Non-Technical Summary

(November 2020)

Solent Marine Sites (SEMS)

A Natural Capital Study: of Benthic Ecosystem Services and How they Contribute to Water Quality Regulation

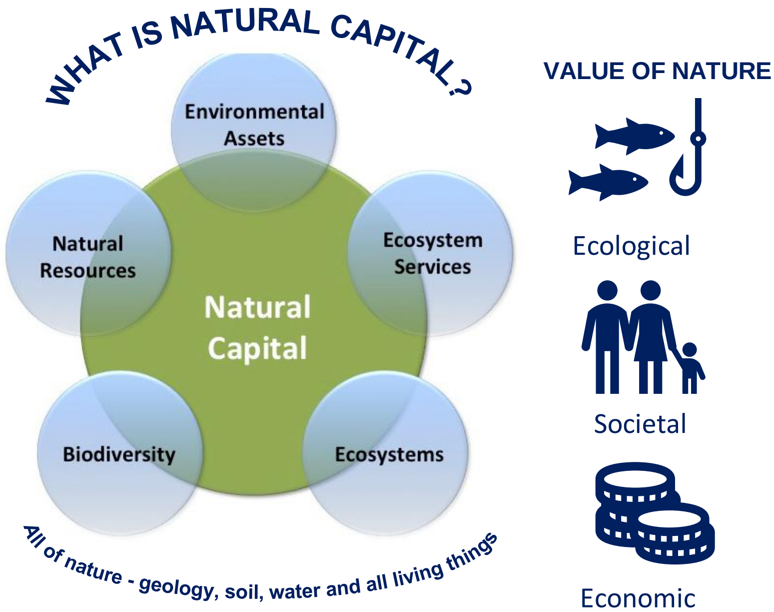
What are the aims of the project?

The overarching aim of the project is to investigate and assess the natural capital value of the Solent Marine Sites (SEMS) in terms of the function of coastal habitats and key species controlling water quality (particularly relating to nitrogen [N] and phosphorous [P] inputs). More specifically the project provides evidence to help value several ecosystem service flows which are interlinked with water quality. A further aim is to consider future management trade-offs and risks to these ecosystem services.

Natural Capital Assets are sometimes referred to as natural capital stocks or flows. Using the language of accounting can help to emphasise the value of natural assets – as benefits to the economy, or to society, or to nature itself.

Why do we need it?

The benefits that come from nature are in decline. Across the Solent, we have lost significant amounts of coastal habitat including intertidal mudflats, saltmarsh, seagrass and native oyster beds due to multiple pressures including climate change, overfishing, development and human-induced eutrophication. This means less nutrients removed by coastal habitats, more CO_2 released to the atmosphere and reduced nursery habitat for commercial species. Listing the benefits of nature and the risks of them being reduced – or even disappearing – helps decision makers to deliver habitat protection and restoration measures.



How did we go about it?

An assessment of natural capital assets (habitats) has been carried out at the national scale[1]. But the Solent needed something more detailed to help decision makers identify what risks exist, and how to secure the benefits and value of marine nature for the area. The University of Portsmouth, developed a Natural Capital Asset Register for the Solent Marine Sites (SEMS) to test and refine the application of the natural capital approach in the marine context. The register will enable targeted recommendations to support sustainable use of natural capital in the SEMS.

The Natural Capital Approach

The Natural Capital Asset Register for the Solent Marine Sites, which has been developed by the University of Portsmouth is the first ever detailed study of valuing water quality in the UK for a marine environment.

