An Ocean Health Index+ assessment for South West England

TECHNICAL REPORT

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UNIVERSITY OF EXETER

OCEAN HEALTH INDEX

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1. Introduction

The Ocean Health Index (OHI) is a tool to measure the benefits and services that the ocean provides for people now and into the future. Assessing a suite of socio-economic and ecological goals, the OHI is developed with the support of local stakeholders to better understand how to sustainably balance current and future ocean use.

OHI was originally designed as a global framework by a team of research scientists led by Ben Halpern at the National Centre for Ecological Analysis and Synthesis, University of California, Santa Barbara (see https://ohi-science.org/). This current project is an independent assessment (OHI+) that tailors the OHI methods to the South West England marine environment. Using available information and knowledge, the project adapts the global framework to encompass cultural, social, and ecological priorities across the South West England assessment area to provide an objective, numerical model which measures the impacts of marine management efforts on our coastal seas. The results provide a baseline description of marine health. As the OHI+ framework is repeatable over time, it can be integrated into ongoing policy initiatives now, with the potential to support sustainable ocean management into the future.

The OHI+ South West England assessment is delivered by an interdisciplinary team of research scientists from the University of Exeter, overseen by a project steering group. We anticipate that the assessment outputs will be relevant to a variety of marine management groups or initiatives including Local Nature Partnerships, the Environmental Growth Strategies and Maritime Strategies of the County Councils and Unitary Authorities, the Blue Growth Agenda and local and national Marine Spatial Planning efforts.

1.1. Background

Marine planning

Anthropogenic pressures are intensifying in the marine environment (Butchart et al., 2010; Halpern et al., 2015a, 2008). Fisheries, recreation and military activities face increased competition for three-dimensional space with the expansion of offshore renewable energy, aquaculture and Marine Protected Areas (MPAs) (Agardy et al., 2011; Day, 2002; Douvere, 2008). In response, countries with coastal waters are attempting to develop cohesive marine management plans that integrate multiple conservation, industry and recreation activities for optimal use of space, to minimise conflict, and to ensure sustainable use of resources (Gill, 2005; Wiirsig and Gailey, 2002). Regular, preferably

independent, ecosystem assessments can help track progress towards management targets and support delivery of expected benefits. A quantitative baseline of ecosystem health is needed from which to evaluate change over time, and hence assess the relative success of marine policies.

1.2. Global and regional OHI assessments

Global Ocean Health Index (OHI)

The Ocean Health Index (OHI) is an indicator index metric, developed to quantitatively measure the benefits and services the ocean provides (Halpern et al., 2012). The metric integrates a suite of socio-economic and ecological objectives (referred to as goals). Its primary objective is to improve progress towards sustainable ocean management whilst acknowledging human-ocean interactions (Halpern et al., 2012). The original application of the OHI was a global scale assessment of 220 coastal states and territories, with the Exclusive Economic Zone (EEZ) of each country defining a distinct assessment area (Halpern et al., 2012). Annual repeat assessments have since been performed to establish both spatial and temporal trends in ocean health (Halpern et al., 2017).

Independent assessments (OHI+)

The OHI method has been used by different research groups (termed OHI+) to undertake regional assessments, from cities to ocean basin scales (Burgass et al., 2019; Daigle et al., 2017; Elfes et al., 2014; Halpern et al., 2014; Ma et al., 2016; O'Hara et al., 2020; Selig et al., 2015). To date, 17 independent EEZ level assessments and 13 sub-EEZ, assessments have been completed or are in advanced stages (https://ohi-science.org/projects/ohi-assessments/). These OHI+ assessments benefit from the open-source, repeatable nature of the OHI framework, which facilitates collaboration, transparency and repeatability ((Halpern et al., 2012, Lowndes et al., 2015). Regional OHI+ assessments enable higher resolution and potentially more relevant localised data to be incorporated (Elfes et al., 2014), helping to reflect local realities and management priorities (Lowndes et al., 2015). Results have been used to report progress on regional initiatives including Marine Strategy Framework Directive (MSFD) descriptors and global strategies including Sustainable Development Goals (Schemmel et al., 2018). The independent uptake of the OHI methodology highlights the demand for a repeatable, quantitative tool that can be applied to assess management progress and the broader health of our oceans at a variety of spatial scales (Lowndes et al., 2017).

OHI as a communication tool

Clear communication of modelling outputs is fundamental to the OHI process. OHI scores are visualised using a flower plot (Figure 1a) specifically designed to facilitate the communication of results to a wide audience in an intuitive manner. Each petal within the flower plot represents a single goal or sub-goal. In most OHI assessments, goals are equally weighted, so the width of each goal is consistent. This may be represented by one petal, or subdivided into two narrower petals where the goal comprises two sub-goals. Petal length and colour are used to help communicate the OHI scores. Shorter, lighter coloured petals indicate low goal scores, whilst longer, darker petals reflect higher scores to a maximum of 100. The final score for each region is calculated by taking the average (mean) score of all goals, and displayed as a single value (0-100) at the centre of each flower plot to allow easy comparison of final scores between regions if desired.

The flower plots allow a reader to visually compare the scores of different goals with in a region or compare a single goal performance across multiple regions. By maintaining a standard design, future OHI assessment for the same assessment area can similarly be compared, allowing changes through time to be easily interpreted. It is important to note however, comparing these outputs among different OHI studies should be avoided. Local OHI+ assessments use varied data from one another and from the annual Global OHI assessment. OHI and OHI+ results are therefore not directly comparable.

(a)

(b)

Figure 1. OHI petal plot and South West study area. (a) each petal represents a single goal or sub-goal. Narrower petals indicate a goal consisting of two sub-goals (e.g. the 'Biodiversity' goal is comprised of two sub-goals 'Habitats' and 'Species'). When combined, these sub-goals are equal to a single goal. Petal length and colour are used to help communicate the OHI scores. Shorter, lighter coloured petals indicate low goal scores, whilst longer, darker petals reflect higher scores to a maximum of 100. The final score for each region is displayed as a single value (0-100) at the centre of each petal plot. (b) South West England and inshore (12 nmi) zone.

1.3. An OHI+ for South West England

This project makes use of OHI+ in the UK for the first time. By adapting an established methodology, we examine how the tool performs in the context of UK relevant data and whether OHI+ provides useful insight for existing management of marine and coastal areas.

The project considers the maritime region (out to 12 nm) of South West England (Figure 1b). This busy maritime area encompasses the Western Approaches, English Channel and Celtic Sea, which provide important fishing grounds, and supports numerous recreational activities and a diverse range of temperate habitats and species. The area will soon benefit from a distinct marine plan, the South West Marine Plan (SWMP), implemented and managed by the Marine Management Organisation (MMO). Whilst the performance of the SWMP will be subject to periodic review as mandated by UK law, an independent assessment of performance using internationally recognised metrics and benchmarking offers additional transparency and accountability. In applying the OHI methodology to South West

England, this project also seeks to highlight the value of OHI+ to other regional marine management initiatives.

Synthesis of regional datasets required by OHI+ has the added benefit of generating a comprehensive marine geo-database for South West England and identifying important priority areas and data gaps. Collating data in this manner futureproofs the project, enabling repeat assessments with reduced effort. As with other OHI+ assessments, all analysis uses open source, collaborative software (R, RStudio, Git, GitHub). This ensures the OHI+ assessment can be updated with the most recent data annually, or on other management timeframes, with less effort than its initial development. There is also the potential for this OHI+ assessment to expand to other English or United Kingdom (UK) regions as most datasets used are drawn from national repositories.

The application of the global OHI method to South West England requires substantial stakeholder engagement to ensure that the OHI+ contains local indicators that are both informative and relevant. Through an expert steering group, policy mapping and stakeholder engagement, we developed the OHI+ for South West England in line with the SWMP's management objectives.

In undertaking an OHI+ assessment for South West England, we depart from the global OHI assessment in a number of ways. First, we have excluded or combined some goals to better reflect the local marine environment, its uses, and local management priorities. Second, many of the datasets used for the OHI+ regional assessment are drawn from UK datasets that offer greater relevance and utility than those used in the global OHI assessment. Third, the OHI global assessment provides a tool to compare ocean health performance among regions (e.g. EEZs), and this premise is integrated into many goal calculations by using inter-regional benchmarks as reference points for assessing performance. In the OHI+ assessment for South West England, the assessment criteria and scoring instead use within-region benchmarks and do not endeavour to make comparisons among regions within the assessment area.

This OHI+ assessment undertook the following actions:

1. Tailor the OHI+ framework and goals to ensure their relevance to South West England.
2. Collate regional data sets relevant to the measures in the OHI+ framework and calculate scores for South West England as a whole and associated geographic regions.
3. Engage with regional stakeholders to validate choices made in the application of OHI+ indicators and inform iterations of the OHI+ model.
4. Identify the relevance of the OHI assessment to the SWMP through policy mapping and stakeholder engagement.
5. Validate the results through stakeholder engagement.
6. Communicate the project findings to regional and national stakeholders.

The results of this initial assessment will enable managers, policy makers and the public to interrogate and communicate the current status of marine ecosystems, identify priorities, and design targeted management actions to improve ocean health.

Parlour pots

Drew Collins

1.4. Project Governance

To ensure that the South West England OHI+ assessment incorporated relevant and informative indicators, we engaged a project steering group of regional stakeholders. The group comprised representatives from Cornwall Council, Cornwall Wildlife Trust, Devon Wildlife Trust, Isles of Scilly Inshore Fisheries and Conservation Authority, the Marine Management Organisation, Natural England and the South West Marine Ecosystems network. The group provided the primary source of stakeholder input and was regularly engaged throughout the project lifecycle. Three principal meetings involving the entire steering group (where possible) were held at locations across South West England. These meetings corresponded to completion of key OHI iterations, occurring approximately six months, one year and 18 months after the project commenced. The primary purpose was to elicit input on project progress including sourcing of data, designing the goal metrics, the utility of OHI goal weightings, setting of reference points, identification of additional stakeholders and the wider communication strategy for project outputs. Individual or group engagement was also sought whenever additional project milestones occurred or decisions requiring specific expertise were needed.

Further stakeholder groups were consulted when required or upon their request. These meetings included, but were not limited to, the Marine Management Organisation Spatial Planning Team, fisheries local action groups, the Centre for Environment, Fisheries and Aquaculture Science (Cefas) and multiple non-government conservation organisations. These key stakeholders from industry, policy and conservation were engaged on an *ad hoc* basis to elicit input and ensure the OHI+ assessment for South West England reflected regional priorities. Their input drove various adaptations detailed under each OHI+ goal (Section 4) in this report. Many of these stakeholders were engaged based on recommendation from the project steering group or through connections built by the University of Exeter team.

Broader engagement was achieved through the presentation of the OHI+ South West assessment at regional and national conferences, seminars and workshops to policy teams within conservation and management agencies. These were organised by groups including but not limited to: The Devon Maritime Forum, South West Marine Ecosystems, Natural England, Cornwall Marine Liaison Group and the University of Exeter. The purpose of these presentations was to ensure wide dissemination and longevity of the OHI+ South West project. These interactions allowed input and scrutiny of the project methods, essential for the transparency, legitimacy and enhanced quality of the outputs, and helped to develop a shared understanding and agreement for project conclusions. To support wider outreach, a website was developed (https://www.sustainable-seas.org/).

2. Methods

2.1. Assessment area

The OHI method has no limit to the number of geographic regions that can be defined within the assessment area (Halpern et al., 2012). Assessment area and associated region selection is key as OHI+ scores are calculated for each individual region before being aggregated as a total score for the assessment area. Regions should therefore reflect distinct biogeographic, cultural and economic characteristics (Halpern et al., 2014). This allows spatial comparison of results across the assessment area and helps identify geographic management priorities (Ocean Health Index Assessment Manual, 2016). However, data availability is an important constraint on region selection. Political boundaries are considered optimal in OHI assessments as data are rarely reported at sub-state or county resolution (Halpern et al., 2014). Similarly, management and policy initiatives are often developed by county-level organisations including councils or nature partnerships. Based on these considerations the South West England assessment area was divided into six regions (Figure 2a).

Spatial boundaries for regions were generated using the Geographic Information System (GIS) software ArcGIS (ESRI). The assessment area was defined by creating a 12 nautical mile (nm) offshore polygon projected from the mean high-water mark (Global Self-consistent Hierarchical High-resolution Shorelines (GSHHS) https://www.ngdc.noaa.gov/mgg/shorelines/) from the Forest of Dean in the north east, to East Devon in the far south east (including Lundy and the Isles of Scilly). The northern extremities were adjusted to reflect the MMO SWMP boundary (Figure 2b) with adjacent Welsh waters. Regions were formed using perpendicularly projected lines from county/local authority borders to provide: Region 1 (Forest of Dean to West Somerset); Region 2 (North Devon and Torridge); Region 3 (Cornwall); Region 4 (Isles of Scilly); Region 5 (Plymouth and South Hams); and Region 6 (Torbay, Teignbridge, Exeter and East Devon).

REGION	AREA (KM^2)	COAST LENGTH TO MEAN HIGH WATER (KM)	COASTAL (10KM) POPULATION (2011)
SBC-1	903.1	470.8	1,375,047
NOD-2	2884.6	248.7	127,426
CWL-3	7026.7	1082.5	501,067
IOS-4	2460.0	149.1	2,204
SWD-5	1562.8	359.9	355,988
SED-6	1438.5	244.3	482,261

Table 1. OHI+ at sea region area, area coastal length and population

Region 1 incorporates multiple county/local authorities with limited marine areas into a single regional unit. North and South Devon marine areas (Regions 2, 5 and 6) were treated as independent regional units due to high potential variance in biogeography and socioeconomics between the English and Bristol Channel. South Devon was additionally divided into an East-West region (Region 5 and 6) to reflect the boundary prescribed by the MMO SWMP and South Marine Plan (SMP). Cornish waters were designated a single distinct region (Region 3) as were the Isles of Scilly (Region 4). An initial iteration of the OHI+ model included all waters within the Exclusive Economic Zone (EEZ), following the global OHI method. However, due to the wide variation in maritime area coverage among regions that this created, and the limited datasets that encompassed the total EEZ, the regions were ultimately bounded by the 12 nm limit.

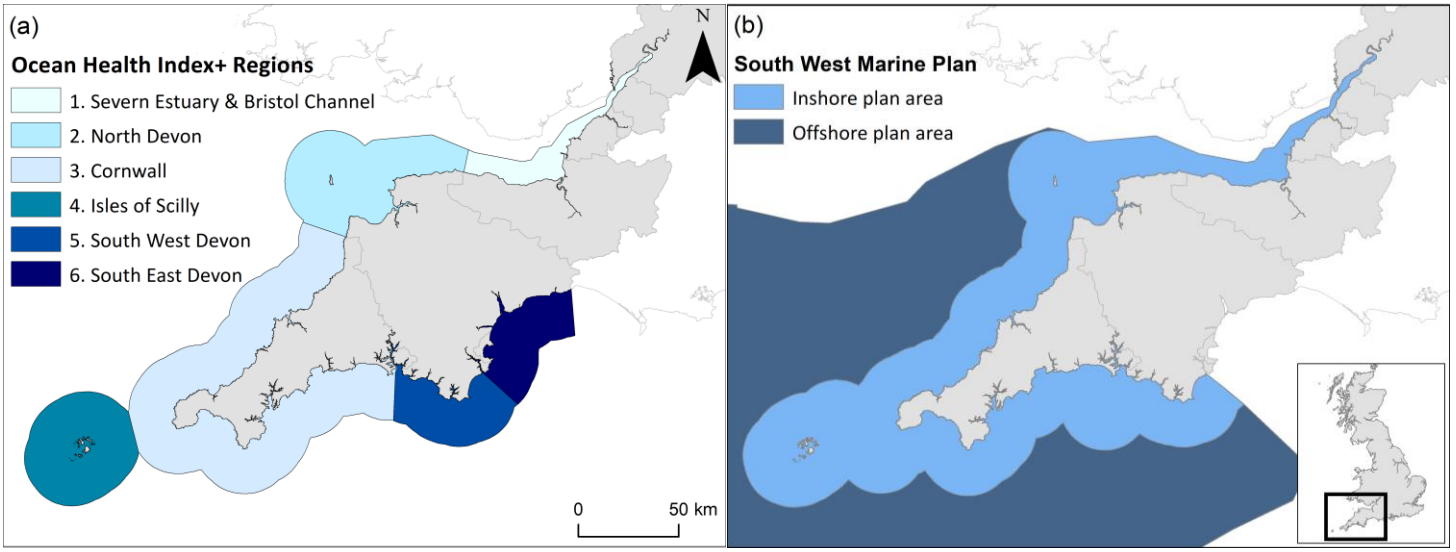


Figure 2. OHI+ study area. (a) South West England OHI+ assessment area showing distinct coastal regions to 12 nautical miles. (b) Marine Management Organisation (MMO) South West Marine Plan boundaries

2.2. What we measure

For the South West England OHI+ assessment we adapted the global OHI framework and goals to ensure their relevance to South West England. As such, we evaluated eight goals of which five comprised two sub-goals each. Goals are described with reference to the global Ocean Health Index (https://ohi-science.org/goals).

Clean Waters

Measuring pollution in coastal water

People value coastal waters that are free of pollution and debris for aesthetic and health reasons. Contamination can arise from point or diffuse sources and may comprise organic and inorganic inputs, disease pathogens and suspended and floating matter. In turn, this may result in visual degradation of the marine environment and cryptic contamination with consequential threat to human health, marine organisms, and the marine ecosystem. The Clean Water goal captures the degree to which local coastal waters are unpolluted by natural and human-made causes.

