Marine ecosystem valuation

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The UK Marine Bill – Marine Nature Conservation Proposals- valuing the benefits

Published in *Ecological Economics* (Hussain *et al.*, 2010)

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Background to the study

- Different *drivers* impact on marine ecosystems

- Study in *Science* (Halpern *et al*.,2008) applies a multi-scale spatial model to analysis anthropogenic drivers of ecological change in 20 marine ecosystems.

    - 41% are strongly affected by *multiple* drivers.

- These drivers stimulate a shift in the production of *ecosystem goods and services* (e.g. gas and climate regulation)

- These services can be *valued*

- According to study in *Nature* (Costanza *et al*., 1997) service provision by marine ecosystems constitutes around two-thirds of the global total

Anthropogenic impacts
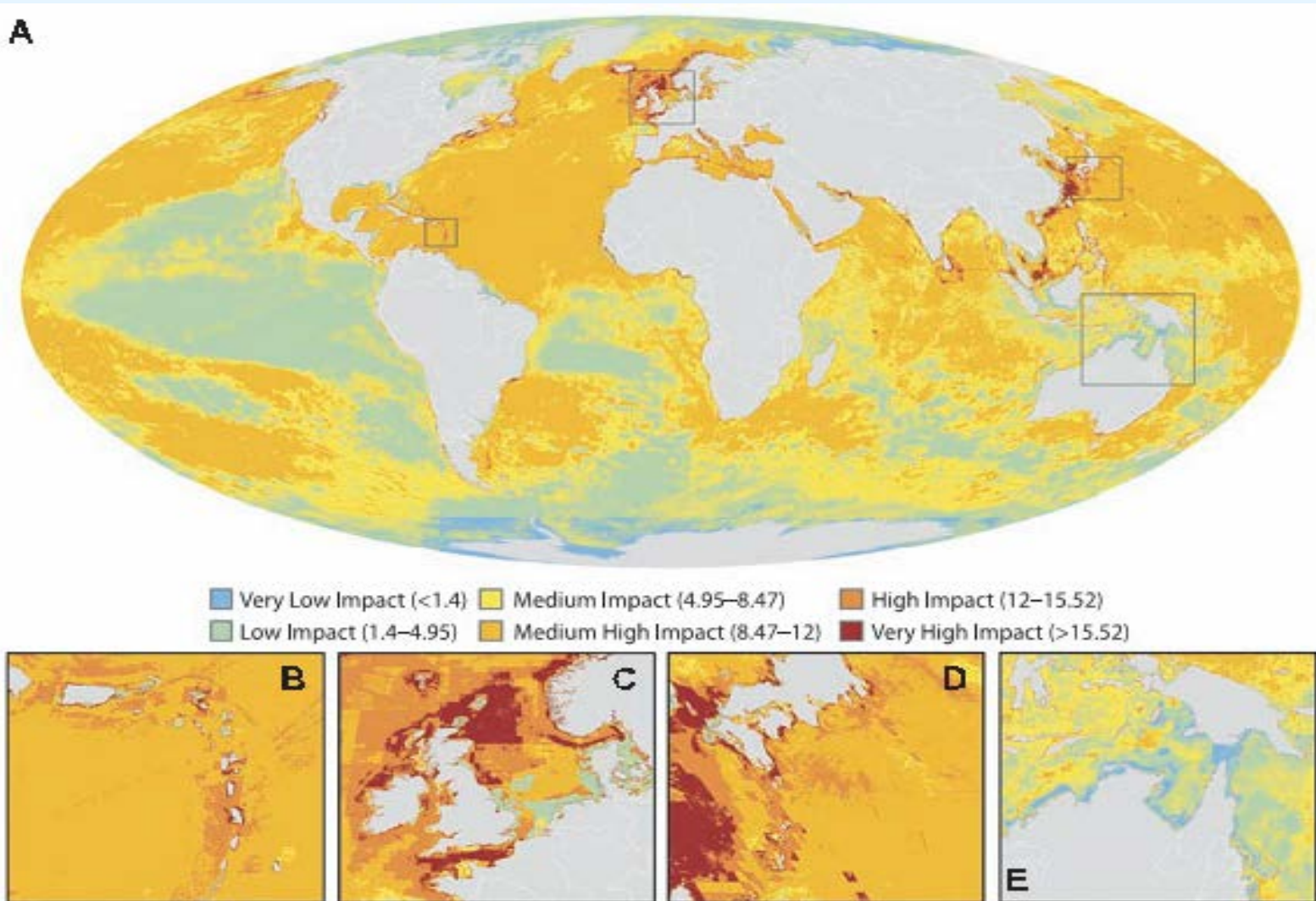
The three network scenarios selected by Defra from Kaiser *et al.* (2006)

| Scenario	% of OSPAR Species and Habitats included	% of UK Marine Landscapes included	Network size (1000 km2)	Additional Criteria
A	20%	10%	125.7	None
G	60%	10%	156	Commercial fishery species spawning and nursery areas preferred to protect areas essential to life history stages
J	60%	10%	147.2	Locked out sites licensed for aggregate extraction, dredging and dredge disposal activities.

