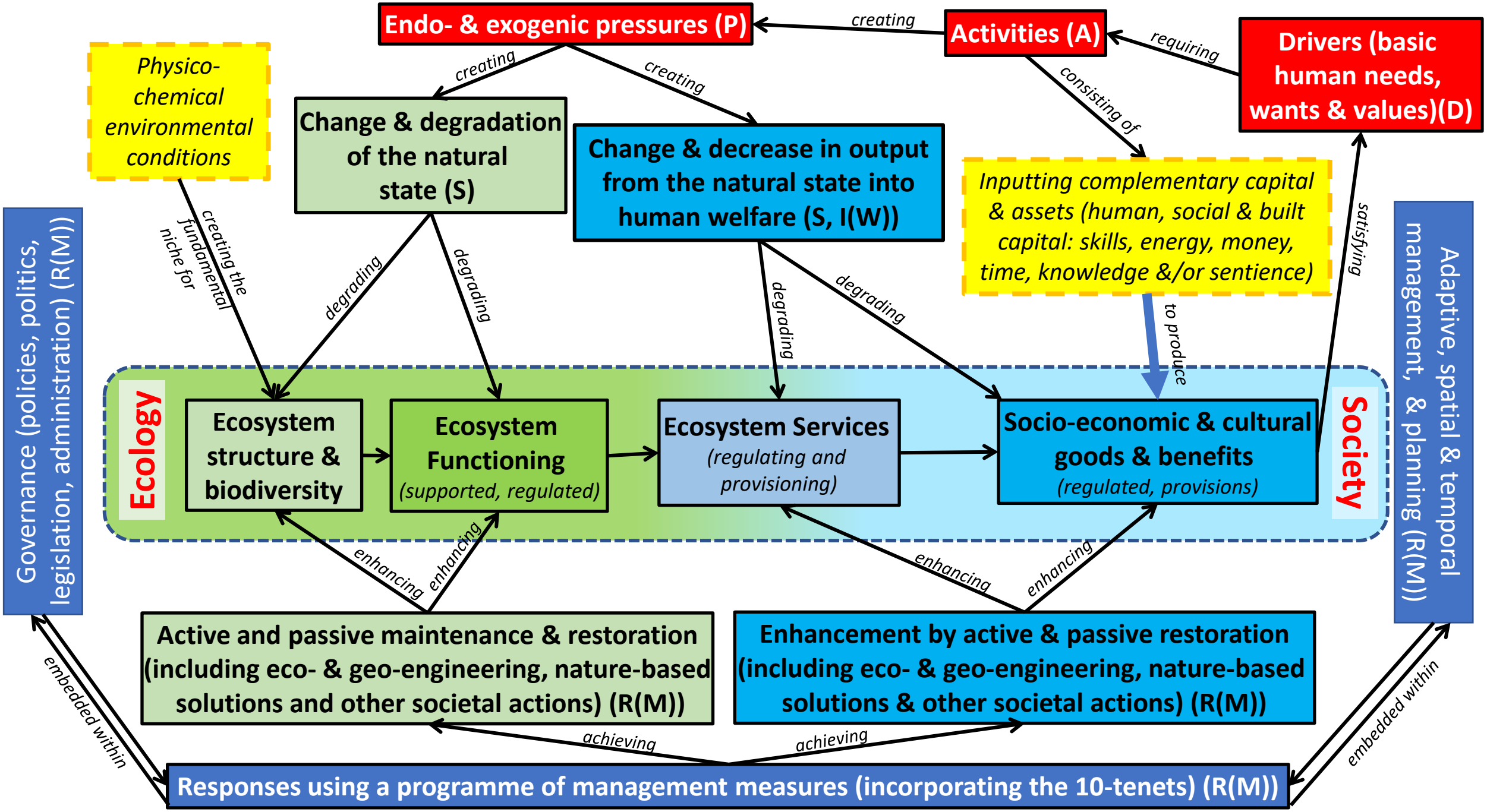


There is only one big idea: *how to maintain and protect ecological structure and functioning while at the same time allowing the system to produce ecosystem services from which we derive societal benefits.*

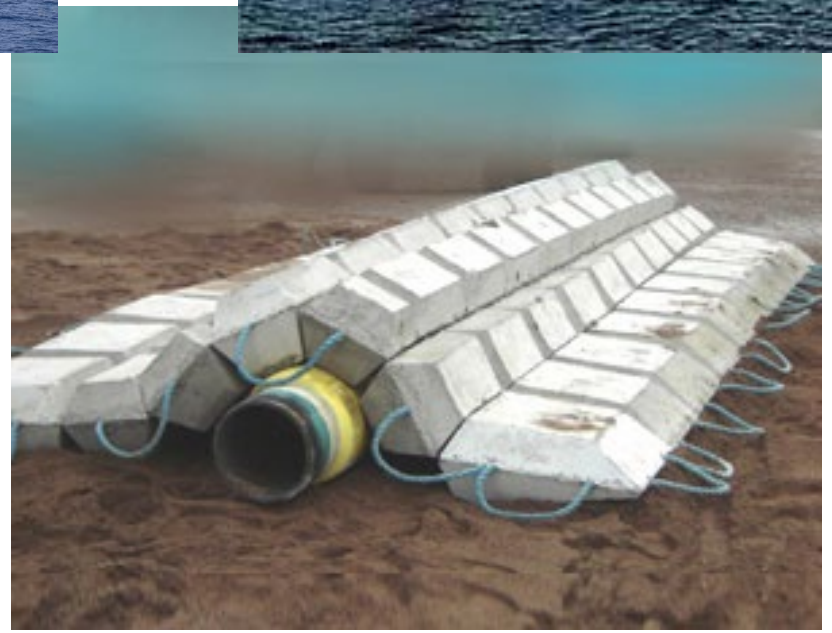
- Recovery/coping with historical legacy
- Endangered coastal and marine ecosystem functions
- Legal & administrative framework
- Economic prosperity and delivery of societal benefits
- Coping with climate change & moving baselines