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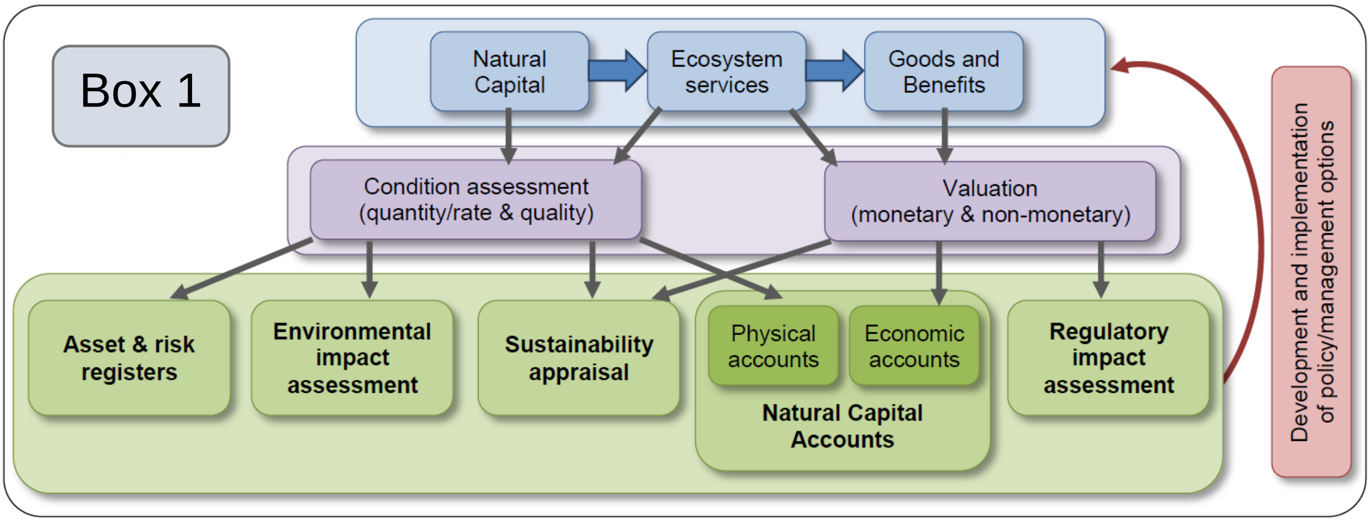
[1]Watson, R., Albon, S., Aspinall, R., Austen, M., Bardgett, B., Bateman, I., Berry, P., Bird, W., Bradbury, R., Brown, C. and Bulloch, J., (2011). UK National Ecosystem Assessment: Technical Report. United Nations Environment Programme World Conservation Monitoring Centre.

The natural capital approach



There are several different mechanisms for organising and evaluating natural capital, goods and services in order to support the decision-making process (**Box 1**[2]). A particular focus of the approach has been the development of the asset register which is a key foundation of the evidence base, and is an inventory of natural capital assets (habitats) in an area, which records their type, extent and quality. There are two types of asset register accounts: physical accounts consider the extent and quality of natural capital, and quantities of ecosystem services, while economic accounts consider monetary values. A risk register also systematically documents the threats to natural capital, services and benefits, including the potential scale of their impact.

Recording the assets – a four-step approach

1. What are the assets?
2. What condition are the assets in?
3. What ecosystem services are linked to those assets?
4. What is the value of the ecosystem benefits?

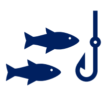
We defined SEMS assets (habitats) and mapped their extent and condition. We then looked at the literature to determine the level of provision of ecosystem services from each habitat and assigned an associated benefits value[3].

The ecosystem services we assessed were:

- Waste remediation (nitrogen and phosphorus).

- Climate regulation (carbon sequestration and storage).

- Commercial, recreational and subsistence fisheries.



- Nursery function and supporting the existence of biodiversity.

- Recreation, tourism and leisure.

How can we understand risk?

One way to categorise risk is to assess the current status of ecosystem benefits and how they may change in the future relative to natural or anthropogenic pressures. The Risk Register approach assesses the sensitivity of the asset–benefit relationship against a range of pressures known to occur in the SEMS including:

- Physical abrasion from mobile fishing gears,
- Eutrophication (increases in nitrogen and phosphorous inputs),
- Sea level rise,
- Introduction of microbial pathogens (e.g. *Escherichia coli*).

Sensitivity assessments following the Marine Evidence-based Sensitivity Assessment (MarESA[4]) methodology have been undertaken for each of the pressures relating to whether the asset–benefit relationship is deteriorating and, if so, how rapidly.

[2] From: Hooper, T., Ashley, M., Börger, T., Langmead, O., Marcone, O., Rees, S., Rendon, O., Beaumont, N., Attrill, M. and Austen, M. (2019). Application of the natural capital approach to the marine environment to aid decision-making. Phase 1 Final Report. Report prepared for the Department for Environment Food and Rural Affairs (project code ME5115).

[3] Watson, S.C.L., Preston, J., Beaumont, N.J. and Watson, G.J., (2020). Assessing the natural capital value of water quality and climate regulation in temperate marine systems using a EUNIS biotope classification approach. Science of the Total Environment, 744, p.140688.

[4] Tyler-Walters, H., Tillin, H. M., Perry, F., Stamp, T., & d'Avack, E. A. S. (2018). Marine Evidence-based Sensitivity Assessment (MarESA)–A Guide.