Food Provision: Fisheries and Mariculture

Seafood sustainably harvested for human consumption

Seafood is a fundamental service provided by the ocean to people. This goal, measures the amount of seafood harvested in a given region for use primarily in human consumption via domestic or export markets. It includes wild-caught fisheries and mariculture.

Artisanal Fishing Opportunity

Access opportunity for small-scale fisheries

Artisanal or small-scale fisheries provide livelihood opportunities for many South West England coastal communities. Artisanal fisheries typically refer to households, cooperatives or small firms that operate small-scale fishing vessels (under 10 m in length), rely on moderately small amounts of capital, make relatively short fishing trips (compared to industrial fleets), and land fish mainly for local consumption or trade. This goal uses the trend in landings attributable to the under ten-metre fleet, the associated catch per unit effort and the variation in marine diesel fuel price to measure the opportunity or barriers to a productive and stable fleet.

Livelihoods and Economies: Marine Wages, Jobs and Economic Productivity

Jobs, wages and revenue associated with marine-related industries

Marine related industries contribute widely to the economic and social stability of coastal communities whether it be directly through employment possibilities or income, or indirectly through other social or economic benefits such as community identity, personal wellbeing and tax revenue. This goal tracks marine industry wages against the consumer price index, trend in employment, and regional economic productivity through time.

Tourism and Recreation

Estimating footfall and socially valuing the local recreational experience

The coastal and nearshore marine environment is socially valued by local residents and tourists alike. This goal does not measure revenue or livelihoods associated with tourism and recreation but seeks to capture how much people value coastal areas (by willingness to travel) and assesses the access potential to local recreational activities. This goal captures the trend in domestic and international visitors, the recreational potential within coastal and nearshore marine environments, and the aesthetic appeal of the coastal surroundings.

Designated Areas: Valued Landscapes and Ecological Features

Community valued coastal systems; Environmentally regulated ecological features

Coastal and marine areas are valued for aesthetic, cultural and recreational reasons, and may be environmentally regulated to protect their ecological features. This goal measures the percentage of designated coastal and nearshore marine zones that hold community value, or that are identified as areas critical to ecological conservation.

Biodiversity: Habitats and Species

Conservation status of habitats; Conservation status of species

A fundamental principle of sustainable ecological practice is to maintain or improve the health of ecologically valuable habitats, and promote biodiversity of species. This goal tracks habitat health and condition monitoring through time, as well as assessing the conservation status of species pertinent to the South West England marine ecosystem.

Coastal Systems: Coastal Protection and Carbon Storage

Coastal habitats with shoreline protection and with carbon storage potential

Coastal marine habitats have the capacity to provide important ecosystem services. In South West England coastal marine habitats may provide buffering against floods and storms, as well as providing sequestration of carbon from the environment. To do so effectively habitats need to be in good health and to be appropriately managed. This goal asses the ability of these habitats to perform to the best of their potential now and into the future.

Major adaptations from the global Ocean Health Index assessment

All datasets underpinning the OHI+ goals in this assessment were adapted to use regionally relevant data. These adaptations, and any relevant adjustments to reference points are detailed under each goal in section 6. However, certain goals were more heavily adapted from the global methodology than others.

The 'Natural Products' goal from the OHI global assessment was removed entirely. This goal was designed to 'assess how sustainably people harvest non-food products (such as corals, shells, seaweeds, and live fish for the aquarium trade) from the sea'. In South West England only two active industries were considered relevant for this goal: seaweed harvesting and live wrasse fisheries for the use in salmon farms. Due to the currently small scale and relatively new status of these industries, insufficient data were available to run the OHI+ model. When these industries develop and subsequent data become available, the Natural Products goal could be reincorporated into future assessments if required. The paucity of data relating to emerging marine industries such as these reveals the challenges of applying the OHI model at small spatial scales.

The Designated Area goal is adapted from the global 'Sense of Place - Lasting Special Places' sub-goal. The global method applied a target reference point of 30% of inshore waters covered by some form of protective designation. This target was designed to reflect a globally accepted and often cited policy objective for marine protected area designation. Applying this metric to South West England resulted in maximum scores for all regions. This is due to the high number of different designation types that exist under English legislation, each with varying levels of environmental protection and differing objectives. A decision was therefore made to develop a new goal, Designated Areas, adapting the Sense of Place goal's Lasting Special Places and removing the Iconic Species sub-goal entirely.

We applied a target of the total area from 1 km inland to 12 nmi offshore being designated for ecological protection or management of environmental features. A further adaptation to the goal score calculation method entailed assessing the percentage of total area designated (1 km inshore to

12 nmi), rather than a mean of the percentage designated inland (to 1 km) and offshore (to 12 nmi), as applied by the global methods. This change allowed the OHI status scores to be a more transparent reflection of the area physically designated. A second sub-goal, Valued Landscapes, was created to reflect the need for designated areas with the primary purpose of protecting areas valued for aesthetic, cultural and recreational reasons, including those containing diverse habitats, historic sites or rare geomorphology (e.g. national parks). The Valued Landscapes sub-goal measured area designated as a proportion of the total area available (1 km inshore to 3 nmi offshore). The 3 nmi offshore extent was selected as representative of an accessible boundary for people wishing to access these sites, either visually from clifftops or via recreational watercraft. This was a further adaptation from the goal methodology which employs a mean proportion of inland (1 km) area designated and offshore (12 nmi) designated under some form of protection.

The global OHI Biodiversity: Species sub-goal uses the IUCN Red list distribution and assessment data to attribute species to regions and score them. Applying the global OHI method, where all species that intersect the study area are included, 700 marine and coastal species were considered relevant to the South West OHI+. As such, the model was deemed too insensitive to change. If an individual species ranking were to change, it would adjust the score by a maximum of 0.14%, assuming a region held the maximum 700 species. IUCN species assessments also rarely reveal inter-annual variation, with many updated every five to ten years, again reducing the goal sensitivity. As a result, a list of locally important species, similar to the global Iconic Species sub-goal (removed when adapting the Sense of Place goal) was developed. This list of 40 species, spanning a variety of taxonomic groups, increased goal sensitivity and allowed for local condition and monitoring data to be incorporated for many of the species.

The Coastal Systems goal is an adaption of two goals from the OHI global method, Carbon Storage and Coastal Protection. Whilst describing two distinct ecosystems services (i.e. the ability of coastal habitats to sequestrate carbon emission and provide natural defense from sea level rise and storm events) there is considerable overlap in the source data across the two goals. In the global methodology, there exists a greater diversity of habitats, making each goal sufficiently distinct to warrant separation. Across the South West study area there exist only a limited number of habitats that provide these ecosystem services and only a subset have comprehensive data available for use in the OHI assessment. As such, this resulted in the duplication of saltmarsh and mudflats and seagrass within each goal. Some of these data are further used in the Biodiversity: Habitats goal. This results in certain dataset exerting a high level of influence over OHI South West regional and total OHI South West England assessment scores. Due to these considerations, Carbon Storage and Coastal

Protection were combined into a single goal named Coastal Systems, thus reducing their influence on OHI South West analysis. The decision was actively made to retain the two sub-goals distinctly, as opposed to merging into single goal. Whilst at present both contain many similarities; each have distinct considerations and recommendations for future adaptation, detailed in their respect sub-sections of section 6.

Atlantic puffin

Guilherme Romano

2.3. Calculating scores

Calculating goal and region scores

Ocean Health Index assessments are evaluated from a social, economic and ecological perspective. The cumulative index score is calculated through goals and associated sub-goals, each scored between 0 and 100. Goals or sub-goals are shaped by multiple input data sets contributing to four elements: **status**, **trend**, **pressure** and **resilience** (see Appendices). Each goal score is the average of its current status and likely future status. The scores of individual goals and sub-goals are combined to give an overall score for ocean health. For the South West England OHI+, assessment scores were calculated for eight goals, including ten sub-goals across six regions of South West England.

Current status and the importance of reference points

The OHI process gathers disparate datasets such as, categorical/continuous data or spatially dissimilar (region-specific/regional/national), into a holistic framework from which goal scores are calculated. All data used to calculate goal scores are rescaled to a maximum value of 100 (Figure 3). This regularises data to the same numerical scale and enables the current status (described by the most recent year of data) to be determined. To facilitate this, data are scaled relative to a reference point that indicates a desirable goal (Appendix 7). This reference point may be a target such as an established scientific or policy target, or a benchmark. For the OHI+ South West assessment benchmarks were set that compared a region's current performance against its own past performance. We chose to calculate benchmark references from the five most recent years of data, primarily due to data availability. Five goal/sub goals: Mariculture, Artisanal Fishing Opportunity, Tourism and Recreation, Livelihoods and Economies were assessed using benchmark reference points. Six goal/sub goals: Fisheries, Carbon Storage, Coastal Protection, Ecologically Designated Areas, Landscape Designated Areas and Species were assessed using target reference points. Two goals/sub-goals: Clean Water and Habitats were assessed using a combination of both benchmarks, and targets (Appendix 7).

Likely future status: integrating trend, pressure and resilience

Three dimensions are used to calculate likely future status: **trend**, **pressure** and **resilience** (Figure 3). **Trend** is the change in status based on the most recent five years of status data (Appendix 8). This is calculated by estimating the yearly proportional change in status using a linear regression model (Halpern et al., 2017). Trend is constrained between -1 and 1.

Pressure describes the cumulative stressors acting on a goal or sub-goal which may suppress the goal score. Each goal or sub-goal may be influenced by multiple stressors (Appendix 4 & 6). Individual stressors are categorised as either ecological or social (Halpern et al., 2017). Ecological stressors are further sub-categorised as pollution, habitat destruction, fishing pressure, climate change and alien species. The intensity of each stressor is scaled from 0 to 100, with 100 indicating the highest stress.

(Halpern et al., 2017). The sensitivity of each goal or sub-goal to each stressor is ranked as having high (3), medium (2), low (1), or no (NA) impact (Appendix 4 & 6). These rankings are based on peer-reviewed literature or expert judgment (Halpern et al., 2012). Firstly, the cumulative ecological pressure score is calculated for each ecological stressor sub-category, with the maximum value being constrained to 100. Sub-categorical cumulative pressure scores are then aggregated using a weighted average, with the weighting being determined by the maximum stressor rank in each ecological sub-category. Finally, ecological and social pressures are aggregated with equal weightings.

Resilience data integrate ecological and social factors that support an increase in status by reducing or negating pressures (Halpern et al., 2017). Data are described by three categories, ecological ecosystem integrity, ecological regulatory resilience and social integrity resilience (Appendix 5 & 6). Each resilience category is composed of 1 or more data layers with values scaled from 0 to 100 reflecting the magnitude of resilience for each region. Resilience data may be binary (e.g. signatory to a convention where 0 = NO or 100 = YES), or continuous (e.g. proportion of area covered by Marine Protected Areas in the coastal zone). Each resilience data layer is assigned a weight of 0.5 or 1 that is applied equally across all the goals or sub-goals influenced by the resilience layer (Appendix 5 & 6). These data are used to calculate a resilience score for each category. Ecological resilience categories (ecological ecosystem integrity and ecological regulatory resilience) are averaged (mean) and then combined with social resilience (mean score using equal weighting).

The OHI process combines scores for **trend**, **pressures** and **resilience** to calculate likely future status (Figure 3 & 4), this is constrained to a maximum value of 100. Current status and likely future status are then averaged (mean) to produce region-specific goal or sub-goal scores.

Goal and cumulative index scores

The OHI cumulative index score for each region is calculated as an equally weighted average of the region-specific goal scores. Where a goal comprises of sub-goals: Designated Areas, Livelihoods and Economies, Biodiversity, and Food Provision, sub-goal scores are first aggregated using an unweighted mean (for Designated Areas, Livelihoods and Economies and Biodiversity) or weighted mean (Food Provision). Overall goal scores and index scores were calculated as an area weighted

average (mean) of region-specific outputs. Weights were derived from region-specific sea areas (km^2) from coast (mean high water) to 12 nmi offshore.

Data sets and regional relevance

For the South West England OHI+ regional assessment, scores were calculated for eight goals and ten sub-goals across six regions. This analysis incorporated 80 status data layers (69 [86%] region-specific, 3 [4%] national apportioned by region, 2 [3%] regional, 3 [4%] national, 3 [4%] global), 33 pressure data layers (28 [85%] region-specific, 5 [15%] national) and 17 resilience data layers (4 [24%] region-specific, 13 [76%] national).

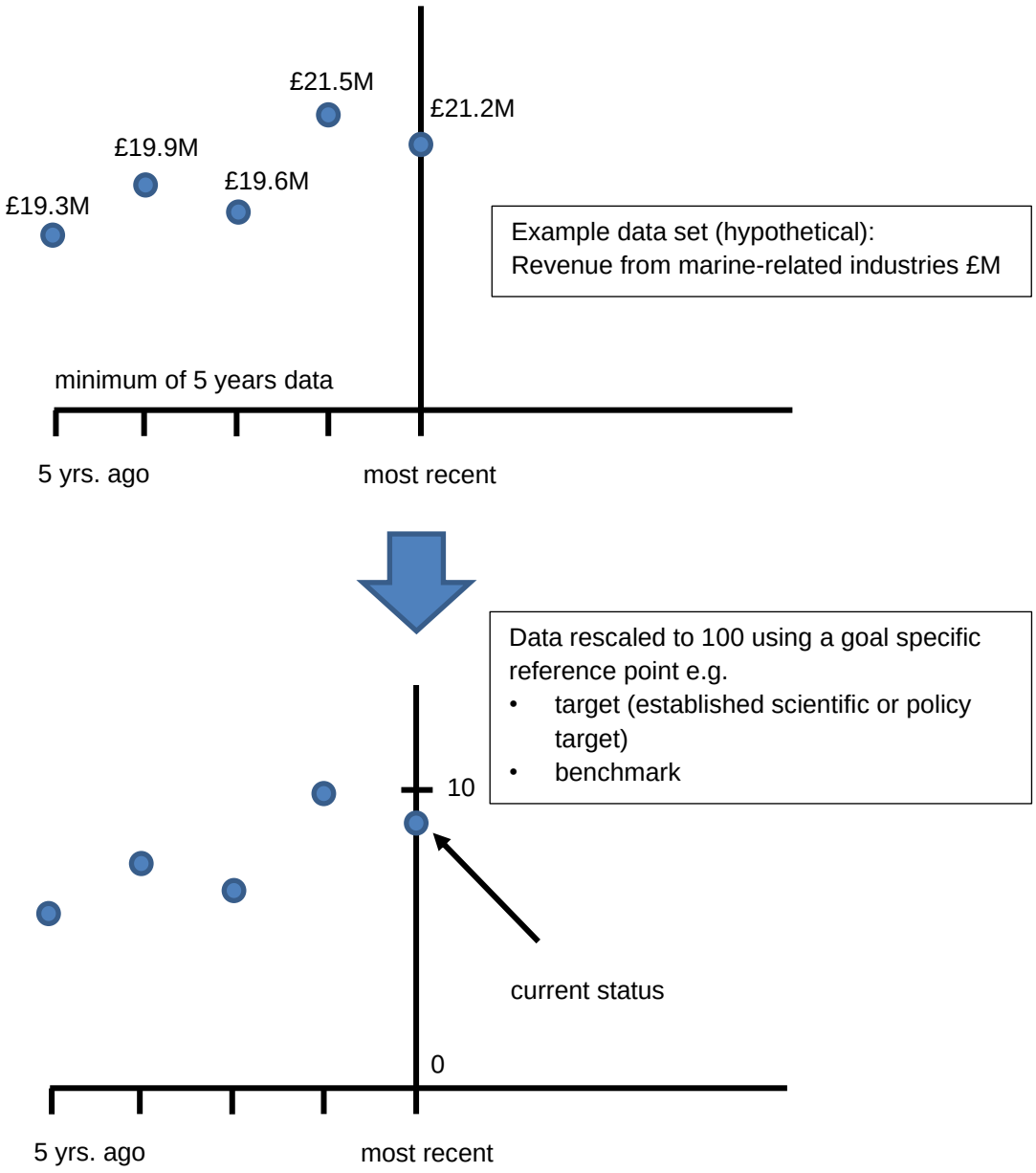


Figure 3. OHI goal status calculation. The OHI process determines current status of each dataset relative to a reference point. This reference point may be a target such as an established scientific or policy target, or a benchmark which will compare a region's current performance against past performance. As such, status data are rescaled to a maximum value of 100. For the South West England OHI+, the benchmark reference point was set using the maxima of the five most recent years of data.