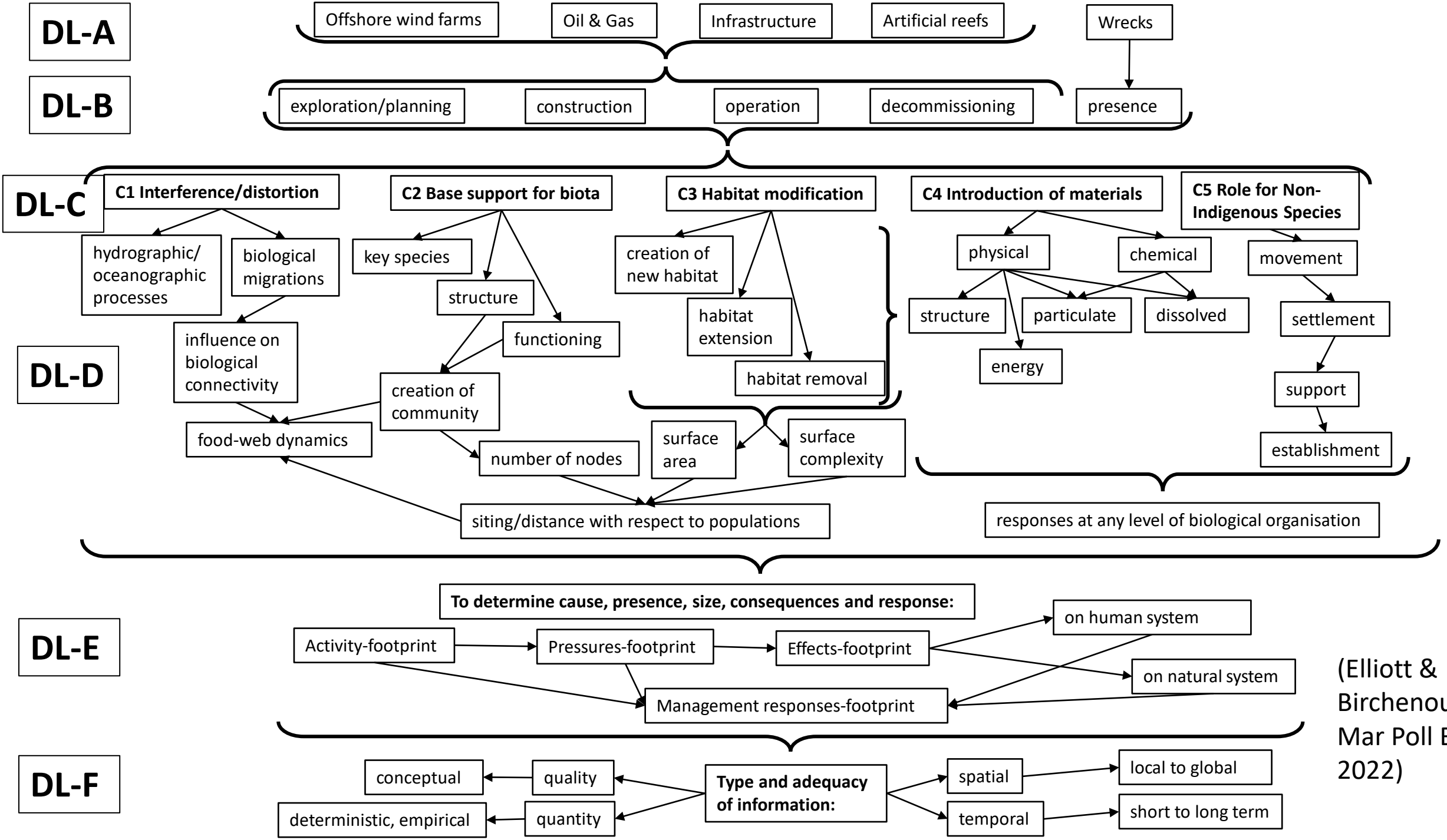
In other words:

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


Endo- & exogenic pressures (P)
creating
Activities (A)
requiring
Drivers (basic human needs, wants & values)(D)
Physico-chemical environmental conditions
creating
creating
Change & degradation of the natural state (S)
Change & decrease in output from the natural state into human welfare (S, I(W))
consisting of
Inputting complementary capital & assets (human, social & built capital: skills, energy, money, time, knowledge &/or sentience)
satisfying
Governance (policies, politics, legislation, administration) (R(M))
creating the fundamental niche for
degrading
degrading
degrading
degrading
to produce
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
enhancing
enhancing
enhancing
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))
embedded within
achieving
achieving
embedded within
Responses using a programme of management measures (incorporating the 10-tenets) (R(M))