The Solent European Marine Sites (assets) habitats

The building blocks of natural capital assessment are habitats because they are distinct environmental 'units' which can be mapped spatially. Established systems exist for the classification of coastal habitats, principally the European Nature Information System (EUNIS) which distinguishes how coastal habitats are mapped and monitored within the same national-scale programmes as terrestrial habitats. In the SEMS these include coastal plant habitat classes such as, reedbeds, saltmarsh and seagrass beds and sedimentary habitats such as bivalve reefs (**Table 1**).

Table 1 Coastal and marine benthic habitats, based on major biological zones (related to depth).

Class	Zone	Examples of key coastal and marine habitat types in the Solent
Coastal	Coastal margin (splash zone)	Sand dunes, shingle, sea cliffs, rocky shores
	Coastal (between high and low tide)	Intertidal rock, mudflats, saltmarsh, seagrass, mussel beds
Marine	Shelf (from low tide to about 200m deep)	Subtidal rock, sediment, seagrass, kelp/other seaweed beds, oyster reefs

Mapping SEMS Habitats

The asset account was developed for six broad EUNIS habitat types (in ha): littoral sediments (including with green algal mats), coastal saltmarsh, seagrass beds, reedbed, subtidal sediments and native oyster (*Ostrea edulis*), reefs from the Solent (Lymington Harbour to Pagham Harbour) and several inshore areas around the Isle of Wight (Yar estuary to Bembridge harbour). Several other habitats such as sand dunes, rocky shore and kelp beds ecosystems are also important, but it was not possible in this study to quantify the physical flows of services from these habitats.

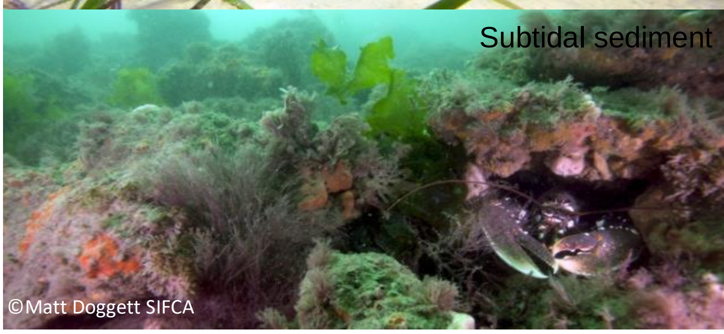
SEMS Habitats

Mudflats

Mudflats with macroalgal mats

Seagrass beds

Saltmarsh and reedbeds



Subtidal sediment

Native oyster reefs

What does the assets register tell us?

The total value of the five ecosystem services which could be quantified in the SEMS was estimated to be **£1.3 billion** in 2020. This is predominantly made up from the ecosystem service of waste remediation which describes the biophysical processes responsible for removing excess N and P inputs from the marine environment (**Table 2**). Fishing and aquaculture, climate regulation and recreation activities were also important.

However, it is important to note that due to the challenges of monetising the services provided by ecosystem assets, it was not possible to quantify the monetary flows for all of the services included in the accounting framework (e.g. nursery function). As such, these estimates do not capture all of the value of the SEMS.

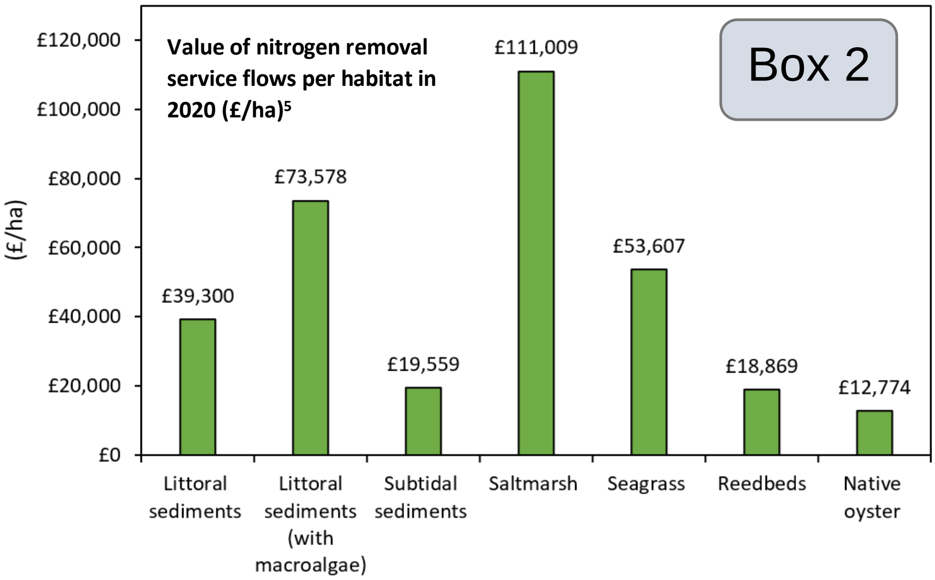
Other services that could also be looked at in the future include:

