# Ecological restoration in estuarine environments: experiences, trajectories and driving factors

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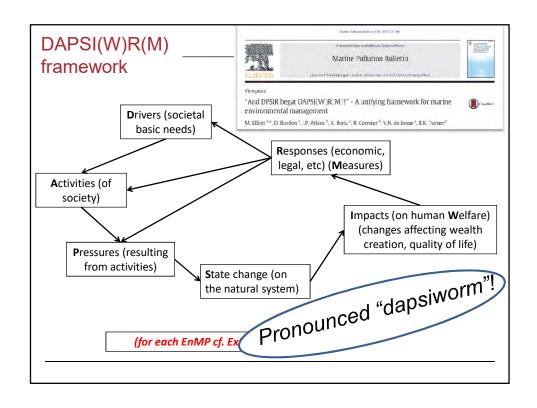
### Challenges for science & management:

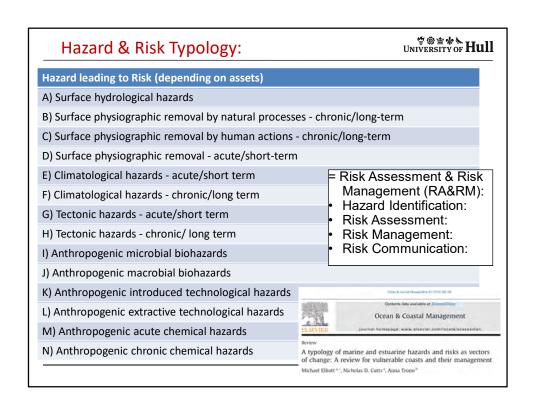


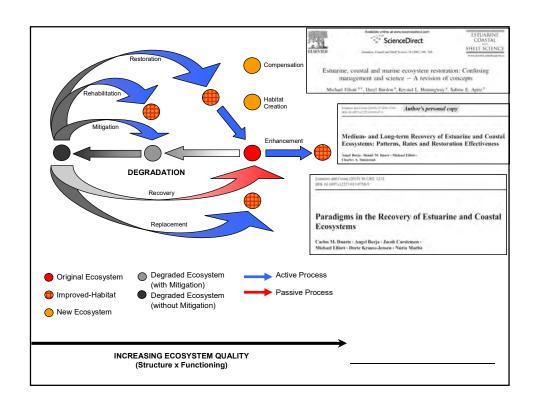


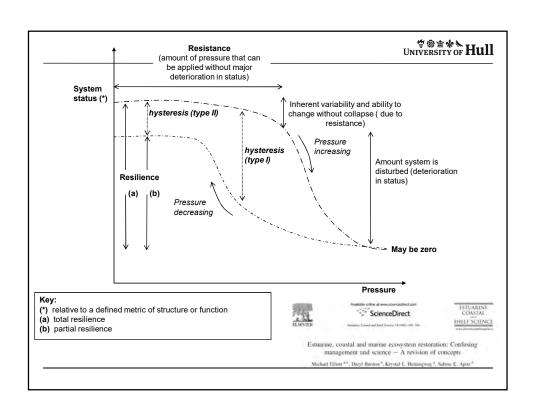
There is only one big idea in marine management: how to maintain and protect ecological structure and functioning while at the same time allowing the system to produce ecosystem services from which we derive societal benefits.