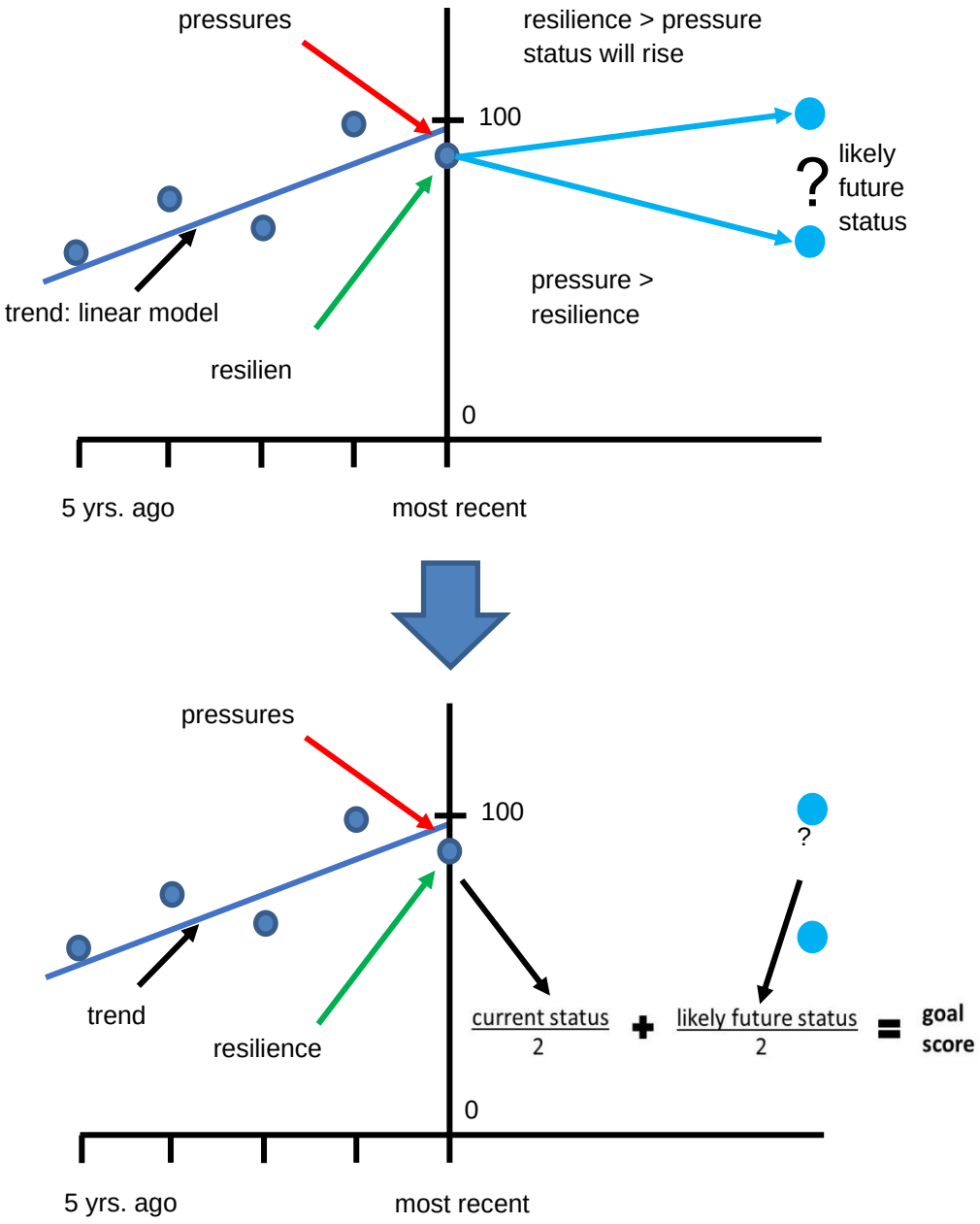


Figure 4. OHI goal score calculation. Three dimensions are used to calculate likely future status: **trend**, **pressure** and **resilience**. **Trend** is the change in status likely to occur in the most recent five years of status data. This is calculated by estimating the yearly proportional change in status using a linear regression model. The OHI process combines scores for **trend**, **pressures** and **resilience** to calculate likely future status. Current status and likely future status are then averaged to produce region-specific goal scores.

Calculating scores for each goal

The following section presents individual goals and sub-goals. For each goal or sub-goal, the following are described and discussed:

- Status data: name, metadata, source and availability (i.e. time-frame of data).
- Method for data manipulation and analysis.
- Reference points: are these benchmarks or targets, and what does a score of 100% represent?
- Current status and trend in data: what are the drivers behind the patterns?
- Goal scores by region: how do regions perform?
- Observations and recommendations: what improvements could be made to make input data and/or analysis more robust for a future OHI+?

Data and coding used in the OHI+ South West England assessment are available here: https://github.com/OHI-Science/esw

Clifton Suspension Bridge
Bristol

Samuel Oakes

3. Scores

The OHI+ assessment categorized and scored eight goals and five sub-goals, representing ocean-derived benefits to South West England. These goals and sub-goals are listed below, along with the underlying datasets, the methods for processing source data, the reference points set, goal scores and any relevant recommendations and limitations to the methods. Links to all source data referenced in this section are provided in Appendix 1.

Short-beaked common dolphin

Owen Exeter

Clean Waters

Measuring pollution in coastal water

The Clean Water goal captures the degree to which local coastal waters are unpolluted by natural and human-made causes. Cornwall (CWL-3) scored highest and Isles of Scilly (IOS-4) scored lowest, though there was little variation in goal scores among regions (Figure 5, Table 2). All regions experienced decreasing trends in status scores and high pressures (Table 2). No region consistently scored highly across multiple status datasets.

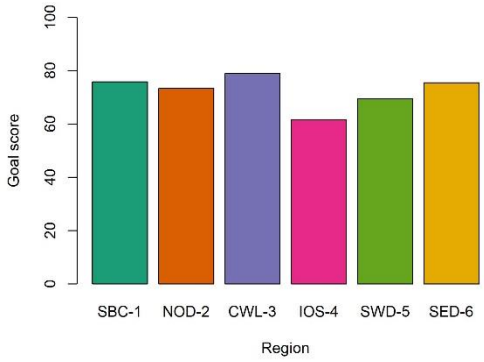


Figure 5. Clean Water goal scores.

Summary

The Clean Waters goal, of all OHI+ assessment goals, incorporated the greatest number of individual data sources, drawing on five region-specific and two national datasets. All regions experienced a decline in overall water quality over the five years considered. Bathing water classification was the only goal for which an increasing positive trend was observed for most regions; all other data trends were stable or decreasing. The Clean Water goal experienced the greatest pressure scores across all regions of all goals/sub-goals. This was primarily due to region-specific pressure scores being calculated as a cumulative sum of individual stressors, and all regions scoring highly in at least one stressor.

Table 2. Clean Waters. Current status, trend, pressures, resilience, future and goal score.

REGION	STATUS	TREND	PRESSURES	RESILIENCE	FUTURE	GOAL SCORE
SBC-1	78	-0.1	100	92	73	76
NOD-2	77	-0.1	100	92	70	73
CWL-3	81	-0.1	100	92	76	79
IOS-4	66	-0.2	100	92	57	62
SWD-5	73	-0.1	100	92	66	70
SED-6	79	-0.1	100	92	73	76

Data sources and reference points

(Appendix 1, 2 & 3 for metadata)

The following datasets were used for this goal:

- *Bathing water classification* [1] *(2004-2017)*

- *Water clarity (suspended matter)* [2] *(2003-2017)*
- *Beach litter* [3] *(1994-2018)*
- *Urban run-off* [4] *(2005-2015)*
- *Pollution from vessels* [5] *(2011-2015)*
- *Nutrients* [6] *(2002-2016) and Pesticides* [7] *(1990-2016)*

Bathing water classification data were sourced for the UK (2004-2017) to provide an estimate of pathogen pollution in coastal waters. Beach pollution categories were transformed into an ordinal scale (0-1) such that: Excellent = 1, Good = 0.75, Sufficient = 0.5, Poor = 0.25 and Closed = 0, and scaled to 100. Data for individual beaches were extracted for the South West of England and aggregated (mean) to provide region-specific status scores by year. No beach data were available for Isles of Scilly as no monitoring was conducted. The Isles of Scilly were therefore assigned the same scores as their nearest geographical neighbour, Cornwall.

Global, annually gridded (resolution 4 x 4 km) gelbstoff and detrital matter data were sourced (2003-2017). These data represent the residue attributable to past oceanic processes and land-ocean interactions. Suspended detrital matter play an important role in the light-induced biogeochemical cycling of many compounds as well as in determining the amount and spectral quality of light available for marine photo-processes (Siegel et al., 2002). Data were extracted for coastal waters (coast to 3 nmi offshore) of South West England and aggregated (mean) to provide region-specific values by year. The most recent five years of data were selected and rescaled relative to the maximum value. Rescaled data were inverted so that a high score represented minimum suspended detrital matter.

Beach litter density data (items m^{-1}; 1994-2018) were sourced from beach clean surveys coordinated by the Marine Conservation Society (https://www.mcsuk.org/beachwatch). Data were extracted for the South West of England. Due to the high degree of variability in spatial and temporal resolution of data a mean value of beach litter collected (items m^{-1}) was calculated for each region across all years. Aggregated values were rescaled and inverted such that the region with lowest beach litter pollution levels scored 100.

Urban run-off was a modelled dataset that combined precipitation data with land cover data (urban / suburban built areas) to arrive at an estimation of the potential for inorganic pollution input to coastal waters. Monthly gridded (resolution 1 km^2) rainfall data (precipitation in mm) for the UK were sourced together with gridded UK land cover data (resolution 25 x 25 m). Total monthly rainfall on urban / suburban built areas within 5 km of the coast was extracted by region and summed by year.

Data were corrected by coastal length to provide an estimate of inorganic run-off to coastal waters by region and year. The most recent five years of data were selected and rescaled using a benchmark reference point and inverted so that 100 represented minimum urban run-off.

Shipping density in nearshore waters as used as a proxy for pollution from vessels. Spatially explicit gridded (resolution 4 km^2) data describing estimated mean weekly shipping density of commercial shipping for UK waters (2011-2015) were sourced. Data were extracted for near-shore waters (mean high water to 3 nmi offshore) and aggregated (mean) by region and year. Data were then rescaled relative to maximum regional values and inverted so that a score of 100 represented minimum vessel pollution.

Annual data were sourced describing UK agricultural use of nutrients (nitrogen, phosphate and potash 2002-2016) and pesticides (1990-2016). Data were apportioned by the area (hectares; ha) of agricultural land (arable or improved grassland) within 5 km of the coast to all agricultural land in the UK. These data were then corrected for coastal length, to provide an estimate of nutrient and pesticide input to coastal waters by region and year. The most recent five years of data were selected and rescaled relative to maximum regional values. Rescaled values were inverted so that a score of 100 represented minimum pesticide/nutrient use.

Indicator data were benchmarked against within-region maxima over the last five years of data for suspended detrital matter, urban run-off, pollution from vessels, nutrients and pesticides. For beach litter the maximum regional value was used. A target reference point of excellent status for all bathing waters was used for coastal pathogens. All rescaled data were aggregated (using a geometric mean) to provide region-specific status scores. A geometric mean was used, as is commonly done for water quality indices (Liou et al., 2004), as a very poor score for any one sub-component would pollute the waters sufficiently to make people feel the waters were 'too dirty' to enjoy for recreational or aesthetic purposes (Halpern et al., 2012). A 100% status score would indicate that within regions, aggregated regional pollutants in coastal waters were at their lowest within the most recent five years of data.

Interpretation

Bathing water scores increased for all regions through time except Severn Estuary and Bristol Channel (SBC-1); with South East Devon (SED-6) showing the greatest improvement in bathing water quality (Figure 6). Severn Estuary and Bristol Channel not only demonstrated a decreasing trend but also had the lowest mean beach status scores year on year. Cornwall, Isles of Scilly, South West (SWD-5) and South East Devon scored similarly for the final year of available data.

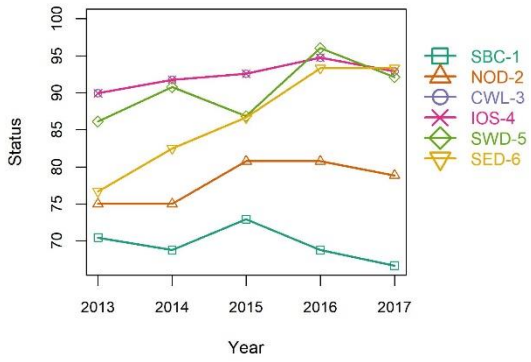


Figure 6. Bathing water status.

There was variation in coastal water clarity (suspended detrital matter) over time (Figure 7a). The greatest water clarity across the five years of data was in 2014 for Severn Estuary and Bristol Channel, North Devon (NOD-2), Cornwall and Isles of Scilly, and 2017 for South West and South East Devon. Raw data demonstrate trends for all regions to be relatively stable (Figure 7b) with the Isles of Scilly consistently having greatest water clarity of all regions; Severn Estuary and Bristol Channel the lowest.

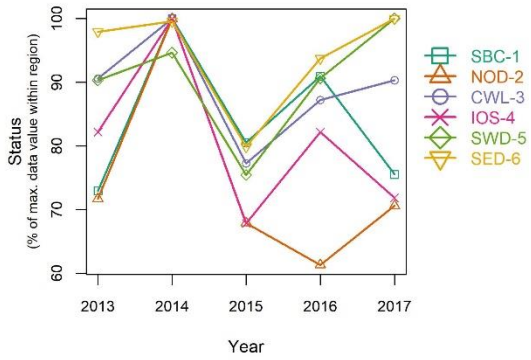


Figure 7a. Water clarity status.

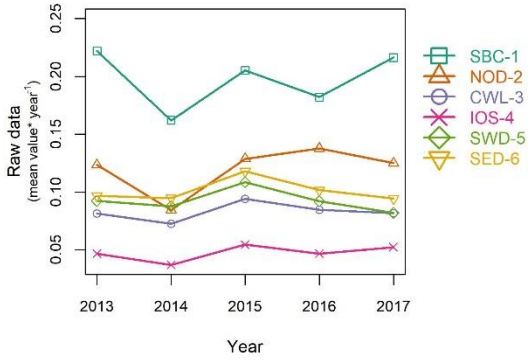


Figure 7b. Water clarity: absorption due to gelbstoff and detritus at 443 nm (m^{-1}).

Beach litter data lacked a time series element due to the high degree of variability in spatial and temporal resolution of data which necessitated calculating an aggregated region-specific value across all years. Isles of Scilly (IOS-4) had the highest status score, recording the least beach litter. Severn Estuary and Bristol Channel (SBC-1) had the lowest status score, recording the greatest density of beach litter (Figures 8a, 8b).

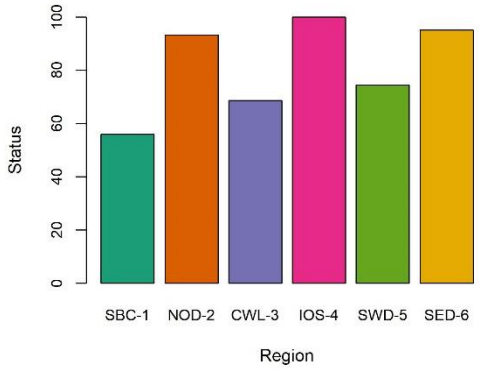


Figure 8a. Beach litter status.

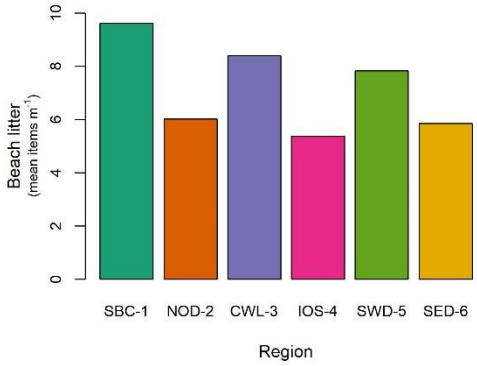


Figure 8b. Regional pattern (long-term mean; 1994-2018) of beach litter abundance.

The modelled urban run-off dataset was driven primarily by variation in yearly rainfall totals (Figures 9a, 9b). Greatest variation in data occurred between 2011 (low yearly rainfall) and 2012 (high yearly rainfall). Trend was relatively stable for all regions for the most recent five years of data.

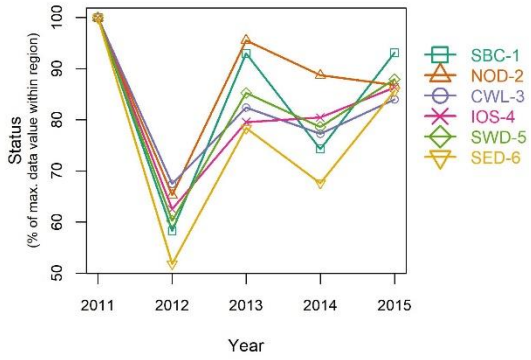


Figure 9a. Urban run-off status.

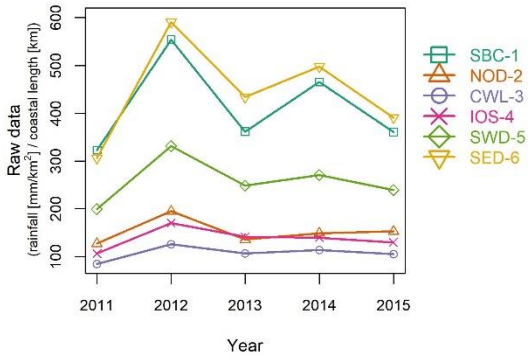


Figure 9b. Urban run-off data.

There was a decreasing trend in shipping density status, reflecting increasing levels of shipping density for all regions in the most recent five years of data (Figure 10a). Raw data indicated that South West Devon (SWD-5) consistently experienced the greatest density of vessels in nearshore waters and North Devon (NOD-2) the least (Figure 10b).

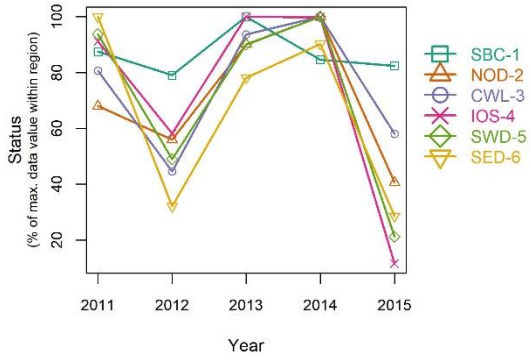


Figure 10a. Vessels pollution status.