Management regimes defined by UK government (Defra)

	Conservation Objective	
	Highly Restricted (HR-MCZ)	**Maintenance of Conservation Status (MCS-MCZ)**
Management Regime Restrictions	• **General presumption against fishing of all kinds, all constructive, destructive and disturbing activities** • Recovery measures appropriate to the local situation (enhanced restoration/aftercare measures on expiry of operating licences)	• New development activities permitted where in the public interest (on social or economic grounds) • **Existing activities to continue if do not cause site condition to deteriorate** • Restriction of bottom fishing gears either spatially or temporally and technical conservation measures • Recovery measures appropriate to the local situation (enhanced restoration/aftercare measures on expiry of operating licences)

Comparisons against the baseline status quo

SAC

Ecosystem service

MCZ

inception

20 years

Time

A

B

C

D
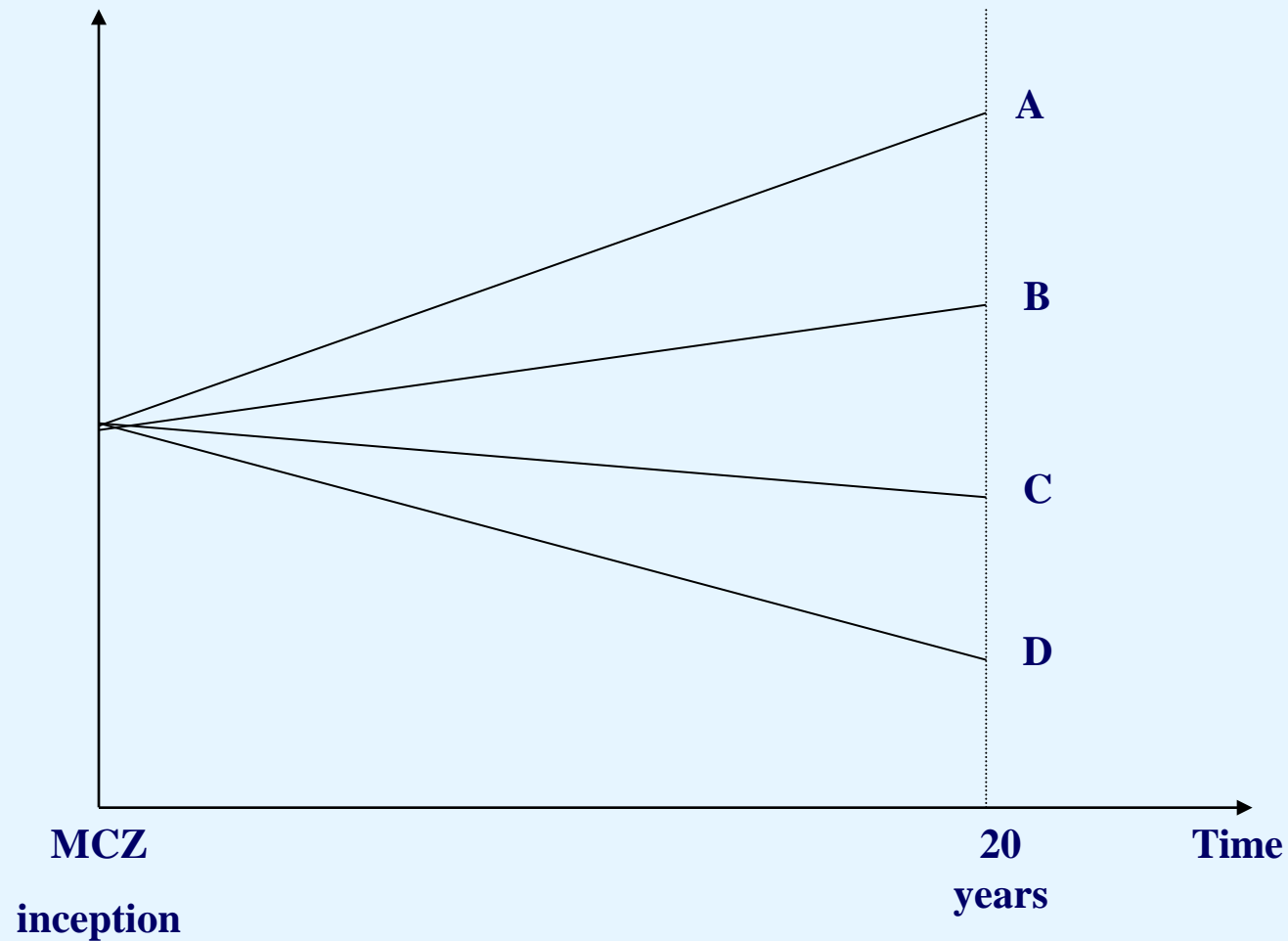
MA categories pertaining to terrestrial marine ecosystems