- 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









## Why Recreate/Restore/Offset?

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1. Policy

2. Obligations Voluntary offsets

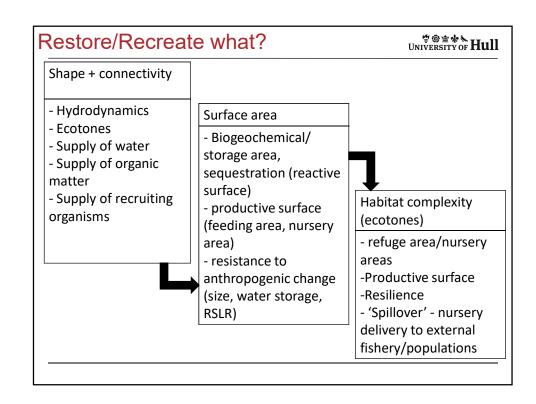
3. Objectives Enforced offsets

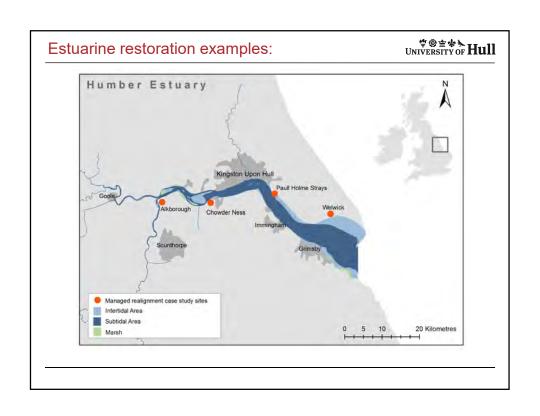
4. Law Legally binding

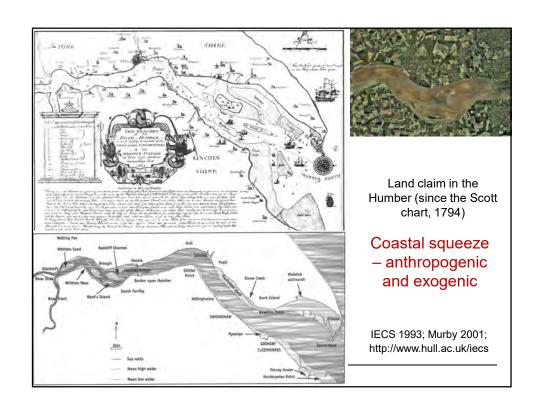
5. Due diligence Economic incentives

6. Green credentials

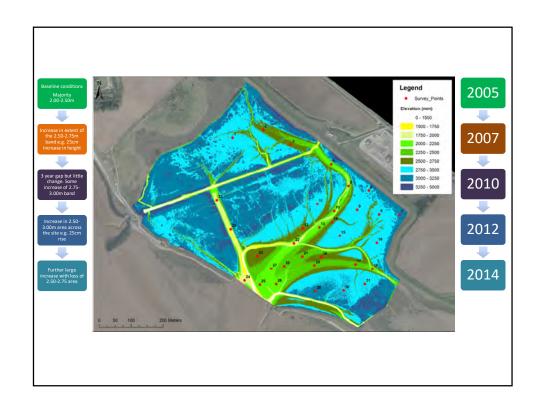
7. Rectify historical losses (restore or increase ecological and socio-economic carrying capacity, ecosystem services and societal benefits)













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#### Habitat Restoration - Managed Realignment

Humber Estuary - Chowder Ness, June 2006

High degree of site preparation

NB Compensation Scheme (with Welwick saltmarsh) for Port Development (gain:loss = 2.5:1)





#### Management?

Elephant in the room: is MR a viable tool in high turbidity estuaries or just a politically expedient tool to meet Directive compliance? Is it just good for the regulators and industry, but not for the estuarine system? Can it be improved as a tool or do we look for alternatives?



2007 cf. 2015

What do we want from a site and is it actually deliverable e.g. SPA/SAC specifics?

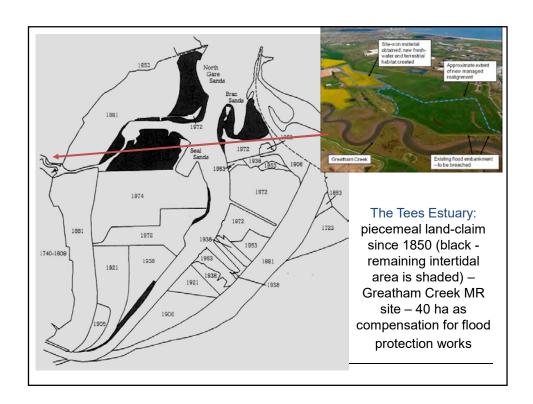
Current techniques potentially fail to deliver for some defined offset metrics unless there is considerable management.