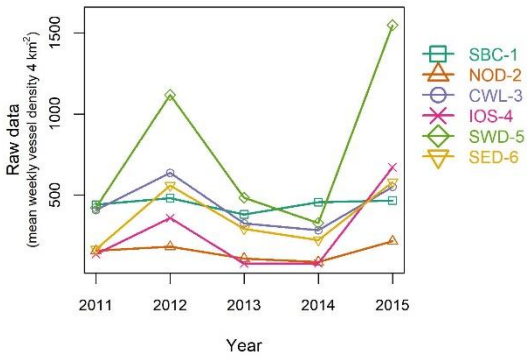


Figure 10b. Regional patterns of annual vessel density.

There was a decreasing trend in status for both estimated nutrient (Figure 11a) and pesticide (Figure 11b) input to coastal waters (representing increasing levels of nutrients and pesticides) for all regions in the most recent five years of data. However, both nutrient and pesticide data were sourced from national datasets and attributed to each region by area (km^2) of agricultural land. Given this limitation, current status and trend was identical for all regions.

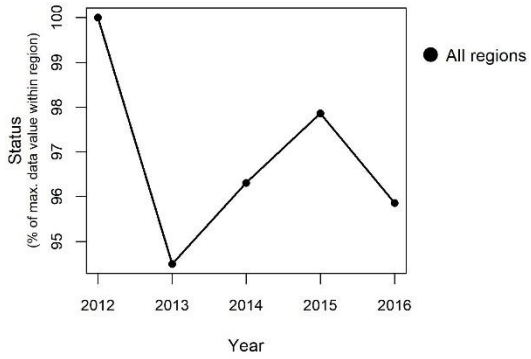


Figure 11a. Annual input of nutrients to South West England coastal waters.

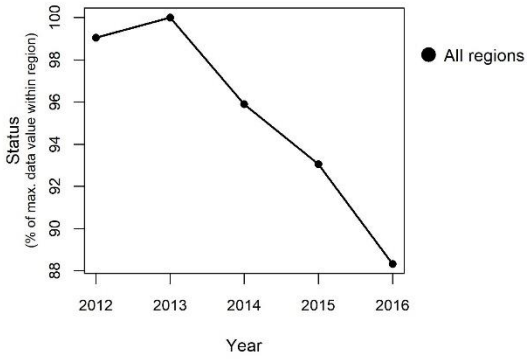


Figure 11b. Annual input of pesticides to South West England coastal waters.

Recommendations and limitations

The Clean Waters goal benefitted from the availability of multiple open source, long-term datasets. This ensured a variety of factors influencing water quality in the South West could be measured in the OHI+ assessment.

Analysis would be further improved by greater granularity of data that described nutrient and pesticide use on agricultural land at region-specific spatial resolution. As these data were drawn from national datasets, inter-regional variation in status and trend were unavailable. Localised surveys or models of input rates should be a priority for development in the future. Additional datasets including the Water Framework Directive monitoring were also considered for inclusion. The Water Framework Directive data are used extensively as pressure layers, acting on numerous other OHI+ goals (Appendix 4). Given the number of datasets already included in the assessment, and to reduce replication of data between goals and pressures, it was felt further additions would reduce the sensitivity of the model to inter-annual changes in water quality. The Water Framework Directive data could however be included in future OHI+ assessments if desired.

As an adaptation from the Global OHI method we incorporated data describing beach litter surveys in South West England. These data provided region specific, survey data, more reflective of local pollution levels than the original layer, drawn from a global model. However, due to the high degree of variability in spatial and temporal resolution of data a mean value of beach litter collected was calculated for each region across all years. Future iterations of a South West England OHI+ may benefit from further beach litter survey data to build comprehensive temporal trends as it becomes available.

Breaking waves

Paul Hanaoka

Food Provision: Fisheries

Seafood sustainably harvested for human consumption

The Food Provision goal measures the amount of seafood harvested in a given region for use primarily in human consumption via domestic or export markets. This sub-goal addresses wild-caught fisheries, while the other sub-goal captures mariculture. Except for North Devon (NOD-2), all regions scored 63 and greater for this goal, suggesting progress towards sustainable landings but room for improvement in all regions.

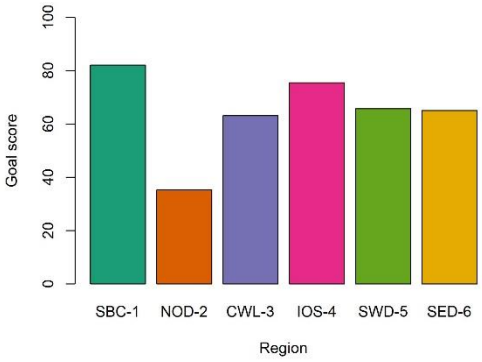


Figure 12. Fisheries goal scores.

Summary

The Severn Estuary and Bristol Channel (SBC-1) was the highest performing region (score 82; Figure 12, Table 3). This score was influenced by fisheries activity limited exclusively to static potting gears, with all reported landings comprised of two stocks – lobsters and crabs – considered sustainable and only marginally overfished respectively. However, the low fishing activity recorded in this region (430 kg landed in 2018) should be acknowledged when making direct comparison with more productive regions (Cornwall (CWL-3) recorded 18,644 tonnes in 2018). The Isles of Scilly (IOS-4) was the second highest performing region (score 76). The region's landings (107 tonnes in 2018) were dominated by 'sustainable' lobster and crab stocks, therefore scoring highly. Cornwall, South West and South East Devon (SWD-5 and SED-6) scored 64, 68 and 69 respectively. These score likely indicate that whilst overfishing of some species occurs, the majority of landings in these regions come from diverse stocks with at least some considered sustainably fished or fished close to maximum sustainble yield (i.e. MCS Good Fish Guide and B/BMSY targets respectively). North Devon scored lowest (35). Landings to North Devon ports were dominated by three stocks with very low sustainability scores: dogfish, rays and whelks. In 2018, 637 tonnes and 80% of North Devon landings were attributed to these three stocks and which have formed the basis of the fishery for the last five years (at a peak of >85% of total landings in 2016).

Table 3. Fisheries. Current status, trend, pressures, resilience, future and goal score.

REGION	STATUS	TREND	PRESSURES	RESILIENCE	FUTURE	GOAL SCORE
SBC-1	77	NA	38	76	87	82
NOD-2	35	-0.2	24	71	36	35
CWL-3	64	-0.1	65	71	62	63
IOS-4	72	0.1	53	73	79	76
SWD-5	69	-0.2	67	74	63	66
SED-6	68	-0.1	68	71	63	65

Data sources and reference points

(Appendix 1, 2 & 3 for metadata)

The following datasets were used for this sub-goal:

- *CEFAS/RAM stock assessment* [1, 2]
- *B/B$_{MSY}$* (2017/2015)
- *Marine Conservation Society sustainable seafood guide* [3] (2020)
- *Landings to port* [4] (2014-2018)

For each species a stock score (0-1) was calculated from B/B$_{MSY}$ data, assessing the ratio of observed biomass to the biomass required to maintain maximum sustainable yield. OHI global assessments apply a penalty for under exploiting stock with high B/B$_{MSY}$ values which is calculated as follows: B/B$_{MSY}$ < 0.95 then B/B$_{MSY}$ = unchanged, B/B$_{MSY}$ >= 0.95 and <= 1.05 then B/B$_{MSY}$ = 1, B/B$_{MSY}$ > 1.05 then B/B$_{MSY}$ is reduced using sliding scale until a minimum threshold is reached (0.25) (Halpern et al., 2017, 2012). For the South West England assessment, we chose to remove the under-fishing penalty as there are few fisheries in this region with recognised potential for increased exploitation. As such B/B$_{MSY}$ >= 0.95 were given a value of 1, B/B$_{MSY}$ < 0.95 were unaltered.

Where B/B$_{MSY}$ data were unavailable for a species a sustainability ranking was calculated from the Marine Conservation Society's (MCS) 'Good Fish Guide' (GFG). The biannual guide assesses the ecological sustainability of 139 species on a 5-point scale, drawing on data from a variety of scientific sources. MCS guide scores were rescaled 0-1 as follows: 'best choice' = 1, 'good choice' = 1, 'ok' =1, 'requires improvement' = 0.5 and 'avoid' = 0.1. Where landings were not reported to species level, an average (mean) of all applicable species in the guide was used. In some cases multiple sustainability ranks were available for distinct capture method (e.g. Beam trawl, Demersal otter trawl). Where ranks varied between capture methods, an average (mean) of all available ranks was calculated for each species as required.

For any remaining species or taxonomic groups without an applicable MCS or B/B_{MSY} value, a mean score was calculated using the scaled OHI scores for all similar species in the assessment. Similarity was based on ecological classifications (e.g. pelagic species) or taxonomy (e.g. crustaceans). Stock scores (0-1) were rescaled to 100. Relative catch (proportion) of each species was calculated per region and applied to species-specific stock scores. The proportional stock scores were then summed by region and year to give region-specific status scores.

The Fisheries sub-goal was assessed using a target-based reference point where the target stock status score = 1. A 100% status score would indicate that harvest from regional fisheries was at the maximum potential of the ecosystem.

Interpretation

North Devon (NOD-2), Cornwall (CWL-3), South West and South East Devon (SWD-5 and SED-6, respectively) demonstrated modest declines in Fisheries trends for the most recent five years of data (Figure 13, Table 3). The Isles of Scilly (IOS-4) experienced a positive trend and due to low levels of landings the Severn Estuary & Bristol Channel (SBC-1) received no trend score. Status scores were only calculated for Severn Estuary & Bristol Channel for 2017 and 2018 as no landings were made in the three previous years. As this goal measures the sustainability of seafood landings, rather than quantity of landings, it was deemed inappropriate to assign scores of zero for years with no landings. Instead, NA values were applied for years 2014-2016.

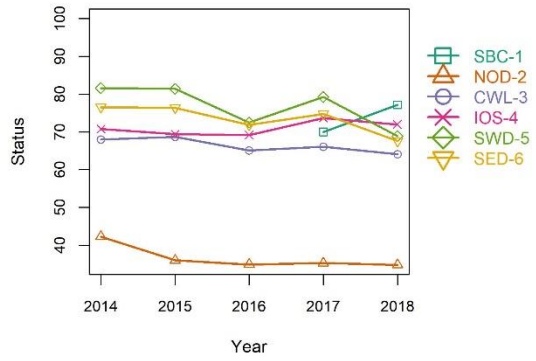


Figure 13. B/B_{MSY} & landings to port.

Recommendations and limitations

As the OHI reports only on the most recent five years of data, long-term trends may be masked by a shifting baseline. Consistent negative trends as displayed in the Fisheries sub-goal, should therefore be highlighted and compared to longer-term datasets spanning several decades. To address this

issue, in future the Fisheries sub-goal may benefit from adaptation to incorporate longer temporal trends in OHI SW assessments.

The Fisheries sub-goal relies on landings at port, therefore lacking spatially explicit data on where stocks are harvested at sea. For example, vessels registered to Plymouth are likely to operate in both Devon and Cornish waters. Initial iterations of the OHI South West England assessment used landings reported by ICES rectangle. Whilst these data ensured greater spatial traceability, the overlap of ICES rectangles boundaries between OHI regions resulted in multiple regions being assigned duplicated data. If the OHI were to be expanded to larger spatial scales (i.e. all English marine plans areas) ICES landings data may be considered preferable and could be explored.

The Global OHI methodology applies a penalty to scores if landings are not reported at a species level. This encourages regions to improve fisheries reporting and ensure species specific stock declines are not masked by high level taxonomic reporting. This penalty was not applied here because data for some species groups (e.g. Rajiformes), though reported in detail at a local level, were re-aggregated in the national datasets used to assess this goal. In future OHI+ assessments, the Fisheries goal would benefit from data at finer taxonomic resolution to allow penalties to be reapplied where necessary.

Finally, this goal would benefit from standardisation of sustainability metrics. B/B_{MSY} assessments are currently considered the preferable indicator metric for the fisheries sustainability. However, B/B_{MSY} data are currently only available for 49.7% of species in the South West. Applying the OHI Global method of median (recently updated to mean) B/B_{MSY} values to gap-fill unassessed species was considered unsatisfactory given the number of unassessed species. Sustainability rankings were therefore drawn from the MCS seafood guide. The comprehensive level of research and regularly refinement of the guide made it a robust data proxy in the absence of B/B_{MSY} assessments. MCS ranks are not, however, directly comparable to B/B_{MSY} as they consider the potential ecosystem level impacts of different gear type (i.e. benthic disturbance, by-catch). Conversely, B/B_{MSY} are a direct measure of species-specific population biomass and do not account for the broader sustainability of different fishing gears. Mixing data sources to calculate sustainability scores is not ideal, however, it was felt preferable to gap-filling using median values alone. This method reduced the number of gap-filled species. For the 10% of species where no B/B_{MSY} or MCS data were available, a mean value of species considered ecologically similar were used. This further improves upon the Global methodology, as species sustainability are informed by variables such as similar life history traits and fisheries harvest methods.

Food Provision: Mariculture

Seafood sustainably harvested for human consumption

This sub-goal goal measures the amount of seafood harvested (tonnes) in a given region for use primarily in human consumption via domestic or export markets. It includes wild-caught fisheries and mariculture. Limitations in available data result in all regions scoring uniformly with the exception of the Isles of Scilly (IOS-4), which due to the lack of any designated mariculture sites, scored zero. Other regions scored highly (Figure 14, Table 4), as national mariculture production was relatively high in 2018, compared to the most recent five years of data.

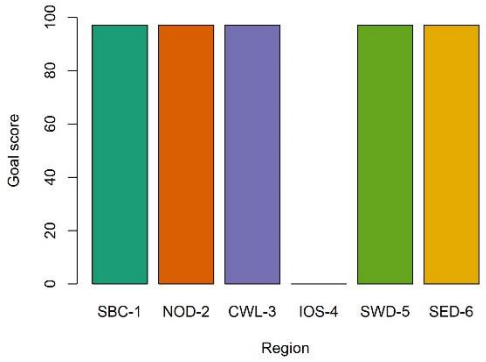


Figure 14. Mariculture goal scores.

Summary

Calculating the Mariculture sub-goal was hindered by data availability. The low number of mariculture enterprises means that production data are aggregated at a national level by the data holder (CEFAS) due to data privacy legislation. This goal would benefit greatly from region and species-specific production data by year. However, such data will need to be considered in relation to production targets that reflect the desired scale of region-specific mariculture operations. Inclusion of a species-specific sustainability metric would also enable this goal to be more comparable with the Fisheries sub-goal.

Table 4. Mariculture. Current status, trend, pressures, resilience, future and goal score.

REGION	STATUS	TREND	PRESSURES	RESILIENCE	FUTURE	GOAL SCORE
SBC-1	94	1.0	81	81	100	97
NOD-2	94	1.0	82	81	100	97
CWL-3	94	1.0	83	81	100	97
IOS-4	0	0.0	62	81	0	0
SWD-5	94	1.0	82	81	100	97
SED-6	94	1.0	83	81	100	97

Data sources and reference points

(Appendix 1, 2 & 3 for metadata)

The following datasets were used in this goal:

- *Mariculture production (tonnes)* [1] (2012-2016)
- *Mariculture production sites (km²)* [2] (2019)

Annual mariculture production data (tonnes) were drawn from a national production database and apportioned to South West England based on national data on spatial extent of production. The estimated South West production was then apportioned to each OHI+ region by area (km²) of waters licensed for mariculture activity. Data were benchmarked against within region maxima for estimated mariculture production using the most recent five years of data. A 100% status score would indicate that within regions, mariculture production was at its maximum within the 5-year assessment timeframe.

Interpretation

Because there were no data available for change in production area over time, there was no variation in status or associated trend among regions engaged in mariculture production (Figures 15a). The Isles of Scilly (IOS-4) has no designated mariculture sites, therefore was assigned an annual status of zero. National production of mariculture was at a five-year high in 2017. Overall there was an increase in status over the most recent five years of data. The total area of current designated mariculture sites within each region gives an indicator of mariculture 'production potential' (Figure 15b), which is highest in Cornwall (CWL-3) and South West Devon (SWD-5), but more limited in the Severn Estuary and Bristol Channel (SBC-1) and North Devon (NOD-2).

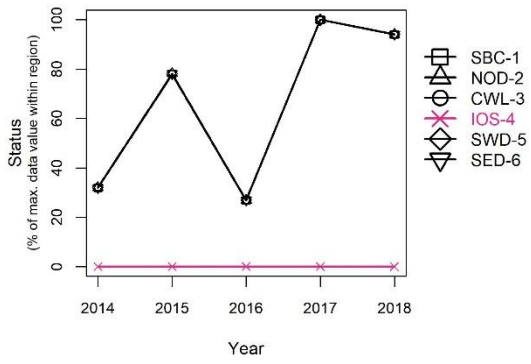


Figure 15a. Mariculture status.

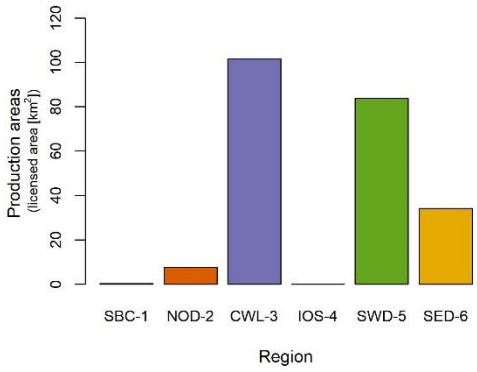


Figure 15b. Mariculture production area.