MEA Category	Ecosystem Good/ Service	Definition
Provisioning	Food provision	Plants and animals taken from the marine environment for human consumption
	Raw materials	The extraction of marine organisms for all purposes, except human consumption
Supporting	Nutrient cycling	The storage, cycling and maintenance of availability of nutrients mediated by living marine organism
	Resilience and resistance	The extent to which ecosystems can absorb recurrent natural and human perturbations and continue to regenerate without slowly degrading or unexpectedly flipping to alternate states
Regulating	Gas and climate regulation	The balance and maintenance of the chemical composition of the atmosphere and oceans by marine living organisms
	Biologically mediated habitat	Habitat which is provided by living marine organisms
	Disturbance prevention and alleviation	The dampening of environmental disturbances by biogenic structures
	Bioremediation of waste	Removal of pollutants through storage, dilution, transformation and burial
Cultural	Cultural heritage and identity	The cultural value associated with the marine environment e.g. for religion, folk lore, painting, cultural and spiritual traditions
	Cognitive values	Cognitive development, including education and research, resulting from marine organisms
	Leisure and recreation	The refreshment and stimulation of the human body and mind through the perusal and engagement with, living marine organisms in their natural environment

Synopsis of valuation literature

SAC

Good/Service	Defra CRO 380		
	Monetary Value	**Valuation method**	**Subjective Reliability**
Food provision	£884.9 million	Market data	MEDIUM: value added factor simplification
Raw materials	£116.5 million	Market data	MEDIUM: some data unavailable
Leisure and recreation	£1.4-£3.4 billion	Market data	LOW: based on market data but wide variability
Resilience and resistance	N/A	N/A	N/A
Nutrient cycling	£ 1.3 billion	Market, WTP	MEDIUM: used 'open seas' estimates
Gas and climate regulation	£8.2 billion	Avoidance cost approach	HIGH: social cost of carbon used
Bioremediation of waste	N/A	N/A	N/A
Biologically mediated habitat	N/A	N/A	N/A
Disturbance prevention and alleviation	0.44 billion	Avoidance cost approach	MEDIUM: based on extrapolated
Cultural heritage and identity	N/A	N/A	N/A
Cognitive values	£453.3 million	Market data	HIGH: based on reliable survey data

Methodological steps

1. For *one hectare* of the habitat/landscape what is the *extra* provision of this ecosystem service brought about by Highly Restricted or Less Restricted as compared with the counterfactual?

2. How many hectares are there in each network scenario A, G and J?

3. What proportion is going to be protected under Highly Restricted and how much under Less Restricted?

- Summing across all habitats/landscapes and across all ecosystem services gives the total value of each network

UK Seabed Landscapes

Seabed landscape

- Aphotic rock
- Barrier beach
- Bay
- Canyon
- Cold deep-water coarse sediment
- Cold deep-water mixed sediment
- Cold deep-water mud plain
- Cold deep-water sand plain
- Continental slope
- Deep ocean rise
- Deep-water mound
- Embayment
- Estuary
- Lagoon
- Photic rock
- Ria
- Sealoch
- Shallow coarse sediment plain - moderate tide stress
- Shallow coarse sediment plain - strong tide stress
- Shallow coarse sediment plain - weak tide stress

- Shallow mixed sediment plain - moderate tide stress
- Shallow mixed sediment plain - strong tide stress
- Shallow mixed sediment plain - weak tide stress
- Shallow mud plain
- Shallow sand plain
- Shelf coarse sediment plain - moderate tide stress
- Shelf coarse sediment plain - strong tide stress
- Shelf coarse sediment plain - weak tide stress
- Shelf mixed sediment plain - moderate tide stress
- Shelf mixed sediment plain - strong tide stress
- Shelf mixed sediment plain - weak tide stress
- Shelf mound or pinnacle
- Shelf mud plain
- Shelf sand plain
- Shelf trough
- Sound
- Subtidal sediment bank
- Warm deep-water coarse sediment plain
- Warm deep-water mixed sediment plain
- Warm deep-water mud plain
- Warm deep-water sand plain