#### But:

Opportunity for other habitats/ species delivery as well as other EcoServs.

Opportunities for new techniques but constraints on their trial (cost/consenting).

Management aims need to either drive location or be driven by the prevalent physico-chemical conditions. Offset outside the estuary?





Originally farmland lying below sea level, Wallasea Island was increasingly difficult to defend from rising sea levels.

Over 3 million tonnes of unwanted soil from tunnels of the London Crossrail project was shipped to Wallasea.

In 3 years, the level of the land has been raised and the sea defences breached to create a mosaic of inter-tidal habitats.

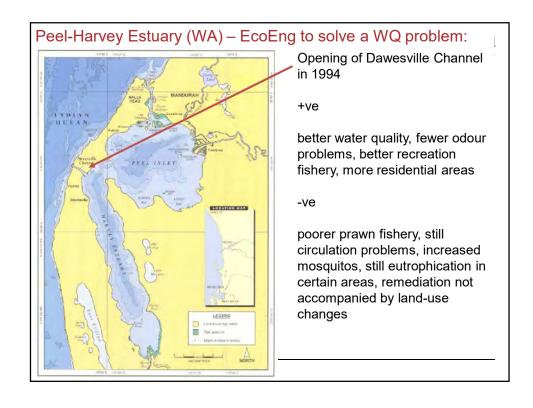
## Restoration as University of Hull problem solving? Wallasea Island - 🤜 Essex

Aim to reduce flood risk and recreate wildlife habitats that are continually under threat for the benefit of species like brent goose, dunlin and avocet.

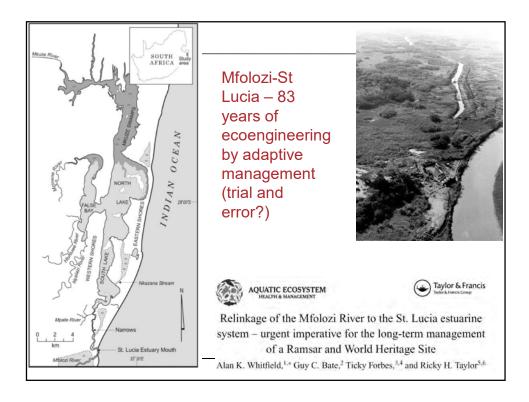
giving nature

rspb a home









# Impediments to achieving restoration success:

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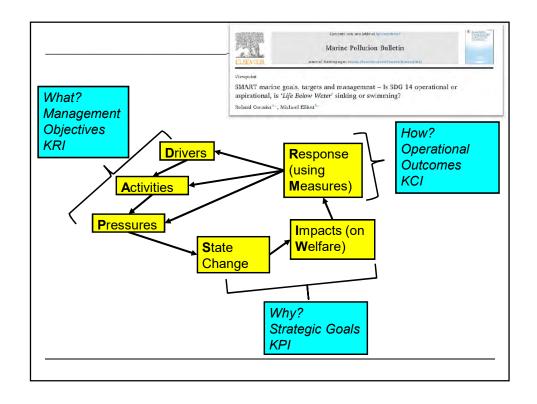
Barriers to strategy development:

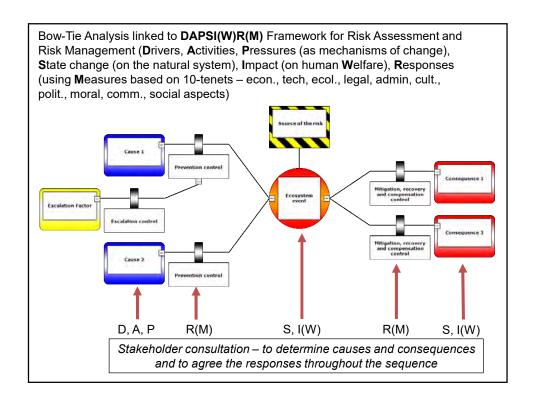
- · High-level policy and organisational barriers
- · Approach and methodological barriers
- Resource considerations (financial, organisational)
- · Inter- and intra-group relationships
- Lack of shared vision and understanding