Recommendations and limitations

The major data limitation for this sub-goal is the lack of local time series data for mariculture production. In the absence of such data we relied on a measure of 'production potential' based on the area designated for production in each region. However, while mariculture production areas were used to apportion national production data to each region, the lack of a temporal dataset showing changes in production area (designation dates were unavailable) meant that it was not possible to assess changing productivity over time in each region. An alternative spatial dataset considered was the 'Strategic areas of sustainable aquaculture production' data product, which may indicate potential suitability for mariculture beyond the existing designated sites. However, a preliminary comparison found that this layer did not overlap consistently with the existing spatial data on production sites. More challenging is that the aquaculture surface is a prediction of potential rather than production and so it is hard to evaluate how much of the available surface should be used to achieve a sustainable and productive mariculture industry. As spatial data on designated mariculture sites are now listed on the Marine Management Organisation's MSP data portal (https://explore-marine-plans.marineservices.org.uk/), the future designation or closure of mariculture sites should be able to be tracked against time and therefore available to inform future OHI South West assessments. This will allow the inclusion of 'production potential', using inter-annual changes in designation to measure progress towards developing the industry across the South West.

The Global OHI methodology aggregates the sub-goal scores for Fisheries and Mariculture using a weighted mean. This is derived from the relative proportion of mariculture production to fisheries landings. Due to the limitations in data for the South West England assessment, mariculture scores were not included in the Food Provision goal or region-specific cumulative index scores. However, to enable sub-goal scores to be legibly displayed in the final assessment results the Fisheries and Mariculture sub-goal scores were assigned an arbitrary 90/10 percentage contribution (respectively) of the Food Provision goal.

Mariculture production is a growing and economically important industry in some parts of the United Kingdom in regions such as West coast Scotland. The industry is considered an important source of sustainable seafood, reducing pressure on wild stocks. However, issues associated with water quality, escapes of non-native species, marine mammal entanglement and reliance on wild fish protein for feed make certain mariculture practices less sustainable than others. Species-specific production is therefore an important consideration when assessing mariculture sustainability in the OHI+. As mariculture has the potential to be an economically important and sustainable marine industry in the South West, the goal was retained and can be improved in future assessments.

Artisanal Fishing Opportunity

Access opportunity for small-scale fisheries

This goal captures the status of opportunities for small-scale fisheries in the South West. It uses the trend in landings attributable to the under ten-metre fishing fleet, the associated catch per unit effort and the variation in marine diesel fuel price. Except for the Isles of Scilly (IOS-4), goal scores were relatively consistent across OHI South West regions (Figure 16, Table 5).

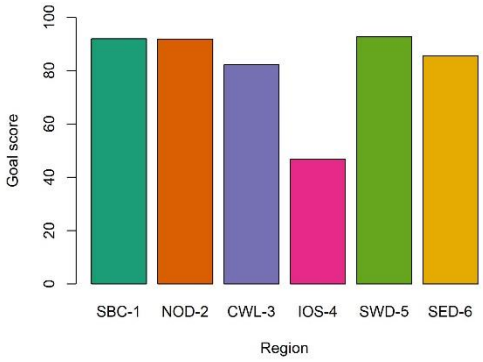


Figure 16. Artisanal Fishing Opportunity.

Summary

The Isles of Scilly (IOS-4) under ten-metre fleet remained proportionally the most productive of any OHI+ South West region, but the proportion of landings caught by under ten-metre vessels in this region has declined, leading to a lower score (Figure 17a). Raw landings data (Figure 17b) reveal 39.3 tonnes of landings in 2018 to be a significant decrease from the 105.1 tonnes reported in 2014 by the under ten-metre fleet. This decline requires further investigation to ascertain why the under ten-metre fleet are experiencing reduced landings and whether the region is experiencing a shift to over ten-metre operations in recent years. The five other regions goal scores were high and comparable (82-93), suggesting that under ten fleets are relatively stable in total numbers and catch for effort across the most recent five years of data across the South West.

Table 5. Artisanal Fishing Opportunity. Status, trend, pressures, resilience, future and goal score.

REGION	STATUS	TREND	PRESSURES	RESILIENCE	FUTURE	GOAL SCORE
SBC-1	87	0.0	38	75	97	92
NOD-2	84	0.3	27	72	100	92
CWL-3	81	0.0	58	72	83	82
IOS-4	56	-0.5	76	71	38	47
SWD-5	85	0.1	33	76	100	93
SED-6	83	-0.1	39	70	88	86

Data sources and reference points

(Appendix 1, 2 & 3 for metadata)
The following datasets were used in this goal:

- *Proportion of catch attributable to under 10 m fishing fleet* [1] (2014-2018)
- *Catch per unit (vessel) effort (CPUE) for under 10 m fleet* [2] (2012-2016)
- *Marine diesel price* [3] (2010-2018)

The proportion of landings attributable to under ten-metre vessels was used as an indicator of the fleet's operational ability compared to larger commercial vessels. Proportion of catch attributable to under ten-metre fishing fleet was calculated from a national landings to home port (tonnes) database. For each region, landings were aggregated to calculate an annual total and relative catch (proportion) for each vessel class (>10 and <10 meters) calculated for the years 2014 - 2018. Catch per unit (vessel) effort data were available for the period 2012 – 2016 from a national landings to port database. Annual average (mean) tonnes landed per kilowatt day (reporting unit of the Marine Management Organization: 'multiplying days at sea in relevant areas by the engine power to give a total of kilowatt (KW) days of effort') were calculated for all under ten-metre vessels by region. Marine diesel price data (£'s per litre) were drawn from a national annual average database.

Region-specific proportion of catch data and CPUE for the under ten-metre fleet were benchmarked against within-region maxima in the most recent five years of data. Marine diesel prices were benchmarked against the national maximum in the most recent five years and inverted so that a score of 100 represented minimum cost per litre. All data were then aggregated (mean) to provide region-specific status scores. A 100% status score would indicate that regional small-scale fishing fleet proportion of catch and CPUE were at their maxima, and that marine diesel was at its lowest price.

Interpretation

Regions recording the greatest decline in proportion of landings by under ten-metre vessels experienced the strongest negative trends and low OHI status scores. Conversely, if a region had experienced a recent increase in the proportion of landings from the under ten-metre fleet, it would receive a higher OHI status score. The Isles of Scilly (IOS-4) experienced a declining trend in its' proportional landings by under ten-metre vessels since 2014 (Figure 17a). Landings data revealed that in 2014 the under ten-metre fleet were responsible for 97% of landings to local Isles of Scilly ports (Figure 17b). However, by 2018 this had declined to 37%, resulting in low goal status scores. Given local byelaws prohibit over ten-metre vessels from operating with the 6 nm limit, these landings are either due to larger vessels operating within the 6 to 12 nm zone, or due to reporting issues in the

source data. In comparison, South West Devon's (SWD-5) under ten-metre fleet experienced a near doubling in proportional landings to 19.1% in 2018. South East Devon (SED-5) performed well because of an increase in the proportional contribution by under ten-metre vessels, despite this proportion being the lowest of all regions (11.2% of total landings in 2018 (Figure 17b)). The relatively low levels of activity in the Severn Estuary and Bristol Channel (SBC-1) prevented five years of trend data being calculated, with landings only recorded in 2018 and 2019. Given the under ten-metre fleet are the only operational vessels in the region, all their landings are attributed to this sector of fleet, resulting in high status scores.

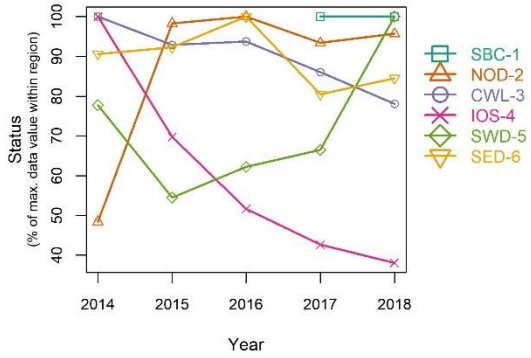


Figure 17a. Proportion of catch evaluated against the max value in each region.

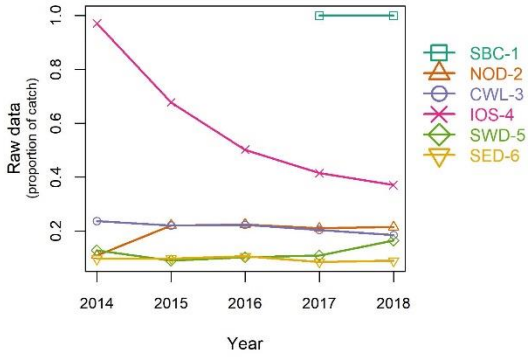


Figure 17b. Proportion of catch.

Catch per unit effort (CPUE), status and trend for the under ten-metre fleet in the Isles of Scilly had declined. Whilst 2014 represented the region's most productive fishing year in terms of effort to landings, reductions in CPUE are evident by ~50% (Figure 18a). Whilst the Isles of Scilly under ten-metre fleet were the most productive of any OHI South West England region in 2012, as of 2016 CPUE had declined to be approximately aligned with a South West average CPUE (Figure 18b). Given the sharpness of this decline, and due to the local fleet almost exclusively using potting gear types for crustaceans, these results warrant further investigation to determine whether specific stocks actually experienced major declines between 2014 and 2016, or if reporting issues in the source data are occurring. Severn Estuary and Bristol Channel scores are limited by intermittent annual landings. All other regions experienced inter-annual variation in CPUE trend but appear stable across the five most recent years of data.

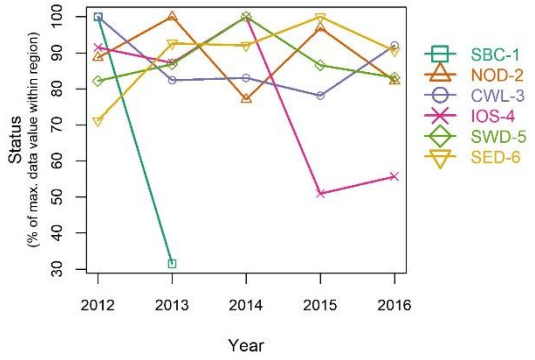


Figure 18a. Catch per Unit Effort (CPUE) evaluated against the max value in each region.

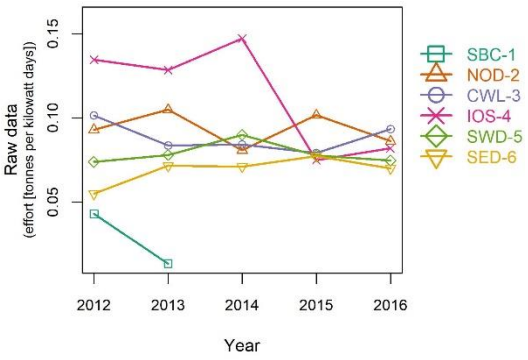


Figure 18b. Catch per Unit Effort (CPUE).

Marine diesel prices were drawn from a national monthly average (mean), resulting in a single status and trend value for all regions. Recent rises in fuel prices have driven lower annual OHI status scores compared to a five year low in 2016. Despite this trend, scores remain relatively high (73) suggesting only moderate price rises to date (Figure 19).

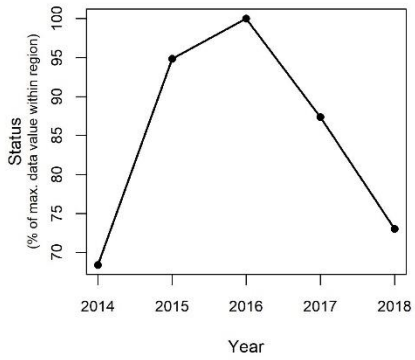


Figure 19. National marine diesel price evaluated against the max value.

Recommendations and limitations

Data calculations

Without management or industry targets defining the desirable proportion of the fleet comprising under ten-metre vessels, the goal calculations assessed the proportion of landings attributed to this sector of the fishing fleet as an indicator of the opportunities available to smaller-scale fishing enterprises.

This approach also means that regions can perform well through sustained improvement even where the proportional contribution of under ten-metre vessels is low (e.g. South Devon), while others have low scores due to decline in the contribution of under ten-metre vessels, despite having the highest contribution among all regions (Isles of Scilly).

Using the proportion of catch landed by under ten-metre vessels without comparison to regional maxima (i.e. a score of 100 would mean that all catch is landed by under tens) is an alternative approach to using this data. This would give higher scores to regions where the overall proportion is greater, irrespective of recent trends. However, in regions where there is a substantial over ten-metre fleet, a score of 100 would be unrealistic and potentially undesirable. Measuring change in proportion was therefore considered preferable to assess the contribution of smaller vessels.

Indicator choice and data availability

CPUE data were only available from 2016 onwards, therefore CPUE and proportion of landings by under ten-metre vessels were assessed using data from different but overlapping time periods. This may contribute to obscuring any trends in small-scale vessel activity, and future assessments should incorporate more recent data to ensure comparable time periods are considered.

Additional datasets were discussed for inclusion in the Artisanal Fishing Opportunity goal in early iterations of the OHI+ South West England assessment. Trends in the number of under ten-metre registered vessels by region were considered an indicator of stability within the fleet, but contribution relative to other sectors of the fleet were considered more appropriate indicators of opportunities for small-scale vessels in a UK context. In line with the OHI conceptualisation of Artisanal Opportunities as representing *access* to artisanal fishing opportunities, other factors such as availability of local processing facilities, central moorings and economic support were considered, but spatially explicit, time series data on these considerations were hard to identify. Data layers such as location of ports were considered to reflect geomorphology rather than indicate physical access to the activity *per se,* and were also not anticipated to change year to year.

The goal could be improved to measure equitable access to opportunities, including access to resources to support artisanal fishing such as: ‘sensible’ costs for landing at quaysides, ability to unload fish from boats (crane/hoist access), logistics to transfer fish to wholesalers, and proximity to local moorings. Collating data on these services should be prioritised in the South West to help understand how the livelihoods and opportunities for small scale fisheries are changing.

The use of metrics relating to the under ten-metre fleet is an imperfect indicator of artisanal or small-scale fishing opportunities in the UK, since this section of the fleet represents a diverse set of activities,

from more artisanal activity through to more intensive commercial fishing. Initiatives such as the Future of Our Inshore Fisheries (https://www.seafish.org/responsible-sourcing/fisheries-management/future-of-our-inshore-fisheries/) project may help to develop more suitable indicators for future monitoring that reflects the local socio-economic contribution of smaller-scale fishing activity.

Surfers

Jeremy Bishop

Livelihoods and Economies: Economic Productivity

Revenue from marine-related industries

This goal tracks marine industry and regional economic productivity through time. With the exception of the Isles of Scilly (IOS-4), Economic Productivity goal scores were relatively consistent (Figure 20, Table 6). The lower goal score for the Isles of Scilly (51) reflects a decline in performance of this region in recent years. However, raw data highlights that the Isles of Scilly's current performance is 'on par' with all other regions.

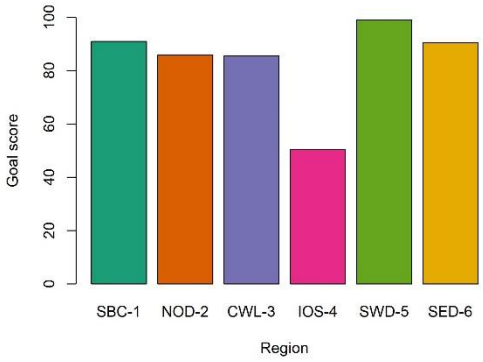


Figure 20. Economic Productivity goal scores.

Summary

Per capita GVA was used as an indicator of marine-related industry productivity. Per capita GVA is a useful way of comparing regions of different sizes (ONS 2020). The steep decline in per capita GVA for the Isles of Scilly (IOS-4), when compared to other regions warrants further investigation. The remoteness of the Isles of Scilly may result in increased pressure on its local industries due to high transportation and communication costs, uncertainties of supply, and a small domestic market. These factors may also limit the possibility of diversification in marine industries and limit the ability of individual businesses to develop economies of scale. Some marine-based industries may also be reliant on a sustained tourism market. As a result, marine-related industries on the Isles of Scilly will be subject to greater economic pressures than other regions in the South West England assessment area.

Table 6. Economic Productivity. Current status, trend, pressures, resilience, future and goal score.

REGION	STATUS	TREND	PRESSURES	RESILIENCE	FUTURE	GOAL SCORE
SBC-1	92	-0.1	57	69	90	91
NOD-2	91	-0.1	54	42	81	86
CWL-3	93	-0.1	72	44	78	86
IOS-4	64	-0.5	81	58	38	51
SWD-5	98	0.0	41	58	100	99
SED-6	92	-0.1	49	49	89	90

Data sources and reference points

(Appendix 1, 2 & 3 for metadata)
The following datasets were used for this sub-goal:

- *Revenue (GVA)* [1] *(1997-2015)*
- *Total workforce* [2] *(2010-2018)*
- *Marine workforce* [2] *(2010-2018)*

Annual data were sourced that described regional Gross Value Added (GVA) for all industries (1997-2015), and the total number of people employed (2010-2018), for all district/unitary authorities in South West England. Data for both datasets were extracted for local authorities with coastal/estuarine tidal waters (Appendix 10) and summed by region and year. The total number of employees engaged in marine industries by region and year was estimated as per the methods described in 'Livelihoods & Economies: Marine Wages & Jobs'. Revenue data were then apportioned by the ratio of marine industry jobs to all jobs to provide an estimate of GVA attributable to the marine industry by region and year (2010-2015). This was then divided by total number of employees engaged in marine industries by region and year to give an approximation of GVA per capita. Data were rescaled to 100 using benchmark reference points of the regional maxima for GVA per capita for the last five years of coincident data (2011-2015). A 100% status score would indicate that within regions, maximum 'economic productivity' is being delivered by minimum workforce.