- Amenity, non-use values
- Fresh water provisioning
- Natural hazard protection (e.g. sea-level rise)
- Raw materials (e.g. biofuels) and medicinal resources
- Sediment stabilisation
- Waste remediation (heavy metals, persistent pollutants, microplastics).

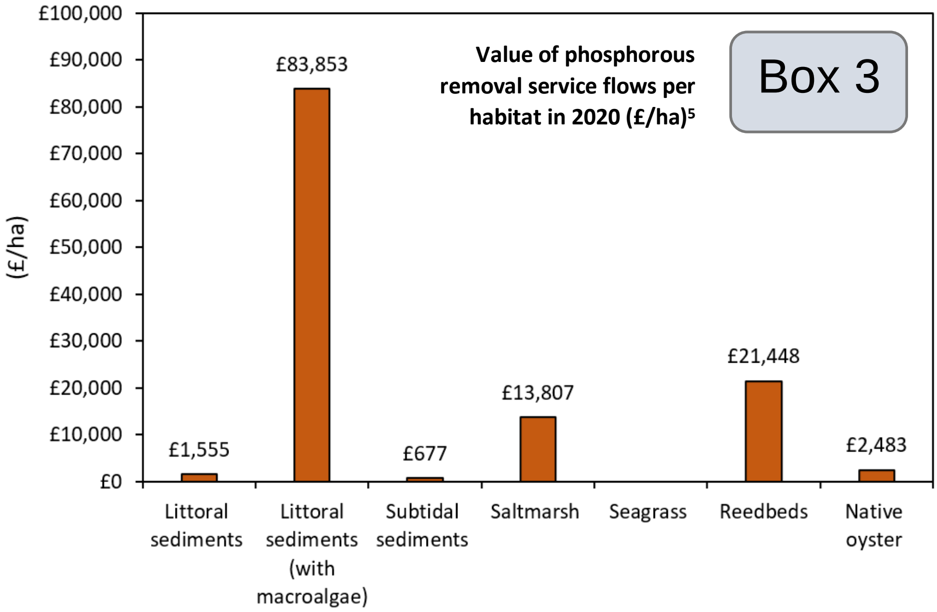
Table 2 Physical and monetary flows of ecosystem services in 2020

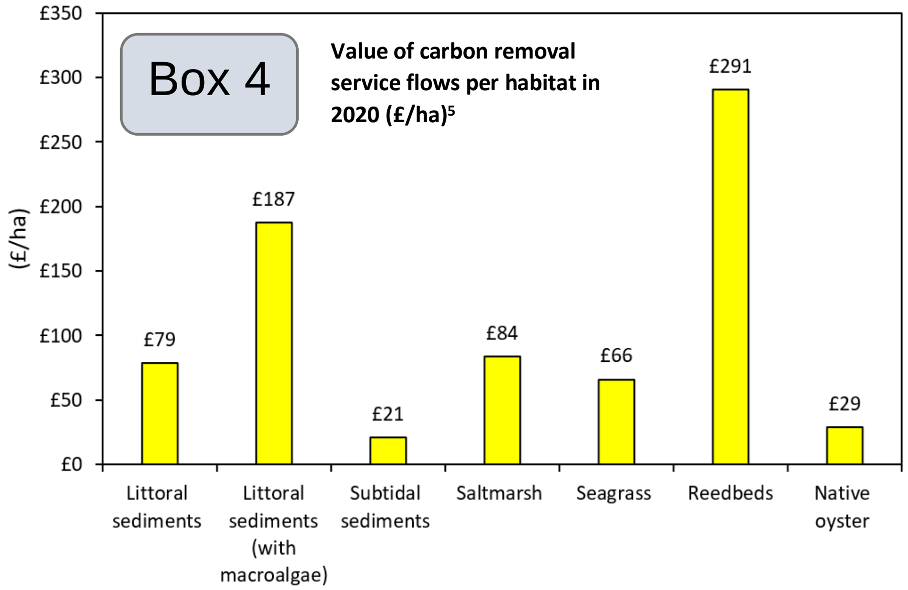
Ecosystem service	Measurement unit	Physical flows	Valuation basis	Monetary flows
Climate regulation (carbon)	Tonnes carbon removed	38,299 (t carbon yr^{-1})	Marginal abatement costs	£2.30 Million
Fishing and aquaculture	Tonnes finfish, shellfish and polychaetes harvested	1,723 (t catch yr^{-1})	Direct and Indirect Gross Value Added to UK economy	£14 Million
Nursery function	Commercially important fish taxa or other species that rely on coastal or marine habitats.	51 (Number of species)	-	-
Recreation, leisure and tourism	Area of water-body available for marine recreation, leisure or tourism	341 (km)	Willingness-to-pay	£2.73 Million
Waste remediation (nitrogen)	Tonnes nitrogen removed	3,590 (t nitrogen yr^{-1})	Replacement costs	£1,059 Million
Waste remediation (phosphorus)	Tonnes phosphorus removed	811 (t phosphorus yr^{-1})	Replacement costs	£229 Million
Total				**£1,304 Million**