Oil and gas and offshore wind infrastructure operation and decommissioning

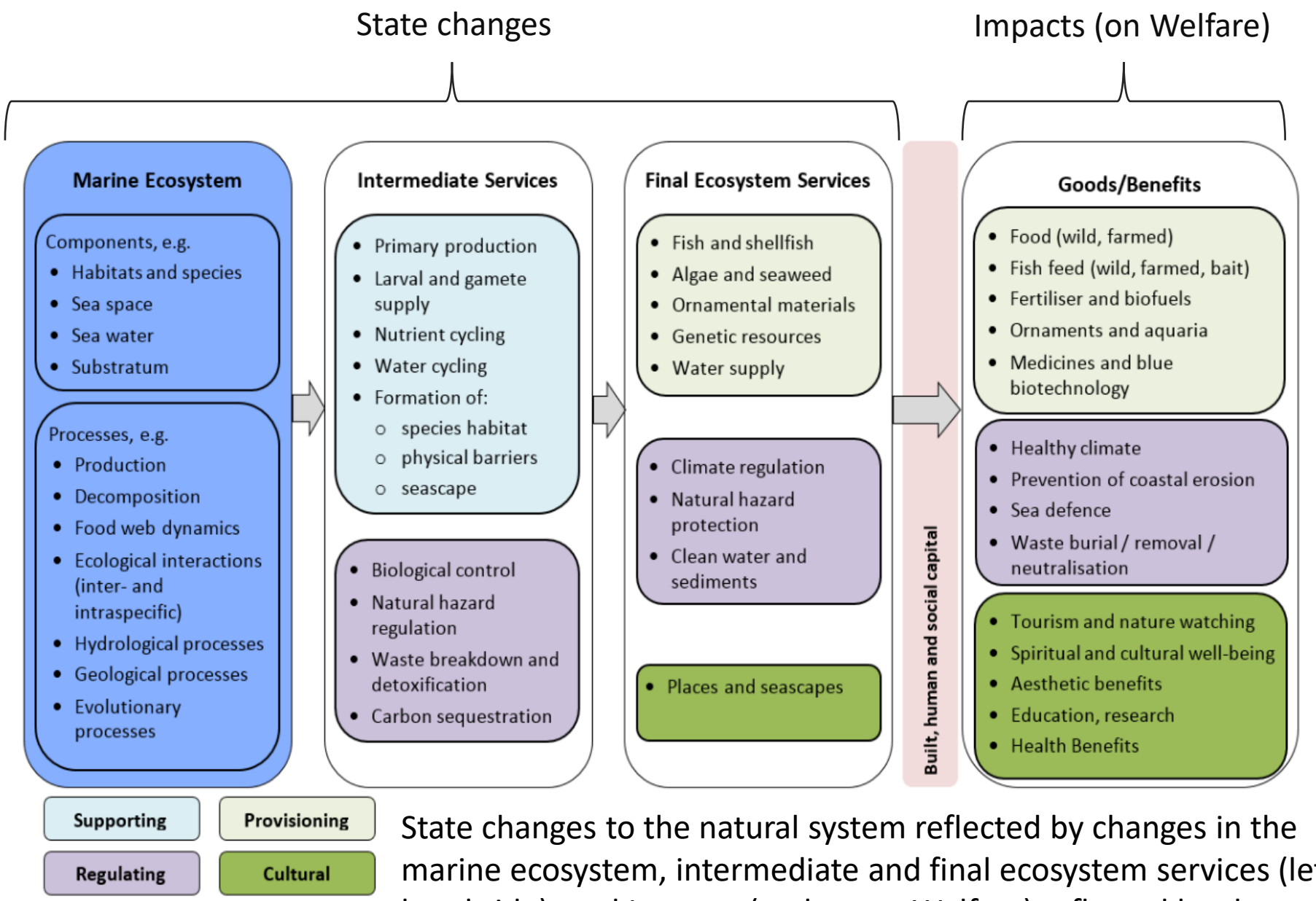




(Elliott & Birchenough, Mar Poll Bull 2022)

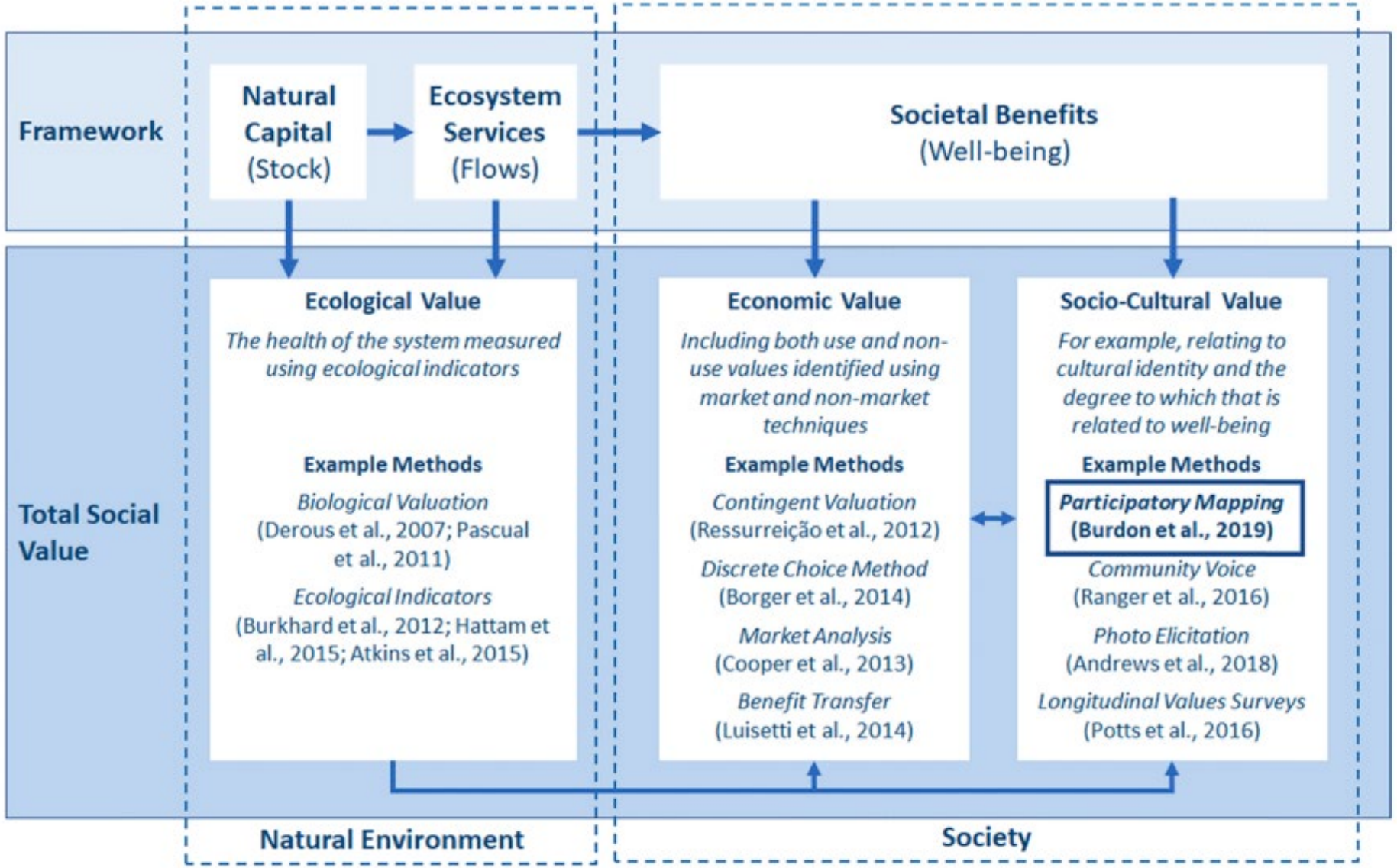
(From Burdon et al., Mar. Poll. Bull., 2018)