Interpretation

Regional values (Figure 21a) showed a small decline (average [mean] -6.7% decrease) in per capita GVA for all regions since 2011; with the exception of Isles of Scilly (IOS-4). Benchmark year for the Isles of Scilly (maximum per capita GVA) was 2012; since 2012 there has been a steep decline (-36.5% decrease) in per capita GVA. The raw data (before benchmarking, Figure 21b) would suggest that the Isles of Scilly historic per capita GVA was notably greater than all other regions but has declined in recent years. Cornwall (CWL-3) consistently had the lowest per capita GVA of all regions.

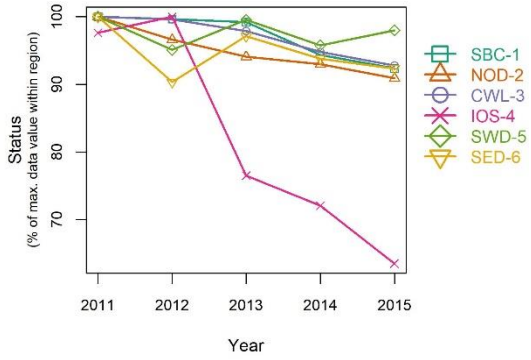


Figure 21a. Revenue (GVA) per capita for marine related industries evaluated using a benchmark reference point.

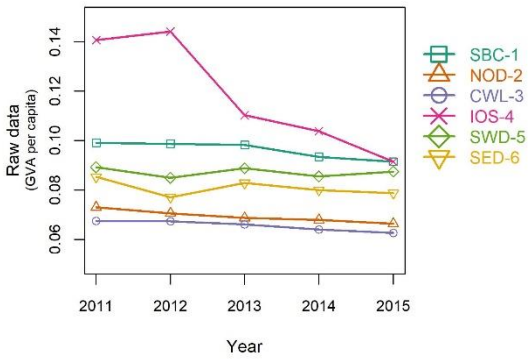


Figure 21b. Revenue (GVA) per capita for marine related industries.

Recommendations and limitations

Analysis was limited by data availability. Whilst workforce data were available up to 2018, revenue data were only available up to 2015. This resulted in estimates of per capita GVA being made only to 2015. This goal would benefit from the inclusion of revenue data to 2018.

Livelihoods and Economies: Marine Wages & Jobs

Jobs & wages associated with marine-related industries

This goal tracks marine industry wages against the consumer price index and trend in employment through time. Marine Wages and Jobs goal scores were relatively consistent among Cornwall (CWL-3), the Isles of Scilly (IOS-4), South West and South East Devon (SWD-5 and SED-6, respectively) (Figure 22). There was a marked difference between North Devon (NOD-2: highest) and the Severn Estuary and Bristol Channel (SBC-1: lowest) goal scores (100 and 17 respectively).

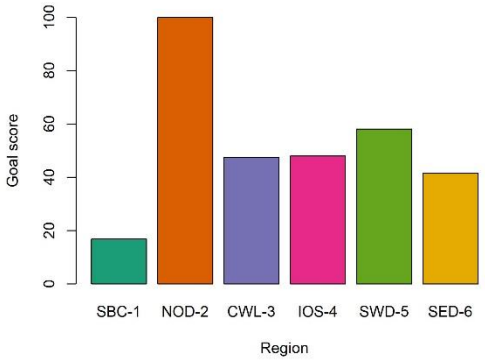


Figure 22. Marine Wages & Jobs goal scores.

Summary

Whilst status scores were the same for Cornwall (CWL-3), the Isles of Scilly (IOS-4), South West and South East Devon (SWD-5 and SED-6) (50), status trend, pressures and resilience influenced future status scores and therefore added variation to the final goal scores (Table 7). The low status score (25) for the Severn Estuary and Bristol Channel was further influenced by strong negative trend, impacting the final goal score for the region.

Table 7. Marine Wages & Jobs. Current status, trend, pressures, resilience, future and score.

REGION	STATUS	TREND	PRESSURES	RESILIENCE	FUTURE	GOAL SCORE
SBC-1	25	-1.0	57	69	9	17
NOD-2	100	0.3	54	42	100	100
CWL-3	50	0.0	72	44	45	48
IOS-4	50	0.0	81	58	46	48
SWD-5	50	0.4	41	58	66	58
SED-6	50	-0.5	49	49	33	42

Data sources and reference points

(Appendix 1, 2 & 3 for metadata)

The following datasets were used for this sub-goal:

- *Employed marine workforce* [1] *(2010-2018)*

- *Per capita average (median) annual wage [1] (2002-2018)*
- *Consumer Price Index [2] (2010-2018)*

Annual data (2010-2018) were sourced that described the number of businesses classified by fifteen Standard Industrial Classification (SIC) coded marine industries (Appendix 9), within nine employment size bands, for all district/unitary authorities in South West England. For each employment band, the total number of marine businesses was multiplied by the median number of employees within that band. These were then summed to provide an annual estimate of employees engaged in marine industries. Data were extracted for local authorities with coastal/estuarine tidal waters (Appendix 10) and summed by region and year. A temporal comparison (by region) was made using a 4-year moving window (due to data limitations). As such, the relative percentage (estimate of marine industry employees for the modelled scenario year 2018 compared with 2014) was calculated. If employee numbers had increased the relative percentage score was capped at 100. If employee numbers had declined, the relative percentage was used.

Annual data (2002-2018) were sourced that described the per capita average (median) annual wage by district/unitary authority. No data were available for the Isles of Scilly (IOS-4) due to data confidentiality issues. As such, the Isles of Scilly were given the same per capita average (median) annual wage values as their nearest geographical neighbour, Cornwall (CWL-3). A regional per capita average (mean) annual wage was calculated. A temporal comparison (by region) was made. The proportional change in nominal wage year-on-year was calculated and tracked against the yearly mean Consumer Price Index (CPI). If the annual nominal wage increased less than CPI then wages scored 0, if annual nominal wage increase was greater than CPI then wages scored 100.

Workforce and wages scores were aggregated (mean) to provide region-specific livelihood status scores by year. A 100% status score would indicate that within regions, the number of marine jobs had not reduced relative to 4 years previously, and year on year nominal wage percentage increases were the same as, or greater than the CPI.

Interpretation

Current status scores (for 2018) indicated the lowest scoring region to be Severn Estuary & Bristol Channel (SBC-1) (Figure 23). This was as a result of wages not increasing in line with CPI in 2018 and there being a net decrease in the number of marine-industry jobs compared with 4 years previous. The highest scoring region was North Devon (NOD-2). This was a consequence of wages increasing in line with CPI and there being no decrease in marine-related jobs. For all other regions, the number of

marine-related jobs increased, or were stable, between 2018 and 2014 but wages did not keep pace with CPI.

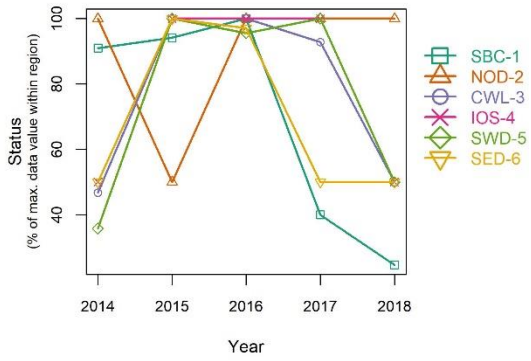


Figure 23. Aggregated workforce and wages status scores.

Recommendations and limitations

Status scores for this goal were an aggregation of a temporal comparison (relative proportion) of the number of employees in the marine industry (using a 4 year lag to buffer year on year variability) and a binary indicator as to whether annual nominal wage increases were greater than the Consumer Price Index (CPI) or not. The inclusion of a binary operator in the status score algorithm potentially creates large year-on-year variability in region-specific status scores. In addition, as wage scores were capped at 100, when annual nominal wage increases were greater than CPI the increase in wages above CPI were not factored into the status score calculation. Despite these limitations the associated algorithm captures a 'no net loss' scenario in both marine-related jobs and wages.

Analysis would be further improved by greater granularity of data that described industry specific per capita average annual wage and workforce.

Tourism and Recreation

Estimating footfall and socially valuing the local recreational experience

This goal measures visitor numbers and the potential for engagement in marine recreation. South West Devon (SWD-5) had the highest regional goal score (Figure 24) (81). Isles of Scilly (IOS-4) had the lowest regional goal score (70).

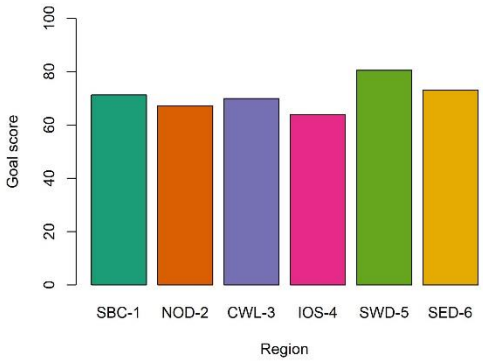


Figure 24. Tourism and Recreation goal scores.

Summary

This goal is heavily adapted from the methods used in the Global OHI. We moved away from solely using data that described visitor numbers to the South West England assessment area and strove to incorporate data that captured the 'visitor experience' to individual regions. To this end we incorporated data that described 'viewshed' (land with sea views within 1 km of the coast) and 'recreational opportunity' into the goal. High scores in South West Devon (SWD-5) reflected that it was the only region with a positive trend in visitor numbers and to experience the greatest number of visitors within the last five years. In Isles of Scilly (IOS-4), whilst this region experienced the greatest proportion of sea-views the overall goal score was negatively impacted by a decline in visitor numbers and a low recreational potential status score, leading to the lowest score overall.

Table 8. Tourism & Recreation. Current status, trend, pressures, resilience, future and goal score.

REGION	STATUS	TREND	PRESSURES	RESILIENCE	FUTURE	GOAL SCORE
SBC-1	71	-0.1	66	82	71	71
NOD-2	72	-0.2	65	67	62	67
CWL-3	73	-0.1	73	70	67	70
IOS-4	72	-0.3	93	81	56	64
SWD-5	75	0.0	42	82	86	81
SED-6	74	-0.2	50	72	72	73

Data sources and reference points

(Appendix 1, 2 & 3 for metadata)

The following datasets were used for this sub-goal:

- *Domestic and international overnight stays* [1,2] *(2010-2014)*
- *Accommodation* [3] *(2019)*
- *Viewshed* [4] *(2014)*
- *Recreational opportunity* [5] *(2014)*

Annual data (2010-2014) were sourced that described the number of domestic and international overnight stays for all district/unitary authorities in South West England. Data were extracted for local authorities with coastal/estuarine tidal waters (Appendix 10) and summed by region and year. Spatially explicit point data for accommodation units (hotels, campsites, guest houses etc.) were downloaded from Overpass turbo (a web-based data-mining tool - https://overpass-turbo.eu) for all district/unitary authorities in South West England. Data were extracted for local authorities with coastal/estuarine tidal waters (Appendix 10) and summed by region. Data were also extracted for locations within 1 km of the coast and summed by region.

To approximate visitor numbers in coastal locations by region and year, domestic and international overnight stays were apportioned by the ratio of coastal accommodation units to all accommodation units and then divided by coastal area (coast to 1 km inland). Data were rescaled to 100, benchmarked against within region maxima for visitor numbers for the most recent five years of data.

Spatially explicit data for viewshed (land with sea views) were sourced and the percentage of land within 1 km of the coast, by region, with a sea view was calculated. The resulting values were then rescaled 0 -1, setting a maximum potential score (1) as 100% of land within 1 km of the coast had a sea view.

Spatially explicit gridded (raster: resolution 1 km^2) data describing the modelled potential for twelve recreational activities (beach activities, boat angling, motorboat, paddle sports, personal watercraft, sailing, scuba diving, shore angling, surfing, wildlife boat, wildlife watching, windsurfing) were sourced and data extracted for near-shore waters (coast [mean high water] to 3 km offshore). Spatially coincident raster grid cells were summed, and the resulting surface rescaled to 1 by dividing each cell by the maximum value of the raster layer. Regional mean values were then calculated.

Visitor numbers, viewshed score and recreational opportunity were aggregated (mean) to provide region-specific tourism and recreation status scores by year. A 100% status score would indicate that

within regions, visitor numbers per km^2 were at their greatest and that 'visitor experience', described by viewshed and recreational opportunity was at its maximum.

Interpretation

Within-region benchmarking (Figure 25a, Table 8) revealed a declining trend in domestic and overnight stays for all regions except South West Devon (SWD-5), with South West Devon experiencing greatest visitor numbers in the last year (2014) of available data. The Isles of Scilly (IOS-4) saw the greatest decrease in visitor numbers of all regions. The pattern observed in visitor numbers for the Isles of Scilly is also reflected in the within region benchmark analysis of the economic productivity goal (Figure 21a). The raw data (before benchmarking, Figure 25b) suggest that even with a declining trend in visitor numbers, Isles of Scilly and South East Devon (SED-6) experienced the greatest density of visitors in coastal areas, whilst Severn Estuary and Bristol Channel (SBC-1) and South West Devon experienced the lowest density, although the Isles of Silly is likely influenced by its small land area all falling within the 1km inland coastal buffer.

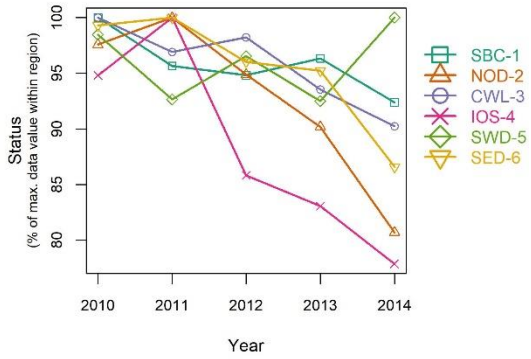


Figure 25a. Visitor number status scores.

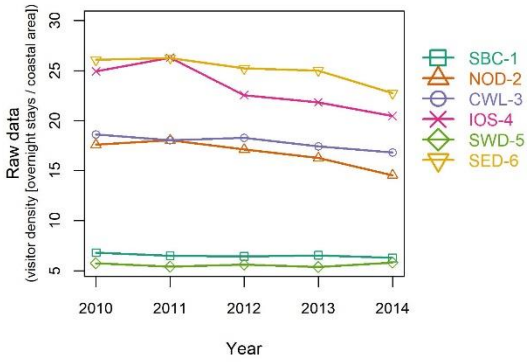


Figure 25b. Visitor numbers.

Viewshed data (land with sea views within 1 km of the coast) lacks a time series element as data are a modelled surface based on the topography of the near coastal land mass and as such have no trend (Figure 26). Isles of Scilly (IOS-4) had the highest status score (100% of land within 1 km of the coast had a sea view); Severn Estuary and Bristol Channel (SBC-1) was the lowest scoring region (72%).

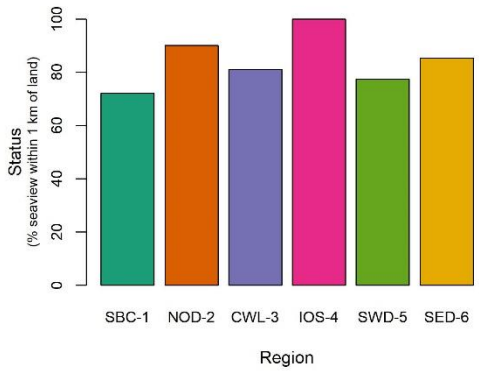


Figure 26. Percentage of land within 1 km of the coast with sea views.

As with viewshed, recreational potential lacks a time series element as data are a modelled surface-based on oceanography, meteorology, topography and recreational resource availability (established access points). There was little variability among regions with South East Devon (SED-6) scoring highest and Isles of Scilly (IOS-4) scoring the lowest (Figure 27).

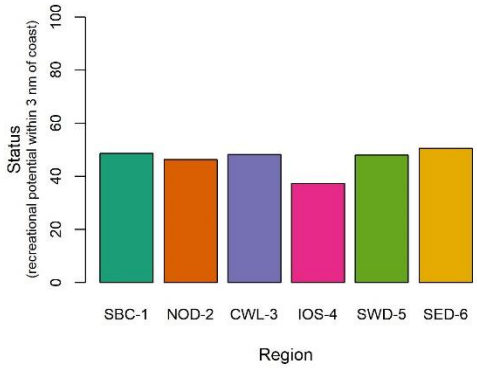


Figure 27. Recreational potential status scores.

Recommendations and limitations

'Viewshed' and 'recreational opportunity' data were modelled from regional topography, prevailing oceanography, meteorology and established access points, and hence lacked trend. As such, future status calculation purely reflects trend associated with visitor numbers. The method for apportioning overnight stay data treats all accommodation units as being equal; the capacity of the accommodation unit is not factored in (i.e. a camp site will have potential to cater for a greater number of visitors than a guest house). As a result, this may introduce a degree of under or over estimation of visitor numbers in some geographic areas.