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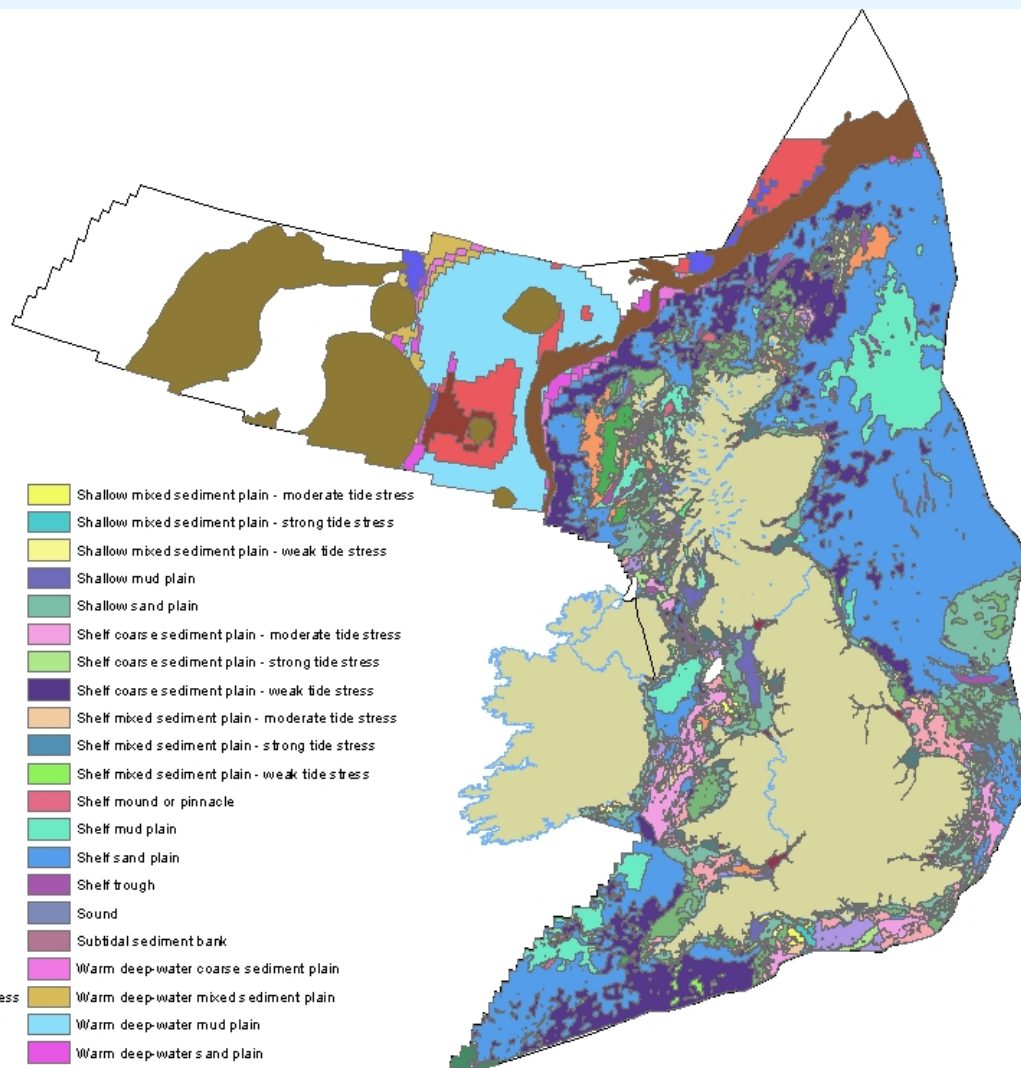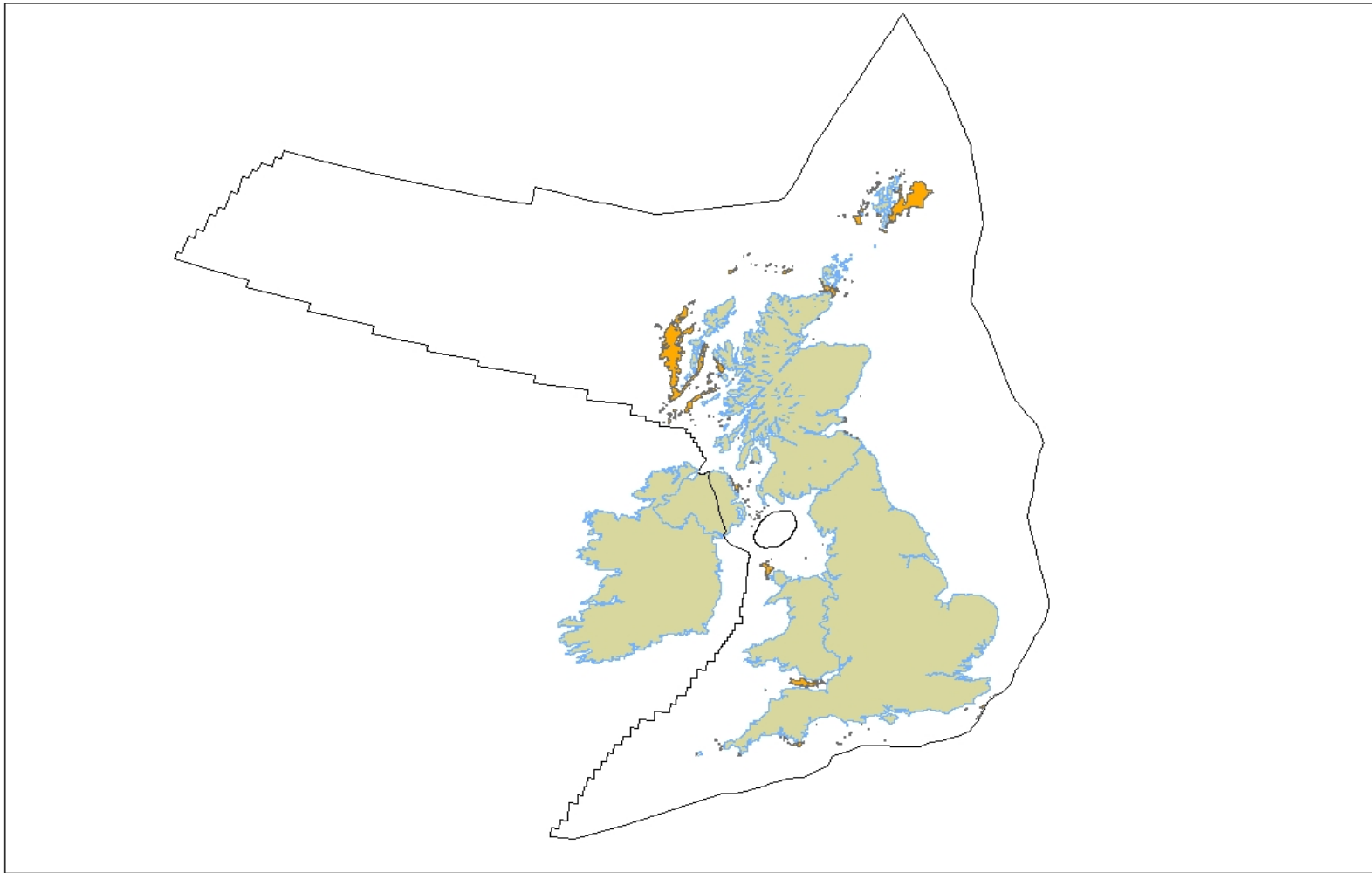
Aphotic reef - UK