	Activity		Pressure																					
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
			Vibration	Above water noise	Transition elements & organo-metal (e.g. TBT) contamination	Hydrocarbon & PAH contamination	Synthetic compound contamination	Noise changes	Introduction of light or shading	Death or injury by collision	Visual disturbance	Introduction or spread of invasive non-indigenous species (INIS)	Introduction of microbial pathogens	Litter	Abrasion/disturbance at the surface of the substratum	Penetration and/or disturbance of the substratum below the surface	Changes in suspended solids (water clarity)	Smothering and siltation rate changes (light)	Smothering and siltation rate changes (heavy)	Physical change (to another substratum type) - change in sediment type/Folk class	Physical change (to another substratum type) - change in substrata	Water flow (tidal current) changes - local	Barrier to species movement (behaviour, reproduction)	Habitat structure changes - removal of substratum (extraction)
1	Common to all decom scenarios	Vessel movements	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	-	-	-	-	-	-
2	Common to all decom scenarios	Embedment Anchoring	-	-	-	-	-	-	-	-	-	-	-	-	✓	✓	✓	✓	✓	-	-	-	-	-
3	Common to all decom scenarios	Suction Anchoring	✓	-	-	-	-	✓	-	-	-	-	-	-	✓	✓	✓	✓	✓	-	-	-	-	-
4	Common to all decom scenarios	Survey sampling	-	-	-	-	-	-	-	-	-	-	-	-	✓	✓	-	-	-	-	-	-	-	-
5	Common to all decom scenarios	Overtrawl survey	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	-
6	P&A	Making safe	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	P&A	Rig placement	-	-	-	-	-	-	-	-	-	-	-	-	✓	✓	✓	✓	✓	✓	-	✓	-	-
8	P&A	Rig removal	-	-	-	-	-	-	-	-	-	-	-	-	✓	✓	✓	✓	✓	✓	-	✓	-	-
9	Top side removal	Detachment of top side	✓	✓	-	-	-	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	Subsea removal	Digging out infrastructure (excavation around jacket footings, pipeline sections, risers etc)	-	-	✓	✓	-	-	-	-	-	-	-	-	✓	✓	✓	✓	✓	✓	-	✓	-	-
11	Subsea removal	Placement of stabilisation material	-	-	-	-	-	-	-	-	-	-	-	-	-	-	✓	✓	✓	✓	✓	-	-	-
12	Subsea removal	Removal of the infrastructure (cutting / explosives)	✓	✓	-	-	-	✓	✓	-	-	-	-	-	-	-	✓	✓	✓	-	✓	-	✓	-
13	Subsea removal	Removal of the infrastructure (pipelines, jacket footings (non-derogation), risers, mattresses) (impact on seabed)	✓	-	-	-	-	✓	-	-	-	✓	✓	-	-	-	-	-	✓	✓	✓	-	-	-
14	Subsea removal	Reinjection of cuttings	✓	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	Subsea In-situ	Concrete Gravity Based Structure (remaining in place)	-	-	✓	✓	✓	-	-	-	-	✓	✓	-	-	-	-	-	-	✓	✓	✓	-	✓
16	Subsea In-situ	Footings (derogation) (remaining in place)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	✓	✓	✓	-	✓
17	Subsea In-situ	Buried mattresses (remaining buried)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	✓	-	-	-
18	Subsea In-situ	Pipeline trenched and buried (remaining as buried)	-	-	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	Subsea In-situ	Pipeline rock dump	-	-	✓	✓	-	-	-	-	-	-	-	-	✓	-	✓	✓	✓	✓	✓	✓	-	✓
20	Subsea In-situ	Pipeline open trench (remaining open)	-	-	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	✓	✓	✓	-	-
21	Subsea In-situ	Cutting a trench (trenching a surface pipeline)	✓	-	-	-	-	-	-	-	-	-	-	-	✓	✓	✓	✓	✓	✓	-	✓	-	✓
22	Subsea In-situ	Seabed preparation (corridor for pipeline)	-	-	-	-	-	-	-	-	-	-	-	-	✓	✓	✓	✓	✓	-	-	-	-	-
23	Subsea In-situ	Drill cuttings (undisturbed)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	Subsea In-situ	Drill cuttings (disturbed)	-	-	✓	✓	-	-	-	-	-	-	-	-	✓	-	-	-	✓	✓	-	✓	-	-



Being revised!

State changes to the natural system reflected by changes in the marine ecosystem, intermediate and final ecosystem services (left hand side), and Impacts (on human Welfare) reflected by changes to the provision of Societal goods and benefits (right hand side) (Elliott et al., 2017, modified and expanded from Turner et al., 2015).



Conceptual framework linking natural capital, ecosystem services and societal benefits with Total Social Value and valuation methods (from Burdon et al., 2022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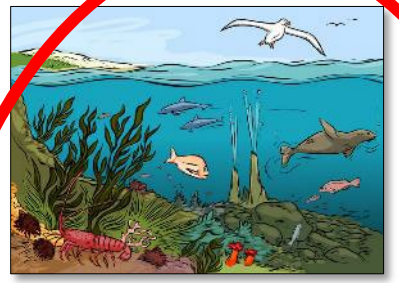
Linking natural capital, benefits and beneficiaries: The role of participatory mapping and logic chains for community engagement

D. Burdon [a,b,*], T. Potts [c], S. Barnard [b,d], S.J. Boyes [b], A. Lannin [e]

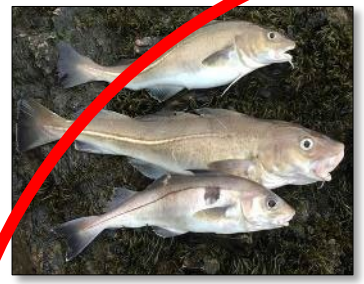
The estuarine, coastal and marine environments can be valued in a continuum covering three terms: ecological valuation, socio-ecological valuation and socio-economic valuation.

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



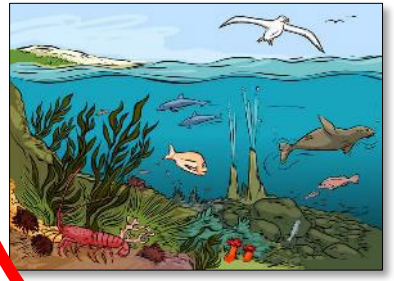
Ecosystem Services (Flows)

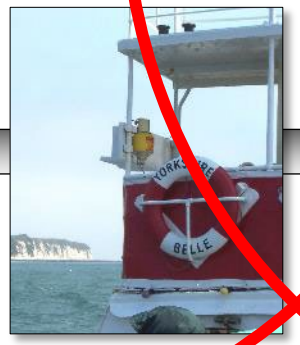
Socio-ecological valuation

Input of Human Capital*

Societal Goods & Benefits (Well-being)

Socio-economic 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)

Ecological valuation – at genetic, species, community, habitat and ecosystem levels of biological organisation

'Ecological value' can be defined as: 'the intrinsic value of biodiversity, without reference to anthropogenic use; it is measured in non-monetary terms'.

See Derous et al 2007 - https://biblio.ugent.be/publication/366992/file/6796068.pdf

Ecological Valuation assesses the value of key habitats and species with reference to their:	
Fragility	Are there any delicate habitats and species?
Irreplaceability	Is the component a fundamental part of the system with major consequences in ecological terms (*1) if it is lost?
Vulnerability/sensitivity	How vulnerable or sensitive is the component to specific natural hazards and pressures (*2)?
Pristineness/naturalness	How untouched are they?
Uniqueness	Are they unique in local, national, regional or global terms?
Rarity	How rare are they in local, national, regional or global terms?

*1 – if this is in societal terms then this refers to anthropogenic valuation; *2 – if this relates to activities or anthropogenic pressures then it is societal valuation

Socio-ecological valuation

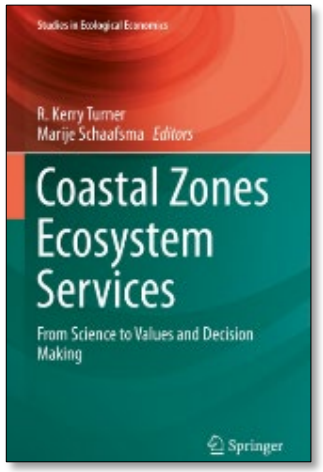
- Socio-ecological valuation relates to the development of ecosystem services from those biological levels of organisation and based on supporting and regulating aspects of ecosystems.
- In turn these give the provisioning services which in turn can deliver societal goods and benefits, including cultural benefits.
- That socio-ecological valuation then ensures that individual and societal welfare and wellbeing can be measured and safeguarded.