A direct measure of recreational engagement, the Water Sports Participation Survey dataset (https://britishmarine.co.uk/Resources/Publications/2019/April/Watersports-Participation-Survey-2018) was considered preferable to the modelled recreational potential layer currently used in the Tourism and Recreation goal. However, as this dataset was not available as open access it could not be included in the South West England OHI+ assessment. Data on blue health was also considered for inclusion in the Tourism and Recreational goal to measure how regional development of blue infrastructure could be impacting the wellbeing of coastal populations. Natural England and DEFRA's Monitor of Engagement with the Natural Environment (MENE) survey was analysed as a potential data source: https://www.gov.uk/government/collections/monitor-of-engagement-with-the-natural-environment-survey-purpose-and-results. Interrogation of national results however revealed small sample size for many OHI+ regions (<10 respondents per year), making the dataset currently unsuitable for inclusion in the South West England OHI+ assessment.

As a greater evidence base relating to coastal recreation becomes available this goal would benefit from the addition of both blue health and regional recreational participation data in the future.

The global OHI method incorporates an among region (country-specific) sustainability metric; the Travel and Tourism Competitiveness Index (TTCI), produced by the World Economic Forum (WEF) which measures the factors and policies that make a country a viable place to invest within the Travel and Tourism sector: http://www.oceanhealthindex.org/methodology/components/tourism-competitiveness-index-tci. The South West England OHI+ assessment would be improved by the addition of a region-specific sustainability metric such as the TTCI, or perhaps a measure of potential 'carrying capacity' for visitor numbers. These could be considerations for future regional OHI+ assessments

Designated Areas: Valued Landscapes

Community valued coastal and marine systems

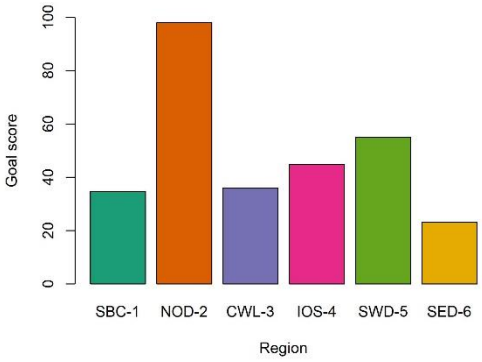


Figure 28. Valued Landscape goal scores.

The Valued Landscapes sub-goal reflects the extent of designated areas with the purpose of protecting areas valued for aesthetic, cultural and recreational reasons, including those containing multiple habitats, historic sites or rare geomorphology. Due to large designations, North Devon (NOD-2) scored highly (98), followed by South West Devon (SWD-5) (55). South East Devon (SED-6) had the lowest score (23) due to low total coverage of designated areas. The likely future status scores have minimal impact on the sub-goal score, with pressures and resilience relatively balanced and stable trends in the majority of regions.

Summary

In North Devon, 96% of the zone from 1 km inland to 3 nmi offshore was under an applicable designation, driven largely by the North Devon UNESCO Biosphere Reserve (total area: 526,088 ha or 5,260 km^2). Similarly, South West Devon (SWD-5) has a significant proportion of its relevant area designated an Area of Outstanding Natural Beauty or as Heritage Coast. Large designated areas such as these, combined with the high number of designation types (nine in this sub-goal) with differing remits covering both ecological and cultural protections, result in high OHI goal scores. In contrast, South East Devon (SED-6) which had the lowest score has a high number of spatially distinct sites under a diverse range of designation types. These sites are however small in area and often lacking connectivity, resulting in a low score.

Table 9. Valued Landscapes. Current status, trend, pressures, resilience, future and goal score.

REGION	STATUS	TREND	PRESSURES	RESILIENCE	FUTURE	GOAL SCORE
SBC-1	25	1.0	66	92	44	35
NOD-2	96	0.0	59	92	100	98
CWL-3	35	0.0	68	92	37	36
IOS-4	42	0.0	55	92	47	45
SWD-5	53	0.0	67	92	57	55
SED-6	22	0.0	68	92	24	23

Data sources and reference points

(Appendix 1, 2 & 3 for metadata)

The following datasets were used for this sub-goal:

- *World Heritage Sites (WHS)* [1] *(2001-2006)*
- *Local Nature Reserves (LNR)* [2] *(1973-2011)*
- *Important Bird and Biodiversity Areas (IBA)* [3] *(2007-2015)*
- *Biosphere Reserves (BR)* [4] *(1976)*
- *Heritage Coast (HC)* [5] *(1974-1992)*
- *Royal Society for the Protection of Birds Reserves (RSPBR)* [6] *(1994-2016)*
- *Areas of Outstanding Natural Beauty (AONB)* [7] *(1957-1995)*
- *Protected Wrecks (PW)* [8] *(1973-2014)*
- *National Parks (NP)* [9] *(1954)*

Spatially explicit polygon data were sourced for WHS, LNR, IBA, BR, HC, RSPBR, AONB, PW and NP. Data were clipped to an inshore zone between 1 km inland and 3 nmi from coast (mean high water). The 3 nmi offshore extent was selected as an accessible area for people wishing to access these sites. A time series (by designation date) of area coverage (cumulative km^2 by successive year) was calculated. The percentage of the inshore zone designated was calculated by year for each region.

Valued Landscapes were evaluated using a target reference point, with the target being that the total area from 1 km inland to 3 nmi offshore being designated in some way. A 100% status score would indicate that regionally, all the terrestrial (to I km internally) and maritime (3 nm) zone are assigned one or more designations. While 100% coverage may not be a feasible or desirable goal in some regions, this approach enables a transparent way to monitor progress in the absence of specific management targets.

Interpretation

Except for the Severn Estuary and Bristol Channel (SBC-1), all regions experienced a uniform trend across the most recent five years of data (Figure 29) for the Valued Landscapes sub-goal. The historical spatial designation of areas has inevitably occurred in intermittent intervals (tranches) to help coordinate research, stakeholder consultation events and the drafting of coordinated legislation. For this reason, it is also likely that sites were designated simultaneously across multiple counties, marine boundaries or biogeographical regions. High inter-annual variation across regions or years is therefore unlikely for the Valued Landscapes sub-goal. When variation in trend does occur, multiple regions will likely see an increase OHI status and trend in the same year. As no new sites considered under this sub-goal were designated between 2014 and 2018 trend remained stable for five of the six

regions. The Severn Estuary and Bristol Channel is the exception due to the extension of the Important Bird and Biodiversity Area network from 7.3% to 25.2%, resulting in an increased coverage and OHI status score in 2015.

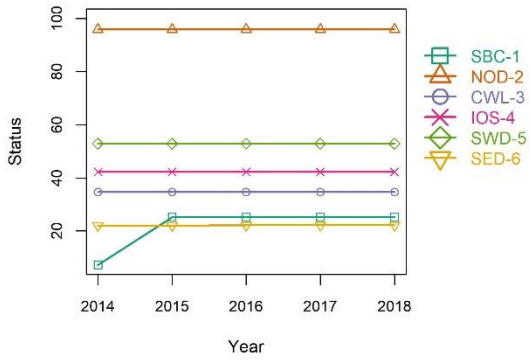


Figure 29. Percentage of total area allocated a Valued Landscape designation.

Recommendations and limitations

As with the Designated Areas Ecological Features sub-goal, the Valued Landscapes sub-goal measures the proportion of total area currently designated by region. The Designated Areas goal is adapted from the OHI Global Sense of Place goal (originally split into 'Iconic Species' and 'Lasting Special Paces' sub-goals). The OHI Global Lasting Special Places sub-goal measured the progress of coastal states in assigning 30% of their inshore waters under some form of protective designation, based on globally accepted and cited policy objectives for marine protected area designation. When considering the broad array of designation types in South West England, it was considered more appropriate to monitor the total extent of designations, since the extent of designation is greater than 30% in many regions, but not all designations are designed for the purpose of ecological protection. In the approach used here, regions with a greater proportion of their inshore area designated for cultural, recreational or intrinsic purpose receive higher scores. However, in the absence of specific policy targets for Valued Landscapes, future assessments could develop this method through an assessment of the extent of protection or management effectiveness. At present this goal does not measure sense of public pride, ownership or connection to designated areas. In future assessments social science data, such as Natural England and DEFRA's Monitor of Engagement with the Natural Environment (MENE), could be incorporated to gain a more holistic understanding how coastal communities use and value designated areas within their region.

Designated Areas: Ecological Features

Environmentally regulated ecological features

This goal measures the spatial extent of areas designated for the purpose of ecological conservation and management in South West England. The Severn Estuary and Bristol Channel (SBC-1) and South West Devon (SWD-5) regions scored highest (42 and 41 respectively) (Figure 30, Table 10) due to several large, distinct sites, designated in both of these regions. Cornwall (CWL-3), Isles of Scilly (IOS-4) and South East Devon (SED-6) had similar status scores, while North Devon (NOD-2) was the lowest scoring region.

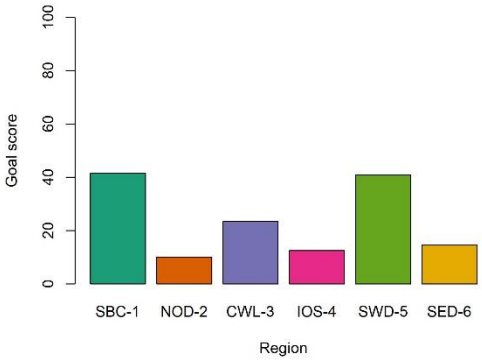


Figure 30. Ecological Features goal scores.

Summary

The Designated Areas goal is adapted from the OHI Global Sense of Place goal, which is divided into the 'Iconic Species' and 'Lasting Special Paces' sub-goals. The Ecological Features sub-goal is intended to reflect the need for designated areas with the primary purpose of protecting single or spatially linked ecological features of conservation concern. This includes key habitats and rare or keystone species. The highest performing regions were the Severn Estuary and Bristol Channel (SBC-1) and South West Devon (SWD-5) (42 and 41 respectively). The Severn Estuary and Bristol Channel are home to the Severn Estuary SAC (737.1 km^2) and South West Devon includes Start Point to Plymouth Sound and Eddystone SAC (249.18 km^2) and Skerries Bank and Surrounds MCZ (340.99 km^2). The designation of the Bristol Channel Approaches SAC in 2019 (5,850 km^2) will further elevate this region's score in future assessments. Cornwall (CWL-3), Isles of Scilly (IOS-4) and South East Devon (SED-6) had similar status scores, with 17.4%, 12.1% and 10.8% of their coastal and inshore marine zone designated respectively. North Devon (NOD-2) was the lowest scoring region, with only 7.3% currently designated under a classification defined as ecologically important in this study.

Table 10. Ecological Features. Current status, trend, pressures, resilience, future and goal score.

REGION	STATUS	TREND	PRESSURES	RESILIENCE	FUTURE	GOAL SCORE
SBC-1	41	0.0	79	92	42	42
NOD-2	7	1.0	48	92	13	10
CWL-3	17	1.0	80	92	30	24
IOS-4	12	0.0	64	92	13	13
SWD-5	30	1.0	79	92	52	41
SED-6	11	1.0	80	92	19	15

Data sources and reference points

(Appendix 1, 2 & 3 for metadata)

The following datasets were used for this sub-goal:

- *Special Area of Conservation (SAC)* [1] *(2005-2017)*
- *Special Protected Area (SPA)* [1] *(1992-2017)*
- *Marine Conservation Zone (MCZ)* [2] *(2013-2016)*
- *Site of Special Scientific Interest (SSSI)* [3] *(1983-2009)*
- *Ramsar site* [1] *(1991-2001)*

Spatially explicit polygon data were sourced for ecological features that benefitted from statutory environmental regulation. These comprised SAC, SPA, MCZ, SSSI and Ramsar sites. Polygon data were clipped to 1 km inland and 12 nmi from the coast (mean high water). A time series (by designation date) of area coverage (cumulative km^2 by successive year) was calculated. The percentage of the marine area designated in each region was calculated by year. A 100% status score would indicate that regionally, all the terrestrial (to 1 km internally) and maritime (12 nm) zone are assigned one or more designations. While 100% coverage may not be a feasible or desirable goal in some regions, this approach enables a transparent way to monitor progress, particularly to recognise progress beyond commonly stated policy targets such as 30% of marine area.

Interpretation

The Ecological Features sub-goal measures the percentage of designated coastal and nearshore marine zones that are identified as critical to ecological conservation. The historical spatial designation of areas for ecological reasons has inevitably occurred in intermittent intervals. Designations often occur in tranches to help coordinate research, stakeholder consultation events

and the drafting of coordinated legislation. For this reason, it is also likely that sites were designated simultaneously across multiple counties, marine boundaries or biogeographical regions.

The Ecological Features sub-goal reveals positive change in status and trend for several OHI South West regions between 2014 and 2018 (Figure 31). This increase, observed across several regions, was primarily influenced by Tranche 2 MCZ designations and multiple new SACs. North Devon (NOD-1), Cornwall (CWL-3), South East Devon (SED-6) and South West Devon (SWD-5) all experienced increases in area designated between 2016 and 2017 as a result. Both trend and status scores will further increase for many regions when Tranche 3 (2019) designations are included in future OHI South West assessments. The Isles of Scilly (IOS-4) status and trend remains stable during the most recent five years of data, with many MCZs previously designated in Tranche 1 (2013). Similarly, the Severn Estuary and Bristol Channel's (SBC-1) large SAC has been active since 2007, and with no MCZ sites designated in recent years, no changes in status and trend were evident since 2014.

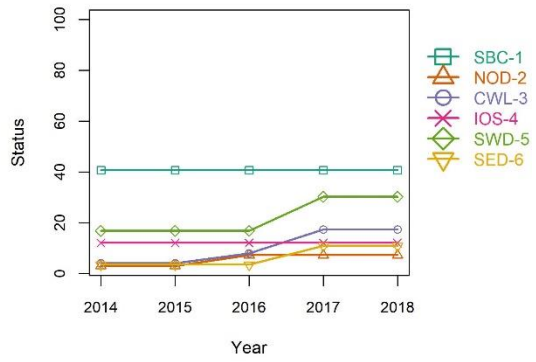


Figure 31. Percentage of total area allocated an Ecological Feature designation.

Recommendations and limitations

The Ecological features sub-goal measures the proportion of total area currently designated by each region, with those regions with a larger percentage of their coast and marine waters designated scoring more highly. Whilst achieving 100% designation is not necessarily feasible or desirable, this approach still allows comparison against well-established policy targets such as the goal of protection 30% of marine area under marine protected areas, and also recognises where designations extend beyond 30%. However, few designations in the South West are designed to completely exclude human activities and are typically considered multi-use zones. This zonal method of designating areas makes extensive spatial coverage both desirable and attainable, as it encourages the holistic management of all relevant species and ecosystems, without requiring cessation of all human activities. This

approach to the calculation of sub-goal scores does mean that regional scores are lower than would be the case if the extent of designated areas was compared against a policy target such as 30%. Furthermore, the variation between the five designation types considered under Ecological Features makes direct comparison difficult. The current assessment incorporates multiple designation types with varying degrees of protection and management effectiveness. Future OHI+ assessments could consider more comprehensive assessment of these designations, including factors such as type of protection (e.g. species versus ecosystem), the presence or absence of management plans, levels of protection (multi-use, highly protected) and frequency of monitoring.

Discussion over the designation of highly protected marine areas (HPMA) in domestic UK waters has increased in recent years. Waters surrounding Lundy Island represent the only no-take, highly protected area in the South West. It is likely that more sites will see the exclusion of extractive and certain recreational activities in the future. Should this occur, the Designated Areas goal could be adapted to measure regional progress towards a highly protected ecological network in addition to multi-use zones.

St Agnes coast, Cornwall

Mia Knight

Biodiversity: Habitats

Conservation status of habitats

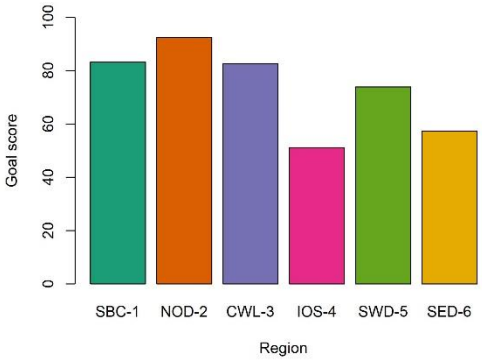


Figure 32. Habitats sub-goal scores.

This Biodiversity: Habitats sub-goal tracks the extent and condition of key marine and coastal habitats in South West England. Key habitats for assessment were selected based on their ecological importance, sensitivity to change and the availability of monitoring data. Regions' sub-goal scores were relatively spread (Figure 32, Table 11), ranging from 57 (Isles of Scilly (IOS-4)) to 92 (North Devon (NOD-2)). This spread was partly driven by variation habitat types occurring across the South West assessment area and variation in perceived pressures occurring between the North and South coasts.

Summary

North Devon (NOD-2) and the Severn Estuary and Bristol Channel (SBC-1) scored highly for the Biodiversity: Habitats sub-goal (Figure 32, Table 11). Without seagrass or maerl habitat mapped within these regions, the final goal score was a more direct measure of benthic condition and littoral sediment condition and monitoring. Low levels of bottom towed fishing gear, used as a proxy for both soft bottom and hard benthic habitats, contributed to these high OHI scores under within region benchmarks. Cornwall (CWL-3) scored relatively well due to moderate benthic habitats condition and relatively high saltmarsh and mudflat scores. The Isles of Scilly (IOS-4) and South West Devon (SWD-5) were the lowest scoring regions. The small extent and low number of littoral sediments associated SSSI units occurring in the Isles of Scilly means its final goal score is more heavily influenced by soft bottom and rock benthic habitat condition. As trawl intensity in 2018 over both benthic habitat types was at its maxima for the 5 years of data, the impact on the final OHI score was high. The Isles of Scilly and both South Devon regions (SWD-5 and SED-6) were predicted to see further declines in the next five years. Low modelled likely future status for these regions reflects increasing trawl pressure, low levels of monitoring at SSSI littoral sediment sites and declines in seagrass condition.