Aphotic reef – network scenario A
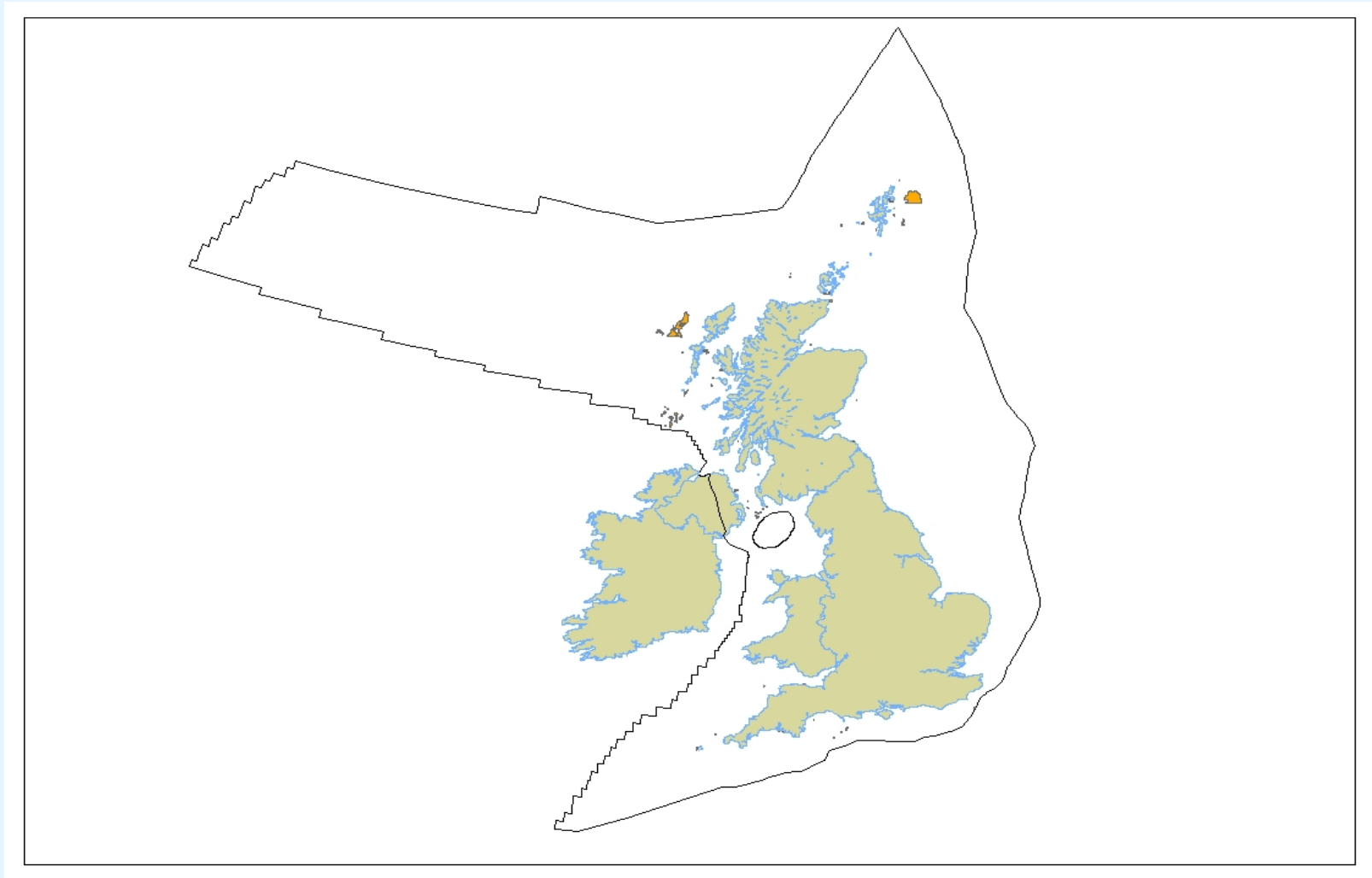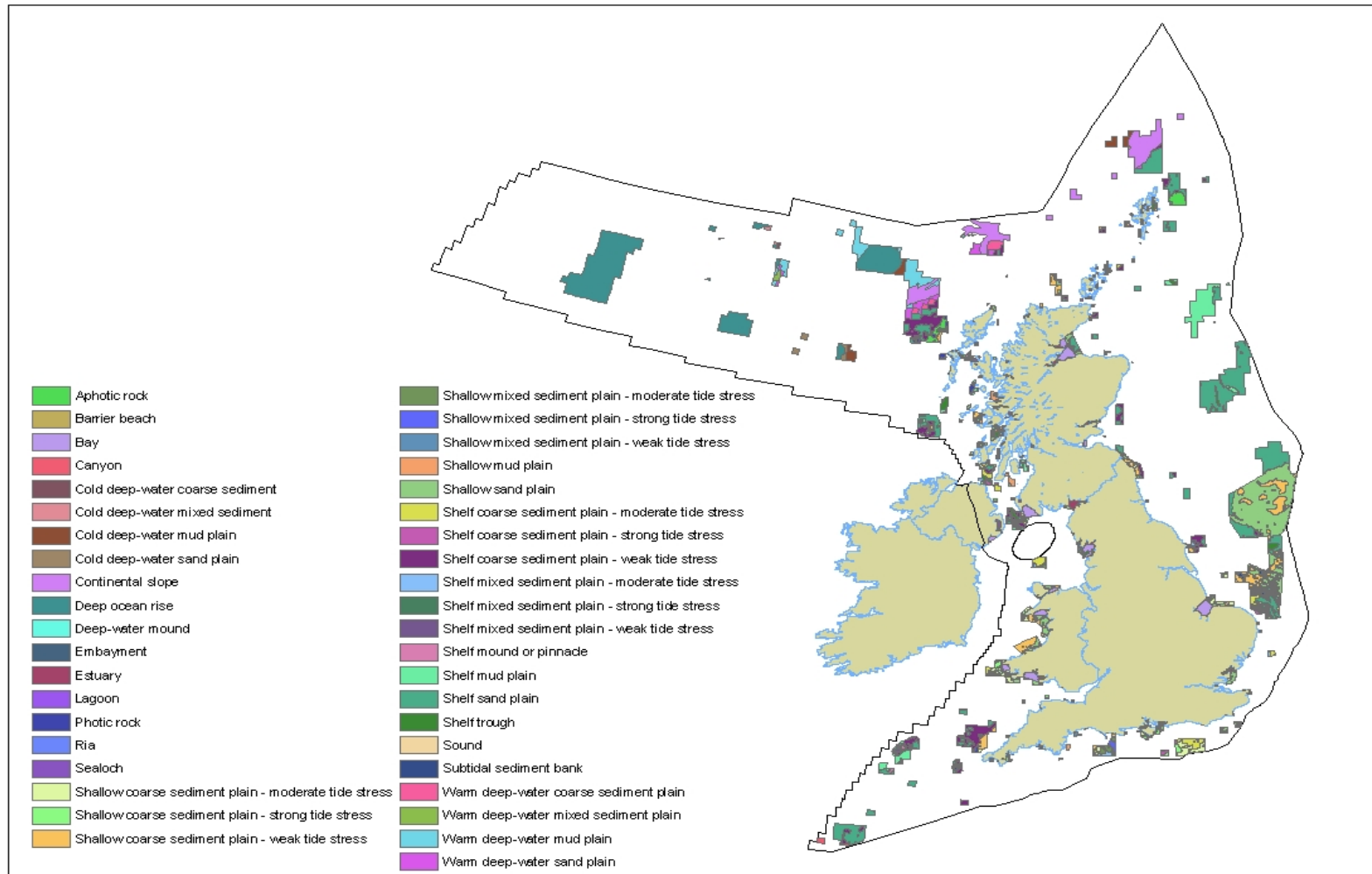
Coding for extent of impacts from MCZ designation (compared with status quo)