Socio-economic Valuation

- Socio-economical valuation relates to the societal and national macro-economics,
- including the employment related to the environment, the economic aspects related to public health and public safety,
- and the protection of people and coastal assets from both endogenic managed pressures and exogenic managed pressures such as climate change.
- The types of valuation can be made in
  - monetary/non-monetary,
  - material/non-material and
  - tangible/non-tangible terms
  - and constitute both natural and human capital.

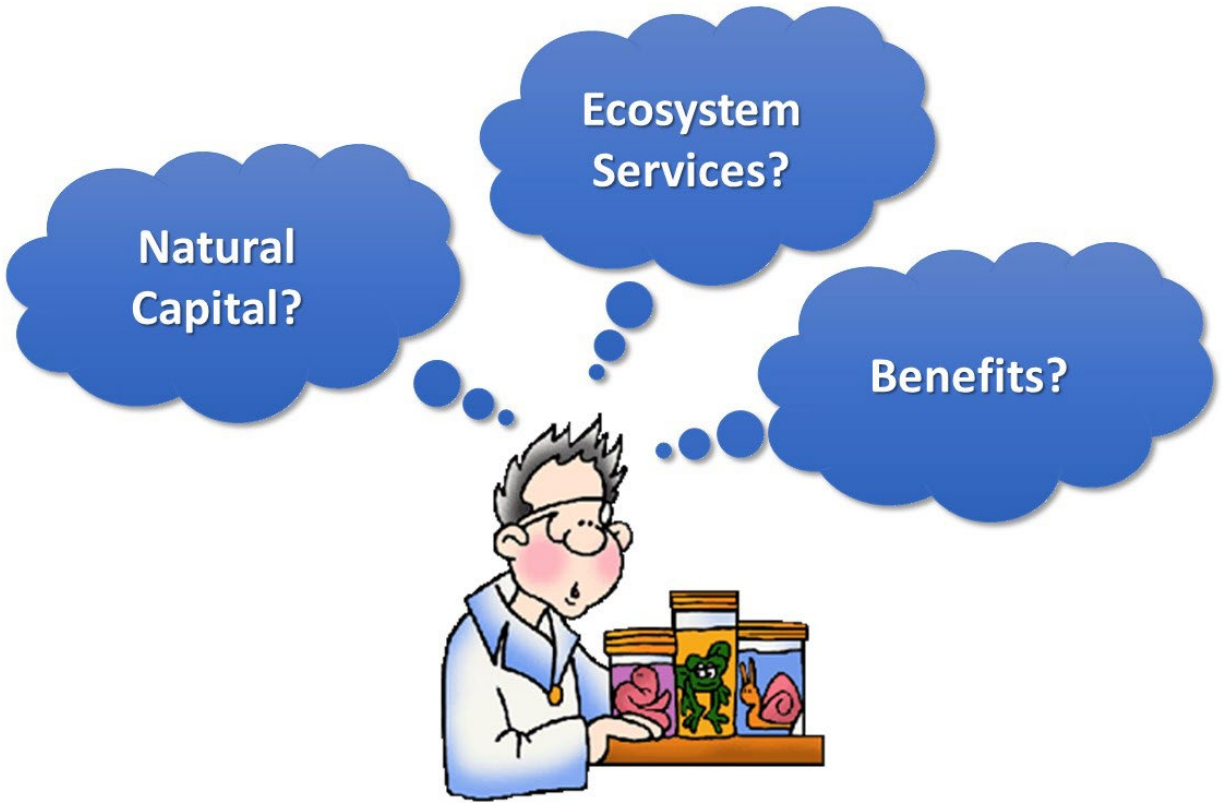
Total Economic Value

- TOTAL ECONOMIC VALUE
  - USE VALUE
    - Non-consumptive use value
      - Aesthetic / educational use value
      - Distant use values
    - Consumptive use value
  - OPTION AND QUASI OPTION VALUE
  - NON USE VALUE
    - Existence value
    - Bequest value
    - Altruistic value



- Economic values are measured in **monetary terms** (£, $, €).
- Total Economic Value comprises both **use and non-use values**.
- Economic values can be captured through the **Willingness to Pay (WTP)** for goods and services or their **Willingness to Accept (WTA)** compensation for a disservice.

Natural Capital, Ecosystem Services, Benefits



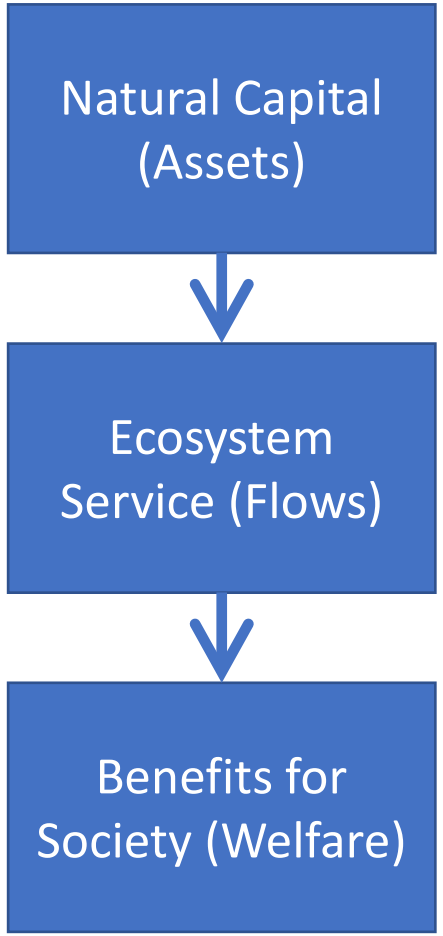
Natural Capital Committee, 2017. How to do it: A natural capital workbook.

Natural Capital: "The elements of nature that directly or indirectly produce value to people, including ecosystems, species, freshwater, land, minerals, the air and oceans, as well as natural processes and functions".

Ecosystem Services: "Functions and products from nature that can be turned into benefits with varying degrees of human input".