With regards to specific habitats, littoral and subtidal sediments (including those with macroalgae) were found to have highest **total nitrogen removal value (£744 million)**. However, in terms of average value per ha, saltmarsh was found to be the most valuable due to the high capacity of this habitat to remove nitrogen through the mechanisms of denitrification (loss to the atmosphere) and burial in underlying sediments (**Box 2**).



[5]Watson, S.C.L., Preston, J., Beaumont, N.J. and Watson, G.J., (2020). Assessing the natural capital value of water quality and climate regulation in temperate marine systems using a EUNIS biotope classification approach. Science of the Total Environment, 744, p.140688





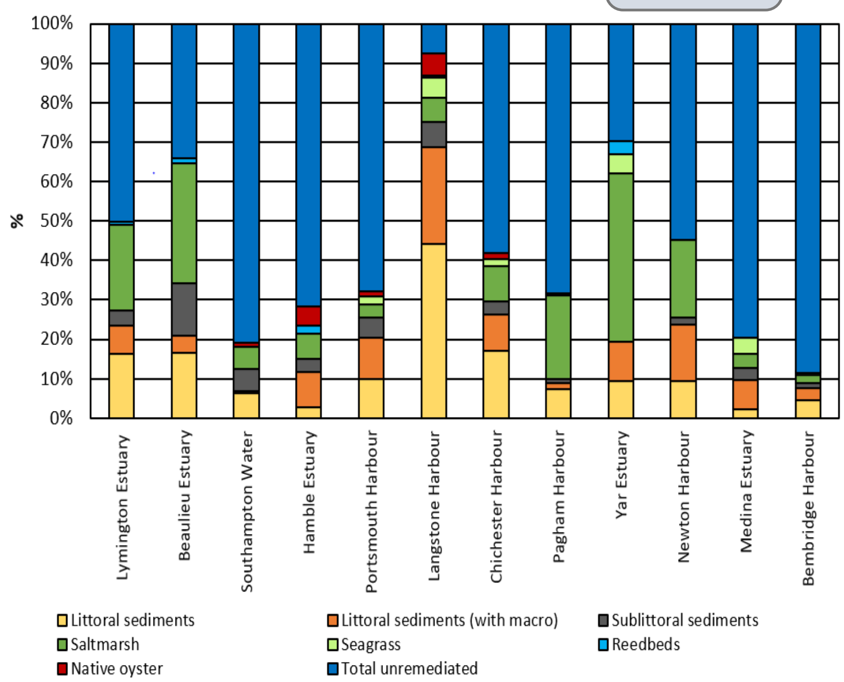
Littoral sediments overlain with macroalgal mats (*Ulva and Enteromorpha spp.*) were found to have high average values in terms of phosphorous and carbon burial and storage (**Box 3-4**) likely due to a direct input of inorganic nitrogen, phosphorus and carbon associated with macroalgal debris. It should be noted that macroalgal mat effects on other ecosystem services (e.g. impacts on leisure and tourism activities and on protected habitats and birds species) may be negative and remain to be synthesized in our valuation estimates.

Saltmarsh and the common reedbed (*Phragmites australis*) were also important as long-term stores of phosphorus and carbon (**Box 3-4**). Seagrass and native oyster habitats were found to have low average values (**Box 2-4**) per ha due to the low densities of native oysters present in the SEMS and the high variability of nutrient storage in these habitats at the estuary scale.