Interpretation of the impact coding for the valuation estimate

Coding	*Percentage range*	*Mid-point*	*High value*	*Low value*
VH (very high)	**90-100%**	**95%**	**100%**	**90%**
H (high)	**50-89%**	**70%**	**89%**	**50%**
M (medium)	**10-49%**	**30%**	**49%**	**10%**
L (low)	**1-9%**	**5%**	**9%**	**1%**
VL (very low)	**<1%**	**0.5%**	**1%**	**0%**

Trajectories for impact path for 10/20 coding
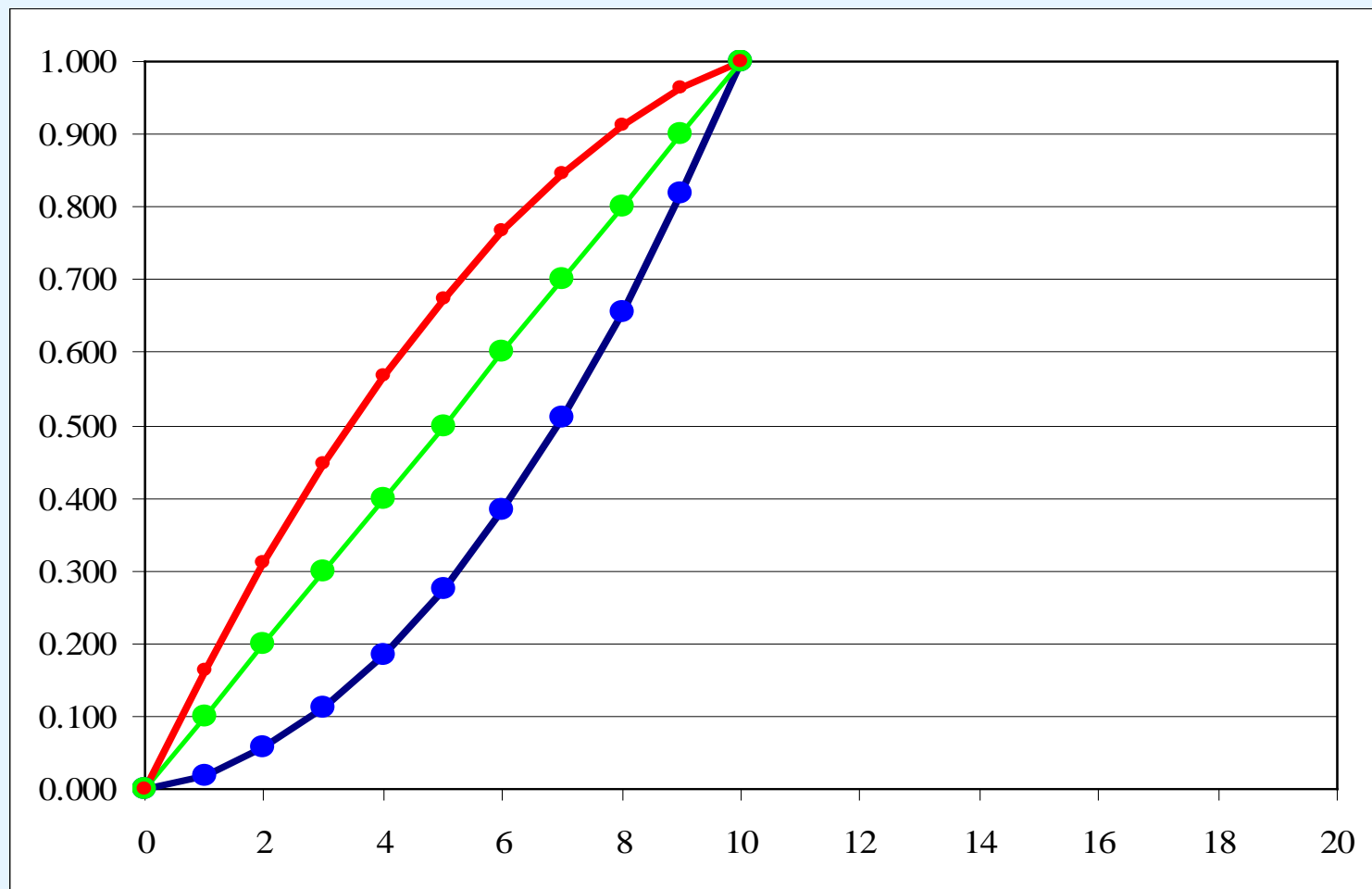
Aggregation of on-site benefit from enhanced provision of ecosystem services

Present values (£) for protecting the entire network under
Highly Restricted Less Restricted (3.5% discounted rate)

Network/ management		Nutrient Recycling	Gas/climate regulation	Food provision	Raw Materials	Disturbance prevention/ alleviation	Leisure and recreation	Cognitive value	**SUM**
Total Value		1,300,000,000	8,238,601,638	884,900,000	116,500,000	440,000,000	3,400,000,000	453,300,000	
A/HP-MCZ	%	95.49	95.49	0.07	0.08	0.07	39.76	127.14	
	Total	1,241,366,354	7,867,017,601	613,414	92,394	304,829	1,351,868,807	576,306,372	**11,037,569,771**
A/MCS-MCZ	%	89.75	89.75	2.37	0.64	0.07	33.74	106.15	
	Total	1,166,762,575	7,394,224,662	20,966,407	751,400	304,829	1,147,060,637	481,176,256	**10,211,246,765**
G/HP-MCZ	%	168.38	168.38	0.12	0.13	0.12	59.74	195.06	
	Total	2,188,948,181	13,872,209,283	1,053,612	149,169	511,987	2,031,245,922	884,192,259	**18,978,310,412**
G/MCS-MCZ	%	157.47	157.47	3.98	1.03	0.12	47.70	159.43	
	Total	2,047,131,025	12,973,459,245	35,212,089	1,198,696	511,987	1,621,700,525	722,703,371	**17,401,916,938**
J/HP-MCZ	%	220.22	220.22	0.14	0.14	0.14	51.08	173.20	
	Total	2,862,802,868	18,142,686,461	1,280,813	167,192	617,613	1,736,676,286	785,128,064	**23,529,359,297**
J/MCS-MCZ	%	212.19	212.19	3.85	1.32	0.14	42.95	146.99	
	Total	2,758,431,506	17,481,244,863	34,074,307	1,533,579	617,613	1,460,315,811	666,290,327	**22,402,508,006**

Take home messages: MCZ study

- The estimated benefit range is **£10.3 billion to £22.7 billion** (at least seven times estimated costs)

- This is an under-estimate and does not include several benefit categories

- Developments in FP7 project **O**ptions for **D**elivering **E**cosystem-Based **M**arine **M**anagement [ODEMM]