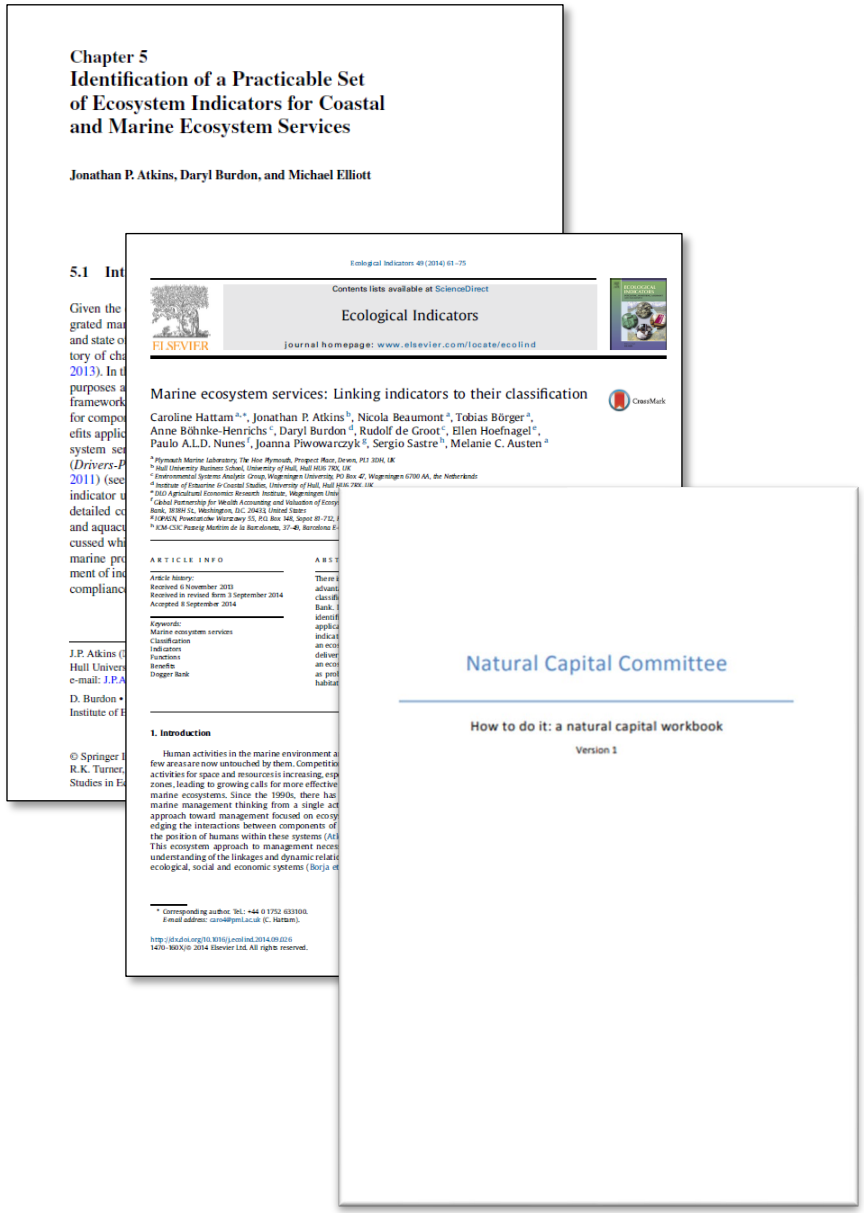
Benefits: "Changes in human welfare (or well-being) that result from the use or consumption of goods, or from the knowledge that something exists".

Natural Capital, Ecosystem Services, Benefits



- Understanding the links between natural capital, ecosystem services and benefits is a **fundamental part of applying an ecosystem approach** to management.
- Provides a means of integrating the **natural and societal** aspects.
- Makes **system complexity understandable** to policymakers and stakeholders and therefore provides a valuable tool for the Abu Dhabi workshops.

Natural Capital, Ecosystem Services, Benefits


Chapter 5
Identification of a Practicable Set of Ecosystem Indicators for Coastal and Marine Ecosystem Services

Jonathan P. Atkins, Daryl Burdon, and Michael Elliott

Ecological Indicators 49 (2014) 61–75

Contents lists available at ScienceDirect

Ecological Indicators

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

Marine ecosystem services: Linking indicators to their classification

Natural Capital Committee

How to do it: a natural capital workbook

Version 1

- Indicators can be used to identify the **behaviour, state and trajectory** of natural capital, ecosystem services and societal benefits.
- **Indicators of stocks and flows** can be used to track natural changes over time or changes as a result of Activities, Pressures and Responses (as Management measures).
- Therefore indicators can be used for **monitoring and management** purposes.

Natural Capital Accounting

System of Environmental Economic Accounting

- Governments attempt to **value the Natural Capital** and generate sets of national natural capital accounts similar to traditional National Income Accounts.
- This requires putting **monetary values** on the natural capital stock by, for example, valuing the range of flows of benefits that natural capital offers at present and into the future.
- **The UN SEEA guidelines enable monitoring of**: pressures exerted by the economy on the environment, in terms of abstraction of natural resources and emissions; impacts in terms of changes in environmental condition, and how the economy responds in terms of expenditure on environmental protection and resource management.

https://seea.un.org/

Use of quantitative matrices to link biodiversity and habitats to ecosystem services and societal goods and benefits (such as the Matrix Approach)

Main aims:

To give:

- The matrix analysis tool which links the natural environmental assets and components being protected to the pressures and the ecosystem services and societal goods and benefits produced;
- The examples of the matrix approach for both highly mobile species (such as birds) and sedentary habitats and species features;
- The data required and limitations of the methods for the Matrix Approach and its implementation across the environments.

The Matrix Approach

Marine Policy 44 (2014) 139–148

Contents lists available at ScienceDirect

Marine Policy

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

Do marine protected areas deliver flows of ecosystem services to support human welfare?

Tavis Potts [a,*], Daryl Burdon [b], Emma Jackson [c,d], Jonathan Atkins [e], Justine Saunders [f], Emily Hastings [g], Olivia Langmead [c]

[a] Scottish Association for Marine Science, Oban, Argyll PA37 1QA, UK
[b] Institute of Estuarine & Coastal Studies, University of Hull, Hull HU6 7RX, UK
[c] The Marine Biological Association of the UK, Citadel Hill, Plymouth PL1 2PB, UK
[d] Central Queensland University, School of Medical and Applied Sciences, Bryan Jordan Drive, PO Box 1319, Gladstone, Qld. 4680, Australia
[e] Hull University Business School, University of Hull, Hull HU6 7RX, UK
[f] Fugro IMU Limited, 1 Mill Court, Durley, Southampton SO32 2EJ, UK
[g] James Hutton Institute, Aberdeen AB15 8QH, UK

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ABSTRACT

This paper examines the potential relationships between the ecosystem services provided by the coastal and marine environment and the designation of marine protected areas. The hypothesis is that relationships exist between the provision of ecosystem services and the features protected by marine protected areas. It is considered that protection will maintain these features in good ecological condition and in some cases will restore ecological functioning with positive effects on the delivery of ecosystem services, as pressures upon the protected features are reduced. As the number of marine protected area designations grows, system-wide effects to communities from improvements in delivery of a range of ecosystem services may be realised. This paper provides a comparative analysis of the jurisdictional marine protected area policies proposed by the English, Welsh and Scottish Governments. It presents structured assessment matrices developed from the literature and expert opinion, of ecosystem service provision by marine protected habitats and species and applies the findings to a range of existing UK marine protected areas to demonstrate its relevance. The approach and case study findings are discussed within the wider context of marine ecosystem services and marine protected area management.