Box 5

Habitat remediation vs nutrient loads into the SEMS

- To investigate the potential for different habitats to contribute to regional-scale water quality goals we combined the previously calculated annual N removal rates with Environment Agency catchment nutrient loading data.
- Habitat processes retain and remove 35% of total N loading into the SEMS.
- Available evidence suggests N reductions are still required across all Solent estuaries and harbours and Southampton Water, Chichester Harbour and Pagham Harbour; P reductions may also be required (see main report for P calculations).



Percentage of nitrogen remediated by habitats in each catchment of the Solent

The effect of green macroalgal mats on SEMS habitats

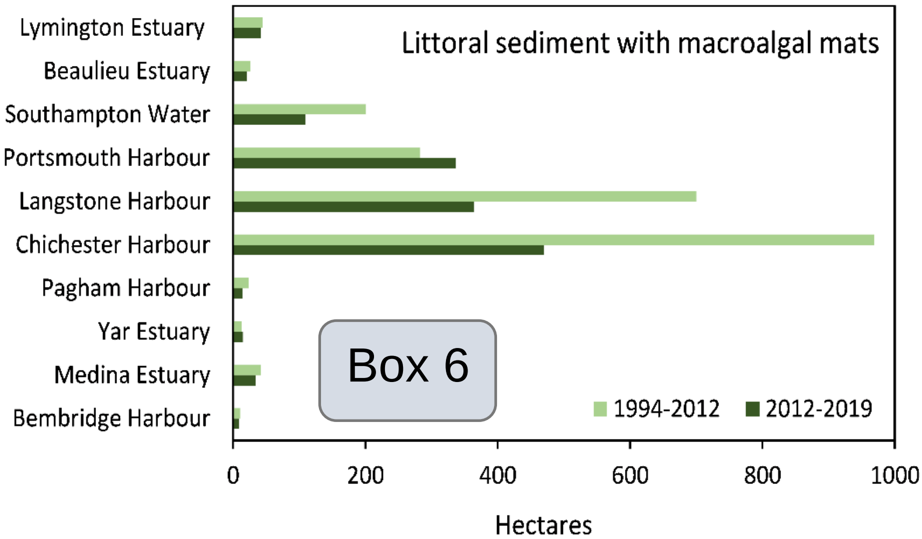
Background

Nitrogen (especially nitrate) enrichment in some Solent estuaries has contributed to the excessive growth of green macroalgae on intertidal mudflats (see picture below) which can have adverse effects on ecology e.g. on invertebrates and wading birds. This process is known as eutrophication. Note that the problem is not nitrate concentration *per se* but the vast area of the mats and their effect on the ecology in some Solent estuaries – there are much higher nitrate levels elsewhere around the UK with no adverse effect on ecology.

Green macroalgae (Portsmouth Harbour)

Path to recovery and ecosystem services

There is clear evidence from Environment Agency data (**Box 6**) that macroalgal mats are beginning to decline across several areas of the SEMS. New research programmes such as the Nutrients in Transitional waters (RansTrans) project and statutory “Nitrate Neutrality” measures operating in the SEMS could also help to reduce excessive algal mats and nutrients helping to increase the ecological status of coastal systems.