Barriers to strategy implementation:

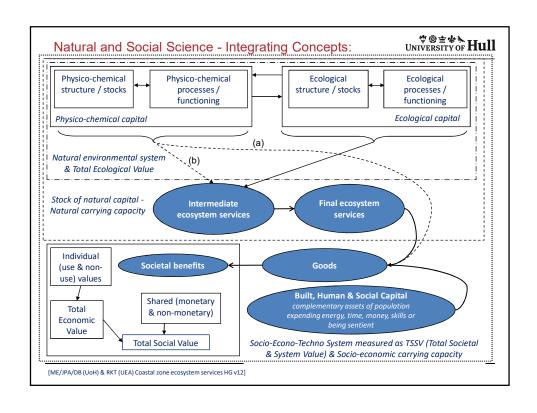
- Cultural and/or policy
- Technical capacity and ability
- Resourcing (staff, finance)
- · Trust and relationships

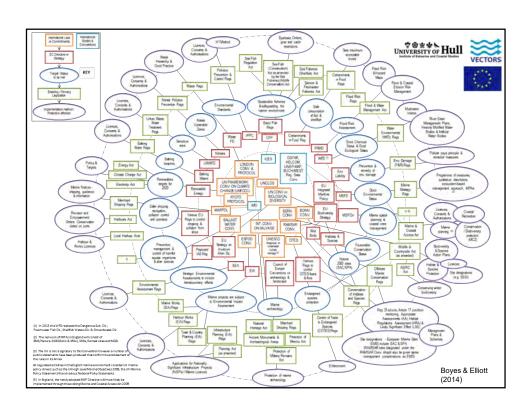
#### Solutions - The 10-tenets: UNIVERSITY OF Hull To be successful, management The UK and Marine Scotland vision: measures or responses to "clean, healthy, safe, productive, biologically diverse marine and coastal changes resulting from human environments, managed to meet the longactivities should be: term needs of people and nature". · Ecologically sustainable Technologically feasible Marine Pollution Bulletin Economically viable Socially desirable/tolerable Legally permissible ScienceDirect · Administratively achievable The 10-tenets of adaptive management and Politically expedient sustainability: An holistic framework for understanding and managing the socio-ecological · Ethically defensible (morally correct) · Culturally inclusive (NB spellcheck -Effectively communicable not "a good night in Scotland"!)











#### Restoration in Law:

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- Wetland Banking in the US under the Clean Water Act 1972
- Conservation Banking in the US under the Endangered Species Act
- EU Habitats and Wild Birds Directives, Water Framework Directive, Marine Strategy Framework Directive
- Offsets in Brazil under the Forest Regulation and National System of Conservation Units under Lei No 4771 of 1965; Lei No 14.247 of 22/7/2002, Lei No 9.985 of 18/7/2000, Decreto No. 4.340 of 22/8/2002
- Federal Law for the Protection of Nature and Landscape in Switzerland
- · Offsets in Australia: Native Vegetation Act 1997
- No net loss of fisheries habitat in Canada under the Fisheries Act under R.S. 1985, c. F-14, Policy for the Management of Fish Habitat (1986)

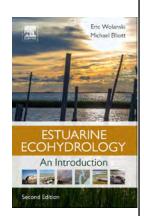
#### **Estuarine Ecohydrology**

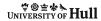
The science and understanding of the links between the physical functioning and the means by which it creates the appropriate ecological functioning of an estuary. It assumes that the ecology is primarily driven by the physics, which in turn affects the biological processes operating within a system.

It includes changing the physiography and manipulating the freshwater flows from the catchment and it is also influenced by the anthropogenic users and uses of the estuary, some of which will have modified and impacted both the physics and the ecology.