1. The provision of ecosystem services and goods/benefits by MPAs

Historically, the fundamental purpose of marine protected areas (MPAs) has been biodiversity conservation [1,2]. However, in the context of MPAs providing direct and indirect benefits for society [3], accounting for the export of ecosystem services from sites is increasingly recognised [4]. The importance of public perception and engagement with the planning and management of MPAs has also been acknowledged [5]. Ecosystem services are defined by the Millennium Ecosystem Assessment as the outputs of ecosystems from which people and society derive benefits [6]. Identifying and valuing ecosystem services from MPAs can highlight the services provided by marine ecosystems in general and can point to those that can potentially be enhanced or supported by MPA processes that improve system quality [7,8,9] This includes local-scale provisioning services (i.e. marine resources such as fisheries) to large-scale and longer-term processes that support human welfare (e.g. carbon sequestration). Capturing the benefit flow from MPAs will inform the debate on the relationship between MPAs and human welfare, and inform the management of future sites, particularly in the context of multiple-use systems and human welfare questions in the adaptive management of marine systems [10]. This paper examines the potential relationships between the ecosystem services provided by the coastal and marine environment and the designation of marine protected areas. The hypothesis is that relationships exist between the delivery of ecosystem services and the features protected by marine protected areas. It is considered that protection will maintain these features in good ecological condition with positive effects on the delivery of ecosystem services. Understanding the portfolio of benefits derived from MPAs will improve planning and management, particularly in the context of making site specific or regional trade-offs over protected area designations and in understanding the ramifications of achieving the prescribed conservation objectives.

* Corresponding author. Tel.: +44 1224395138.
E-mail address: tavis.potts@sams.ac.uk (T. Potts).

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- **Structured desk-based assessment** with peer-reviewed outputs (Potts et al., 2014).
- Assess the **relative importance** of natural capital assets (e.g. habitats and species) in delivering ecosystem services and benefits.
- Provides a **confidence score** for each cell within the matrix.
- Can be used to **inform trade-offs** of Responses (using management Measures).

Should we value nature?

Ecologist advocated **biocentric perspectives** based on **intrinsic ecological values**

Controversy on the value of nature

Complementarity?

Economist adopt anthropocentric perspectives that focus on **instrumental values**

Values affecting decisions far beyond markets

Moral motivation (extended rationality?) conferring rights to nature?

Utilitarian perspective based on cost-benefits rationality

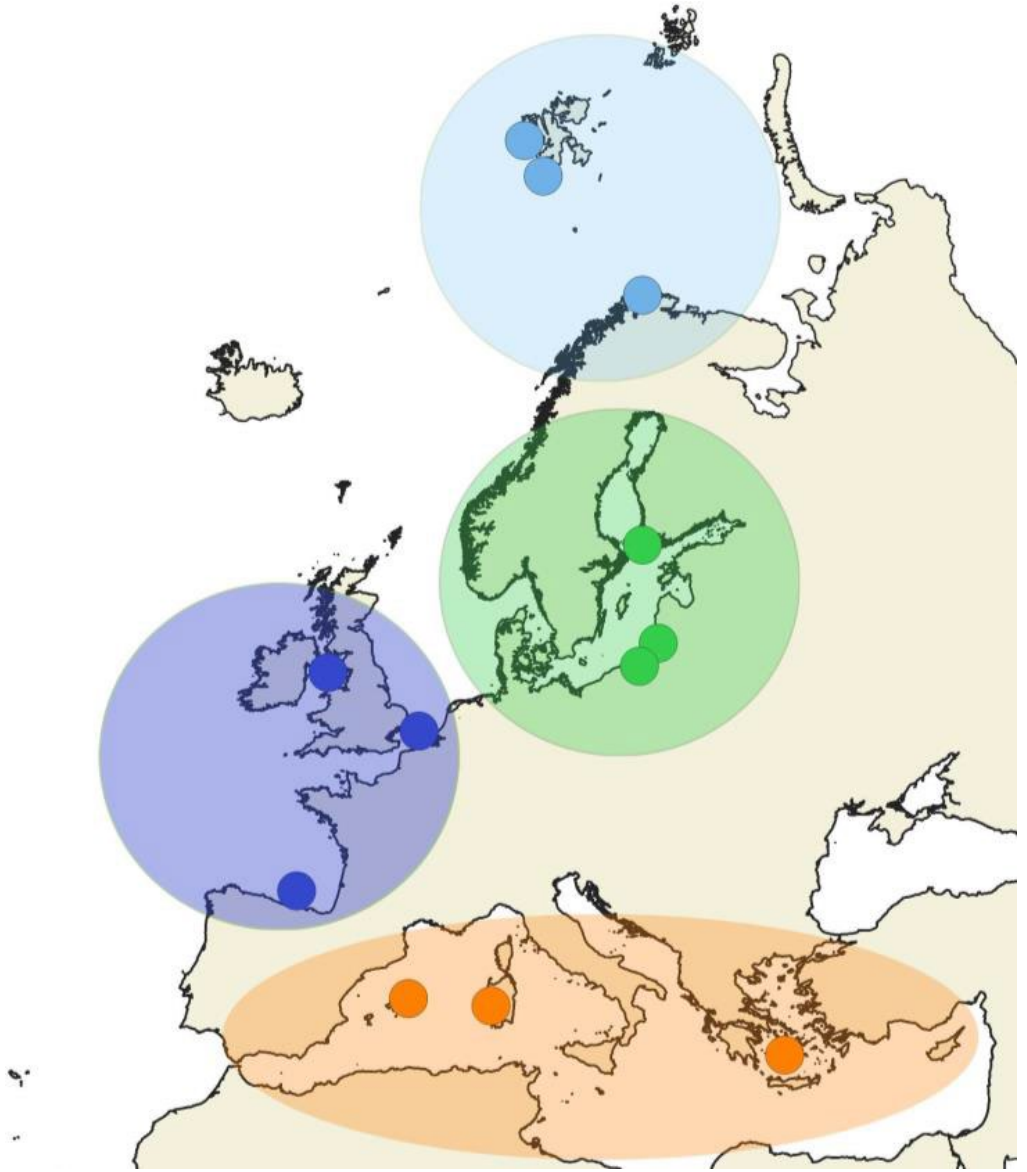
"I suppose I'll be the one to mention the elephant in the room."