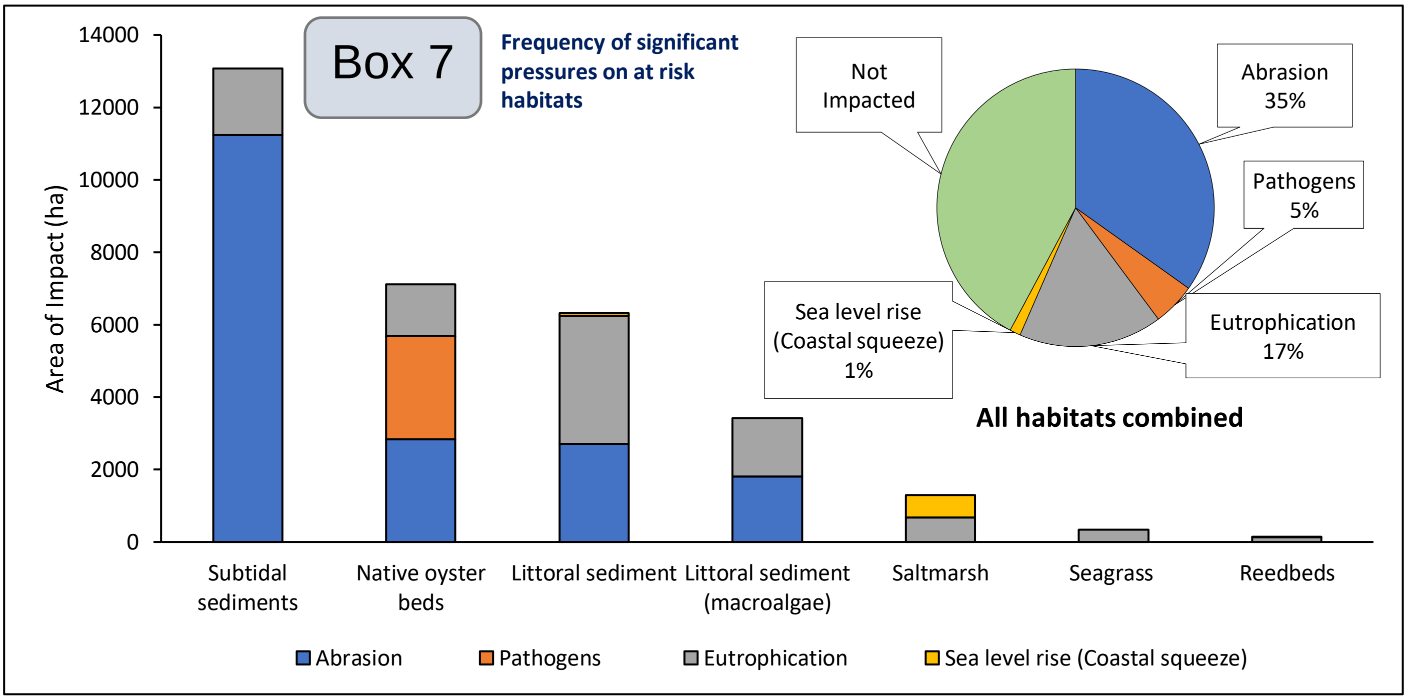


As the Solent recovers from eutrophication the biophysical ‘value’ of nutrients captured by macroalgal mats will reduce, but this ‘value’ will likely be compensated by alternative habitats (e.g., saltmarsh, seagrass) which are characteristic of non-eutrophic coastal systems. This trade-off will also bring additional ecosystem benefits such as water-based recreation activities and aesthetic enjoyment of the marine environment. More research into the different ecosystem services (and disservices) provided by macroalgal mat assemblages should be an important area of research to allow future management trade-offs to be made in the SEMS and other Marine Sites.

What are the risks to water quality ecosystem services?

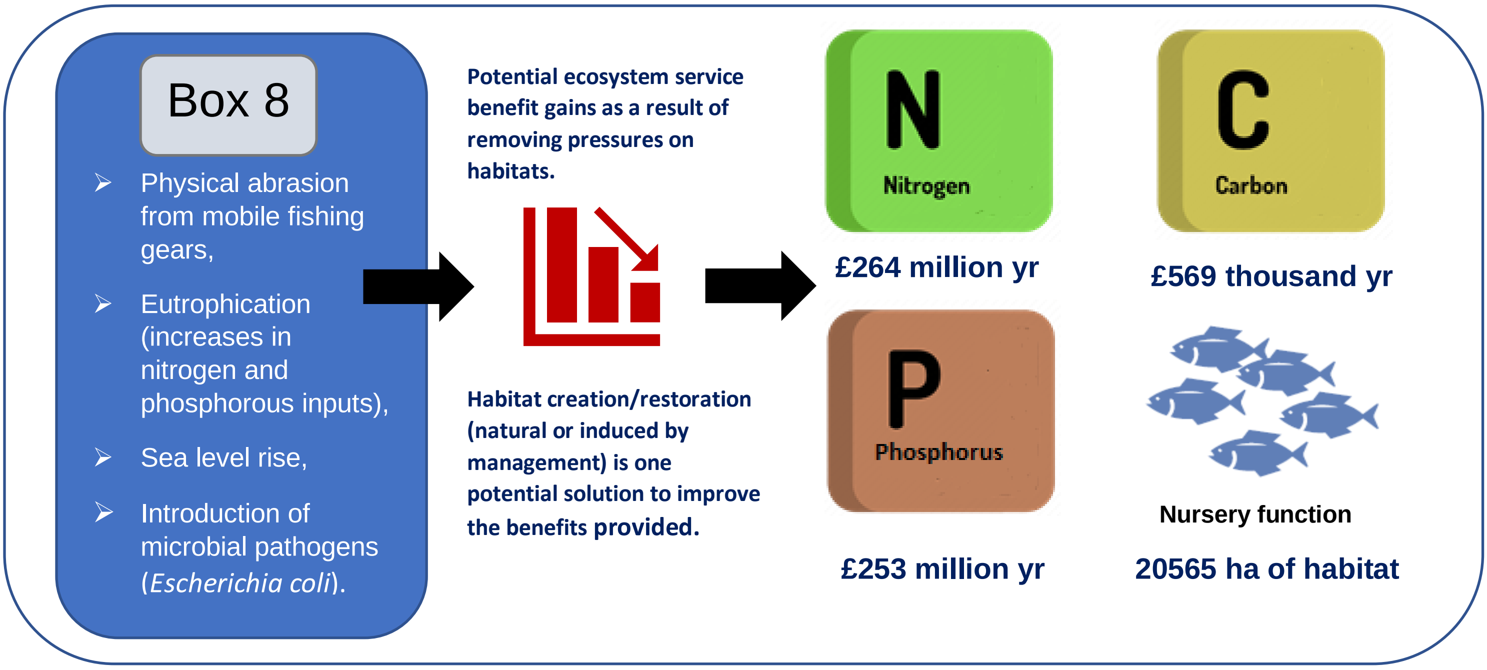
Significant multiple pressures on at risk habitats