It is that knowledge which guides the management of the entire river basin from the headwaters down to the coastal zone, which Ecohydrology views as an ecosystem.







#### Estuarine Ecological Engineering

Uses ecohydrology knowledge to modify and achieve our ecological aims for an area by Engineering:

- (1) the physics, including changing the physiography and manipulating the freshwater flows from the catchment, to produce the ecological niches which in turn lets the ecology and habitats develop, especially if the colonising species are ecological engineers (Type A Ecoengineering).
- (2) the ecology, by restocking or replanting, in turn creating habitats or letting the ecological engineer species modify habitats, thus enhancing the physical-biological links (Type B Ecoengineering).

Ecoengineering initiatives often aim to accelerate natural rehabilitation and sometimes harness dynamic variability. However, they often only achieve establishing a static system (the desired state) even if this does not include all natural successional processes and stages.



#### **Ecohydrology with Ecoengineering**

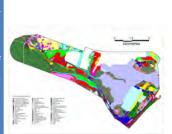
While Ecohydrology aims to operate across the whole catchment-coast continuum, Ecoengineering usually occurs at a smaller scale and will seldom recreate pristine estuaries given the huge human populations living on their shores, but it aims to create ecosystems with at least some attributes of the original systems.

It should be accompanied by regulating certain human activities and is more than just integrated river basin management. Primarily it aims to improve the ecology, and provide benefits for the economy and the safety of society (i.e., so-called triple wins).

# Box 3 Ecohydrology with Ecoengineering (cont.)

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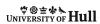
It aims to redress the balance after adverse historical changes, especially coastal and estuarine wetland removal, without unacceptable environmental trade-offs. Ideally, it provides relatively low-cost technologies for mitigating the impact on estuaries and coasts of human activities throughout the river basin, for using and enhancing the natural capacity of the water bodies to absorb and process excess nutrients and contaminants, and for increasing ecosystem resilience to accommodate global stressors such as climate change.



In essence Ecohydrology is the underlying process/ abiotic drivers into which Ecoengineering fits and by which Ecoengineering is delivered, i.e. Ecohydrology provides the underlying science and Ecoengineering is the mechanism for creating the ecology.

#### UNIVERSITY OF Hull Ecohydrological measure categories (see Elliott et al 2016 for examples) Category **Ecohydrological measure type** Hydrology Measure to reduce tidal range, asymmetry and pumping Morphology effects and/or dissipate wave energy Other measures for flood protection Other measures to stabilise coasts improve morphological conditions Measure to decrease the need for dredging Zoning measures Measures to stop or reverse subsidence due to extraction of water and minerals Measure to restore longitudinal or lateral connectivity Estuarine, Coastal and Shelf Science ering with Ecohydrology: Successes and failures in

Michael Elliott " k.o.", Lucas Mander <sup>a</sup>, Krysia Mazik <sup>a</sup>, Charles Simenstad <sup>a</sup>, Flona Valesini <sup>b</sup>, Alan Whitfield <sup>a</sup>, Eric Wolanski <sup>a, a</sup>



# Ecohydrological measure categories (see Elliott et al 2016 for examples)

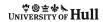
Category	Ecohydrological measure type
Physical /	Measure to reduce nutrient loading (point and diffuse
<b>Chemical Quality</b>	sources)
	Measure to reduce persistent pollutant loading (point
	and diffuse sources)
	Measure to improve oxygen conditions
	Measure to reduce physical loading (e.g. heat input by cooling water entries)
	Measure to reduce sediment inputs and sediment
	loading



# Ecohydrological measure categories (see Elliott et al 2016 for examples)

Category	Ecohydrological measure type
Biology/	Measure to develop and/or protect specific habitats
ecology	Measure to develop and/or protect specific species
	Measures to retain or restore natural gradients & processes, transition & connection
	Measure to prevent introduction of or to eradicate/ control against invasive species
	Measure for direct human benefit of ecological attributes
Human	Measure for early warning/evacuation of natural disasters
safety	Measure for improved resilience of housing and industry