- http://www.liv.ac.uk/odemm/

- http://www.liv.ac.uk/odemm/Work_Package_6.html

EC Marine Strategy Framework Directive: High-Level Descriptors

1. Biodiversity
2. Non-Indigenous Species
3. Commercial Fish
4. Food Webs
5. Eutrophication
6. Sea-Floor Integrity
7. Hydrographic Conditions
8. Contaminants
9. Fish and Seafood Contaminants
10. Marine Litter
11. Energy Introduction (including Noise)
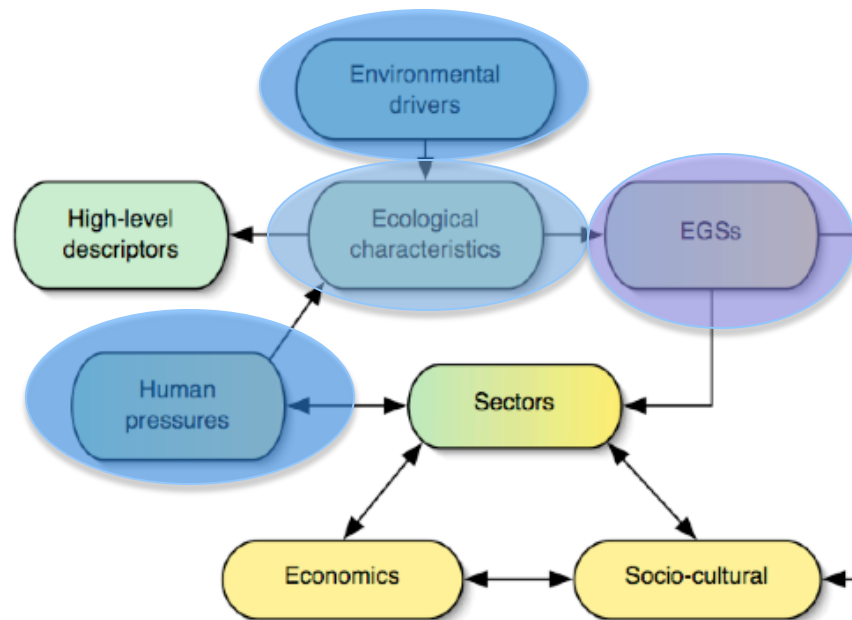
12 Environmental Drivers

1. Climatic Indices
2. Water Temperature
3. Air Temperature
4. Salinity
5. Precipitation
6. Currents
7. Storms
8. Solar Radiation
9. Day Length
10. Primary Production
11. Natural Extreme Events
12. Other Environmental Drivers

17 Ecological Characteristics

Ecological Components
1. Topography/Bathymetry
2. Temperature
3. Salinity
4. Nutrients & Oxygen
5. pH, pCO2

Habitat Types
1. Predominant Habitat
2. Special Habitat
3. Habitat Types Meriting Special Reference

Biological Features
1. Plankton
2. Bottom Fauna and Flora
3. Fish
4. Marine Mammals and Reptiles
5. Seabirds
6. Species listed under Community Legislation
7. Non-indigenous/Exotic species

Other Features
1. Chemicals
2. Other notable Features
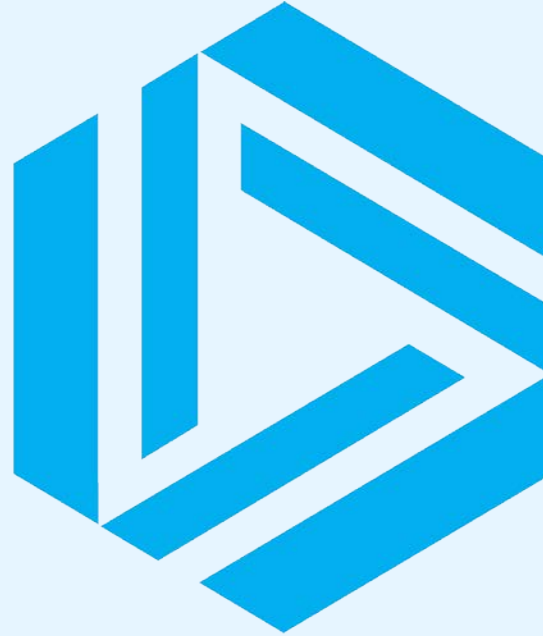
22 Marine Ecosystem Services

1. Sea Food
2. Sea Water
3. Raw Materials
4. Genetic Resources
5. Medicinal Resources
6. Ornamental Resources
7. Air Purification
8. Climate Regulation
9. Disturbance Prevention/moderation
10. Regulation of Water Flows
11. Waste Treatment
12. Coastal Erosion Prevention
13. Biological Control
14. Lifecycle Maintenance
15. Gene Pool Protection
16. Buffering Biological Disturbance
17. Aesthetic Information
18. Recreation and Leisure
19. Inspiration for Culture, Art and Design
20. Spiritual Experience
21. Information for Cognitive Development
22. Cultural Heritage and Identity

ODEMM: where we stand

- Designation of case study sites/management interventions
- Analysis of (i) costs and benefits and (ii) governance/institutional capacity
- Benefit assessment
  - Linking characteristics and ESs
  - Impact assessment: correct unit of account
  - Primary valuation and benefits transfer
- On-line expert tool: final deliverable

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