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

Acknowledgement: Paola Ovando Pol (The James Hutton Institute) 'Introduction to Environmental Economics', 2019.

HorizonEurope Project – MARBEFES - Objectives:

- Develop and use a set of tools for ecological and economic (financial and non-financial) valuation of marine biodiversity and its services and societal goods and benefits for implementing in the Broad Belt Transect areas.
- Characterise the benefits and co-benefits humans derive from coastal and marine ecosystem services for policy and decision making.



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NB – Also with funding from UKRI

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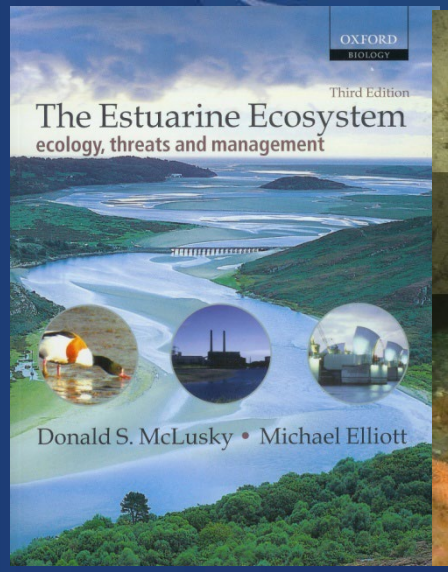
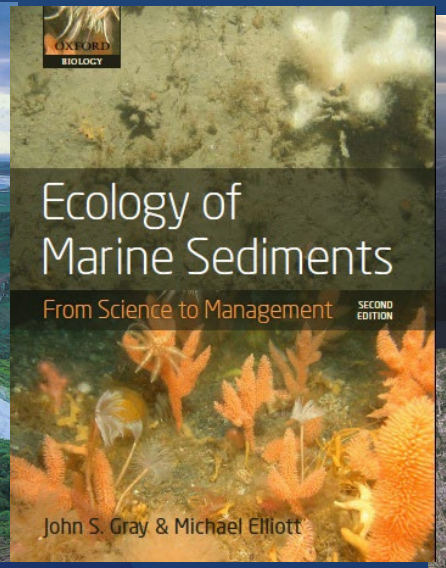
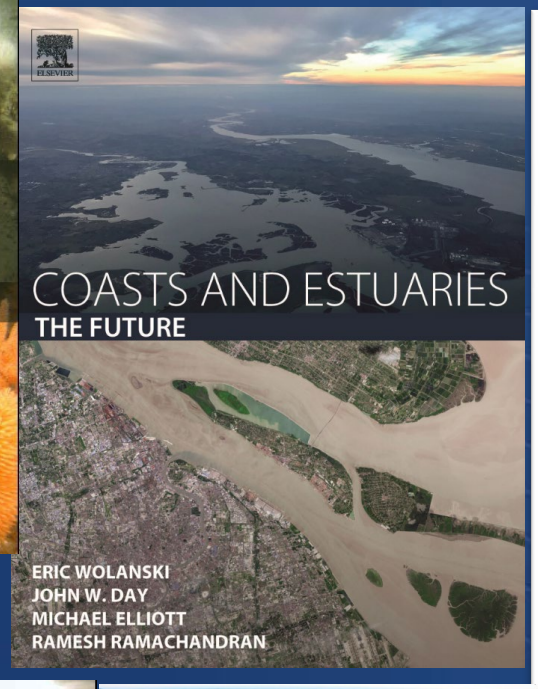
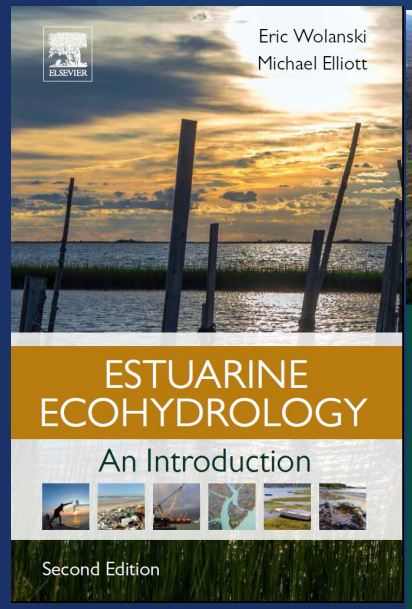
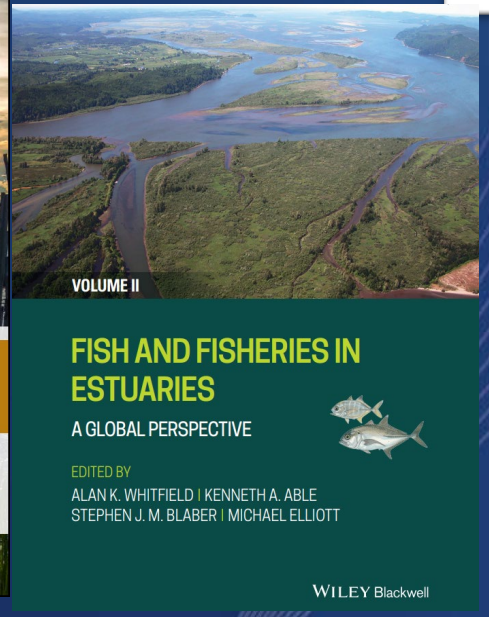


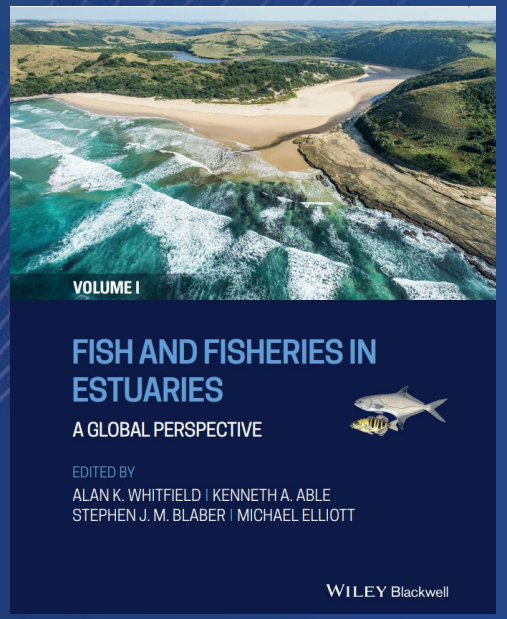




Thanks for listening!







Email: Mike.Elliott@hull.ac.uk;
Mike.Elliott@iecs.ltd;