#### **Ecological Engineering - Principles:**



- (1) ecohydrological principles should be used to ensure a suitable and sustainable physico-chemical system
- (2) the design should encompass local features and so be sitespecific
- (3) the design parameters and features should be kept simple in order to deliver the functioning required
- (4) the design should use energy inside the system or coming from outside, such as flow conditions and working with nature, and that the system should be kept simple to minimise the information required for it execution, and lastly
- (5) the EcoEng design should aid the natural and social systems and so should have an ethical dimension; this may involve 'overengineering the design in order to protect human safety and property.

This therefore ensures the wins for safety, economy & ecology

(Modified from Bergen et al 2001 Ecol. Eng. 18: 201-210)

#### Ecological Engineering (1):



- It will never recreate pristine estuaries but it is aimed at creating ecosystems partly with some attributes of the original systems.
- It should be accompanied by regulating human activities on land.
- It is more than integrated river basin management and it aims to improve the ecology, provide benefits for the economy and the safety of society (i.e. so-called triple wins).
- Aims to redress some elements of the balance after adverse historical changes, especially wetland removal.



## Ecological Engineering (2):



- It provides for low-cost technologies for mitigating the impact on the estuaries and coastal zone of human activities throughout the river basin.
- These are using and enhancing the natural capacity of the water bodies to absorb or process excess anthropogenic nutrients and pollutants, and
- for increasing the estuarine and coastal resilience to accommodate global stressors such as climate change.



What?	Cause?	Reverse?
Land-claim	Wetland removal/dyke construction	Restocking with vegetation, reconnection, resculpting
DO sag	Waste discharges	Reduction/treatment of inputs, reoxygenation, bubbling
Bivalve biogenic reef loss	Siltation, overharvesting,	Adaptation, flushing, regulation, restocking
Eutrophication	Poor flushing, excess nutrients	Reconnection, regulation
Biota kills	Toxin input, WQ problems	Regulation, industry removal
Coral reef loss	Siltation, direct damage, bleaching	Run-off controls, re-creation, global rethinking,
Loss of fish	Overharvesting, climate change, hydrodynamic barriers	Restocking, rethinking, adaptation, regulation

What?	Cause?	Reverse?
Salinity change	Upstream abstraction, impediments to flow	Removal, reconnection
Loss of seagrass	Smothering, nutrient excess, disease, hydrographic change	Reduction, removal, reconnection, replanting
Loss of flow	Diversion, abstraction, structures	Reconnection, reallocation
Seabed extraction	Aggregate removal, loss of sediment fraction	Reseeding, regulation, reallocation
Taxonomic changes	Non-indigenous species influx	Removal, eradication, prevention

## Main Messages:

- We now have good examples worldwide of good and bad practice
- Essence is Risk & Opportunity Assessment & Management
- The essence is in achieving connectivity (good water conditions, ecological wellbeing, conditions fit-for-purpose)
- Estuarine and catchment measures have to be used together
- Initial cost-effective & cost-benefit analyses but need more
- Problem of poor long term vision, objectives, definition of success
- Even if there was a long-term vision, would anyone do anything if it was not met?



#### Main Messages (cont.):

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- Adaptive management is needed but who has the responsibility?
- Some schemes are just 'gardening' ("good for the ecologist not the ecology?")
- Aim for triple wins (for ecologyeconomy-society) but how many sites achieve these?
- Once you start managing the system then you have to keep managing it ....
- · ...... but we don't!



# So what is the problem and solution and why doesn't it always work?

# © \* Hull

#### **Categories of Problem**

Enrichment by substances
Loss of surface and habitat
Biotic compound loss or change
Over-extraction of resources
Water and connectivity loss

#### **Categories of Solutions**

reversal, restocking, regulation, reconnection, re-sculpting, removal, revision, restoration, replanting, reduction, reallocation, reseeding, reoxygenation

Perhaps we don't know our R's from our .....?