Box 7 below shows the frequency of significant pressures on at risk habitats. Abrasion from fishing activities is the most prevalent pressure covering 35% of the SEMS marine area. Other significant pressures include eutrophication (17%), impacts of pathogens (5%) and sea level rise (1%). All habitats with the exception of seagrass beds are subject to more than one pressure. Large areas of littoral and sublittoral habitat are currently at risk, and with impaired quality due to previous fishing activity. Recent fisheries bylaws (e.g. Prohibition of Gathering Sea Fisheries Resources in Seagrass Beds 2016) have helped protect saltmarsh and seagrass habitats from the effects of abrasion but, native oyster habitats are at risk due to degraded habitats and instances of poor water quality. Saltmarsh habitats are also at future risk of loss due to sea-level rise and coastal squeeze impacts.



Impact of pressures on the value (£) of ecosystem benefits

There are particular risks to future benefits provided by habitats including: nutrient remediation (nitrogen and phosphorous), climate regulation (carbon sequestration and storage) and nursery habitat quality. Multiple pressure-based modelling supports this finding. Estimated cost savings of reducing impacts of all four stressors is estimate at £517million per year **(Box 8).** Understanding these risks helps us to identify potential management options and solutions to reduce these impacts.



What are the next steps?

The SEMS Natural Capital Asset Register accounting framework builds to a large extent on existing environmental reporting streams. This is a deliberate choice. Current UK Environmental legislation aims to enhance the extent and condition of specific habitats (under the Habitats Directive) and ecosystems including freshwater, transitional and marine (under the Water Framework Directive). Securing clean, healthy, productive and biologically diverse seas and oceans are also key to achieving different targets of the UK governments 25-year plan.

The added value of taking a natural capital approach for the SEMS is that for the first time a comprehensive and consistent list of indicators for assessing ecosystem service flows based on extent and condition per habitat type are collected. The framework also allows a relative ecosystem "value" to be placed on key habitats and species in a consistent manner that can then be applied in horizontal assessments across different regions and ecosystems.

Overall, the conclusion from the SEMS natural capital accounts is clear, that restoring and improving the existing extent and condition of habitats should be seen as a major consideration for improving water quality in the Solent. This should and could be combined with efforts to mitigate nutrients upstream of catchments to achieve nutrient neutrality.

To achieve such goals, a greater understanding of available asset–benefit relationships is needed. In particular, methods need to be developed to take account of the relative shortage of ecological data for the marine environment compared to land, which may include a greater reliance on modelled data. There is also further work that could be done to create a more comprehensive baseline of the ecosystem services provision by habitats in the SEMS. Other impacts on water quality (e.g. heavy metals, persistent organic pollutants, radioactive materials, microplastics) for example could be included in the future with further data and resource.

Read the full report: "Valuing the Solent Marine Sites Habitats and Species: A Natural Capital Study of Benthic Ecosystem Services and how they Contribute to Water Quality Regulation" Technical Report ENV6003066R.

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