Table 11. Habitats. Status, trend, pressures, resilience, future and goal score.

REGION	STATUS	TREND	PRESSURES	RESILIENCE	FUTURE	GOAL SCORE
SBC-1	85	-0.2	48	77	82	83
NOD-2	85	0.5	33	75	100	92
CWL-3	83	0.0	69	76	83	83
IOS-4	56	-0.4	42	76	47	51
SWD-5	81	-0.3	66	77	67	74
SED-6	66	-0.4	68	75	49	57

Data sources and reference points

(Appendix 1, 2 & 3 for metadata)

The following datasets were used for this sub-goal:

- *Seagrass extent* [1] *(1985-2015)*
- *Seagrass condition* [2] *and monitoring* [2] *(2012-2019)*
- *Saltmarsh/mudflats extent* [3] *(2013)*
- *Saltmarsh/mudflats condition* [4] *& monitoring* [4] *(2003-2016)*
- *Maerl extent* [5] *(2009)*
- *Maerl condition* [6] *(2013)*
- *Soft and hard benthic habitats extent* [7] *(2019)*
- *Soft and hard benthic habitats condition* [8] *(2012-2018)*

Saltmarsh and mudflat condition data were sourced from Natural England's Designated Sites database. Saltmarsh and mudflat habitat condition data were scaled 0-1 using a categorical rank where: favourable = 1, unfavourable recovering/unfavourable no change = 0.5 and unfavourable declining/destroyed = 0. Maerl and seagrass condition data were sourced on an ad hoc basis from Natural England survey reports. Appropriate survey data relating to seagrass and maerl health and extent were extracted from reports and standardised to a 0-1 scale. Monitoring data for saltmarsh/mudflats, seagrass and maerl were similarly scaled where sites that had not been assessed for 6 years or more scored 0, and less than 6 years scored 1. A mean 'relative health score' for each site and habitat type was calculated from condition and monitoring scores. Site-specific scores were aggregated (mean) by habitat type to provide region-specific health scores.

Spatially explicit gridded (resolution approx. 100 x 100 m) data that described benthic habitat types (EUNIS 2007-11 classifications) for South West England marine sublittoral zones were sourced. Data were extracted for both soft (coarse and mixed sediments), and hard (rock and reef) substrata, from

near-shore waters (coast [mean high water] to 12 nmi offshore). Total area (km^2) for each habitat type was calculated by region. Gridded annual Global Fishing Watch data (resolution approx. 1 x 1 km, units: fishing hours $year^{-1}$) were used to calculate total trawl fisheries effort across each habitat type by region and year. Data were divided by area (km^2) of habitat to provide an estimate of fisheries intensity over soft and hard bottom substrata. The most recent five years of data were selected and rescaled using a within region reference points and inverted so that a score of 1 represented minimum trawl-fisheries intensity. These data were used as proxy for benthic substrata health.

Seagrass, saltmarsh/mudflats and maerl were evaluated using a target reference point, this being a categorical ranking 0 (low) to 1 (high). Fishing intensity was benchmarked against within region maxima for the last five years of data. A 100% status score would indicate that coastal-water habitats (seagrass, saltmarsh, maerl) were in 'favourable' condition and benthic sub-littoral habitats were least impacted by bottom towed fisheries. Region-specific habitat health scores (for seagrass, saltmarsh/mudflats, maerl, soft and hard bottom substrata) were proportionalised by relevant area of habitat type to total habitat extent, summed and rescaled to 100 to give region-specific status scores (for seagrass, saltmarsh/mudflats, maerl, soft and hard bottom substrata combined).

Interpretation

Seagrass time series condition data to calculate trend were unavailable for the majority of sites (Figure 33a), with the exception of the Isles of Scilly where Project Seagrass and Natural England provide standardised surveys annually. Many regions lack repeat assessments or standardisation of methods between surveys. Whilst seagrass sites within the Isles of Scilly have reliable, time series condition data, their geographic isolation makes extrapolation to gap fill trend values for all South West regions difficult. A trend estimate, based on a literature review of regional and global seagrass studies, was therefore applied as a proxy. This estimate was derived from a single indicator value rather than annual status values as with other data. All regions with assessed seagrass habitat scored highly. These scores are however influenced by the monitoring metric, with all identified sites currently falling within the 6-year assessment window. These high monitoring rates do potentially mask the OHI+'s ability to detect declines in the actual condition of seagrass beds across the South West. For example, data from the Isles of Scilly suggest a recent decline in seagrass health. Leaf infection scores (used as an indicator of wasting disease) that contribute to the OHI+ condition score have more than doubled between 2014 and 2016 (Figure 33b, where 5 indicates high levels of infection and zero no infection recorded). In future iterations of the OHI+ excluding the monitoring metric could provide a clearer indicator of seagrass health if desired.

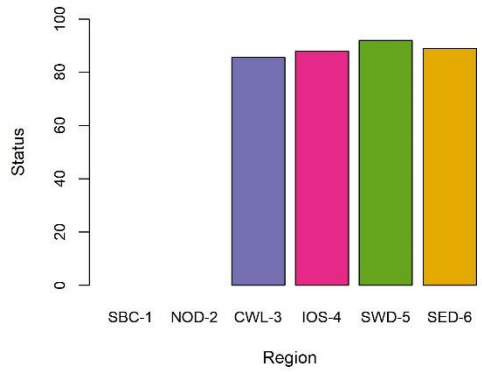


Figure 33a. Seagrass condition and monitoring.

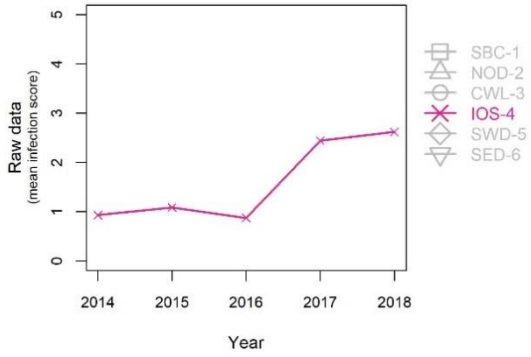


Figure 33b. Isles of Scilly (IOS-4) seagrass mean infection scores from annual surveys.

All regions show a negative trend for saltmarsh and mudflat status scores (Figure 34a). This was primarily driven by the lack of site monitoring in recent years (Figure 34b), as opposed to declines in condition. Without the monitoring metric all regions would have scored very highly, receiving status score of 80 or above, based on the current condition data ranking most sites as being in 'favorable' condition (Figure 34c). However, given the limited number of sites monitored since 2010 (Figure 34b), the confidence in these assessments ranks is low. The Isles of Scilly have a small number of designated SSSI sites to sample from. Changes in the condition/monitoring of these sites have a more noticeable impact on status and trend than in other OHI South West regions, where changes to individual sites may be buffered. This caused the sharp negative trend between 2014 and 2015.

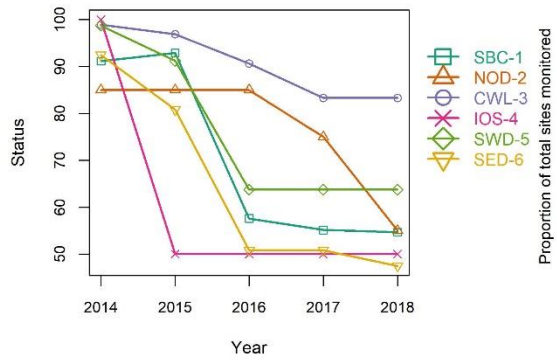


Figure 34a. Saltmarsh and mudflat condition and monitoring status.

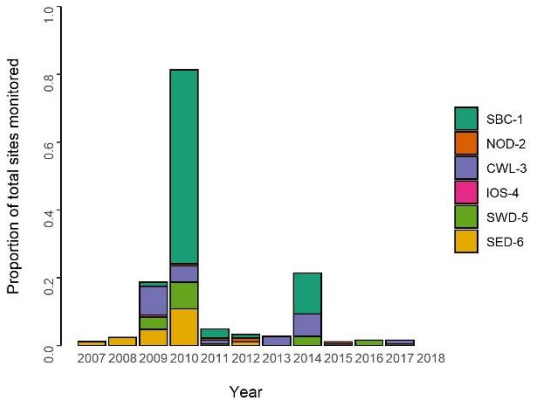


Figure 34b. Monitoring of SSSI saltmarsh and mudflat sites by year.

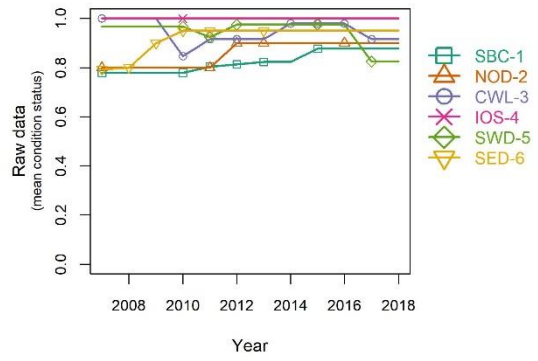


Figure 34c. Saltmarsh and mudflat condition (scaled 0 -1).

Maerl habitat is only recorded in Cornish waters (CWL-3). All other regions are assigned NA values with no impact on their goal scores (Figure 35). As with the seagrass data, maerl sites were lacking standardised time series data to apply as a trend. A similar method to that of seagrass was applied to derive a single indicator value from peer-reviewed and grey literature.

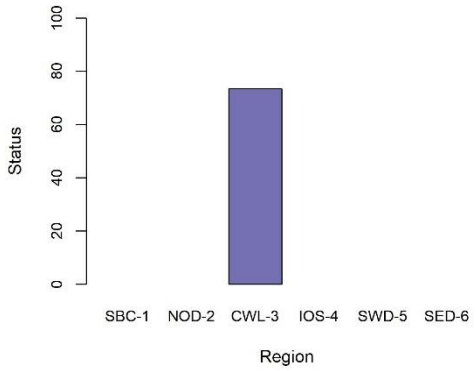


Figure 35. Maerl condition.

Towed bottom gear (trawling) fishing effort was used as a proxy for condition for both soft and hard benthic habitat types. Benthic habitat status and trend were calculated by comparing trawl intensity over relevant habitat types across the most recent five years of data. Regions recording increases in trawl pressure scored poorly, whilst those with reduced trawl activity were considered to have reduced benthic disturbance and received higher OHI status scores and increasing trends (Figure 36a, 37a). As condition was measured by proportional change in trawl intensity, the raw intensity levels are an important consideration (Figure 36b, 37b).

Both habitat types show high variation in trend among years and regions, reflecting the mobility of the South West fishing fleet across regional boundaries. The lack of towed bottom gear activity in the Severn Estuary and Bristol Channel resulted in high status scores and stable trend for both soft and hard benthic habitats. North Devon also scored highly due to reduced trawl pressure over both habitat types between 2014 and 2018. Cornwall recorded a high status score and a relatively stable trend across soft bottom habitat, with relatively low trawling recorded in 2017 and 2018. This was despite the region having the third highest trawl intensity of all OHI South West regions. For hard benthic habitats trawl activity saw a gradual increase since 2015 resulting in a declining trend and the second lowest score of all regions.

South East Devon and South West Devon showed high inter-annual variation in trend, particularly for hard benthic habitats. Despite improvements in 2018, years 2016 and 2017 saw trawl intensity at their maxima respectively, with almost all mapped habitat experiencing disturbance. Given the time required for benthic communities to recover from intensive trawling, reductions in effort in 2018 may be a result of degraded habitat producing lower yields. South West Devon's soft bottom habitats score noticeably better than its rocky reefs. However, the raw data revealed the region had the highest trawl intensity over soft benthic habitats of any OHI South West region in 2018. As with hard habitats, South West Devon performs very poorly for soft benthic habitats. 2017 saw the highest trawl intensity recorded across the five years of data, with only slight improvements in 2018. Inspection of the raw data again reveals the region to have second highest trawl intensity compared to other OHI South West regions.

2018 saw the Isles of Scilly record its highest trawling intensity since 2014 over soft benthic habitats, resulting in low status scores. When compared to other regions, the Isles of Scilly had relatively low levels of trawl activity in raw data which needs consideration. It is also worth noting that trawling activity in the Isles of Scilly occurs almost exclusively between the 6 nm to 12 nm zone, with limited activity within 6 nm (6571 $hours^{-1}$ and 755 $hours^{-1}$ fished respectively in 2018). This is due to local byelaws excluding most large (>10 m) vessels from the 6 nm from shore zone and few under ten-metre trawlers currently in operation. Whilst total trawl intensity may still be far below other regions, the dramatic proportional increase saw the Isles of Scilly score poorly and should be cause for concern. Hard benthic habitats again show declining trends and low status scores due to increases in trawl associated disturbance since 2014. Unlike soft bottom habitats however, the raw data reveal the Isles of Scilly to have very high trawl pressure when compared to other OHI South Wet regions.

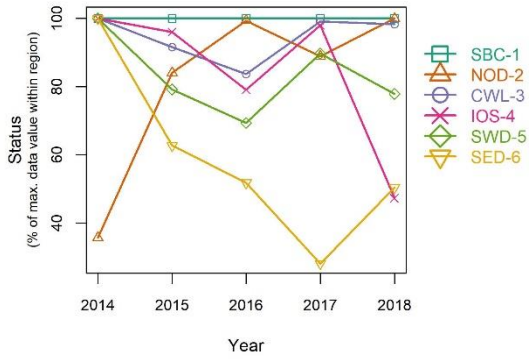


Figure 36a. Soft benthic habitats condition.

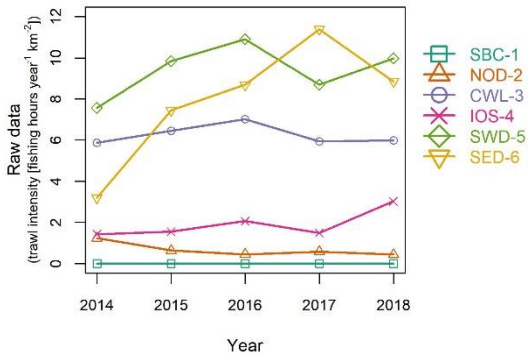


Figure 36b. Soft benthic habitat trawl intensity.

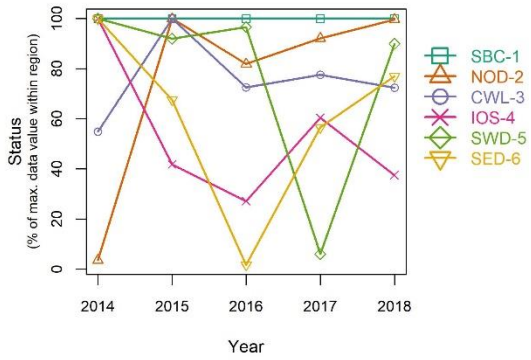


Figure 37a. Hard benthic habitats condition.

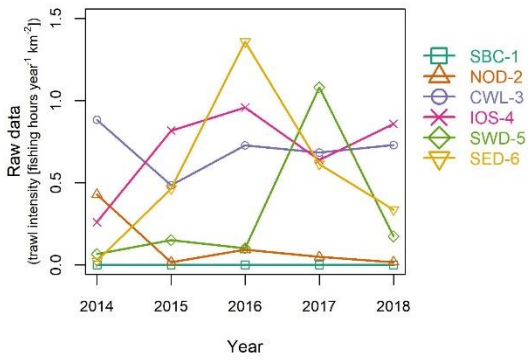


Figure 37b. Hard benthic habitat trawl intensity.

Recommendations and limitations

The monitoring rate metric has a significant impact on score for this sub-goal. Ideally monitoring frequency would be incorporated into the pressures or resilience calculations, allowing status scores to purely reflect habitat condition. The majority of littoral sediment SSSI units occurring in the South West are currently assessed as 'favourable'. However, the data underpinning these ranks are derived from surveys potentially >10 years old. In consultation with key stakeholders a decision to use a monitoring frequency score was made. This reflects the uncertainty in the condition data available. The six-year window for condition assessments is partially informed by the Habitats Directive reporting cycles. This cycle is clearly exhibited in status scores and trends from 2016 onwards. As many sites were last assessed in 2010, many regions see a sharp decline in trend in 2016, when the six yearly monitoring window passes. Whilst this metric provides a useful indicator of uncertainty in unassessed sites, it can, in effect, reward sites that are in poor condition or declining just for being monitored. This

is demonstrated by seagrass sites in the Isles of Scilly experiencing increased levels of leaf infection between 2014 and 2018, yet still scoring highly (85), as the sites are being monitored. In future assessments the monitoring metric should be removed if more regular assessment generates greater confidence in the condition data.

Kelp habitat was considered for inclusion in the Biodiversity: Habitats sub-goal. This was due to its prevalence around South West England and the high number of marine species associated with kelp forests. Whilst extent data exists for kelp habitat, condition data were lacking. Natural England held condition reports were made available for selected sites, however many lacked repeat assessments and there was high variation in survey coverage between OHI South West regions. Seagrass and maerl sites had similar issues, but the data was felt reliable enough to include in this study. Kelp, seagrass and maerl habitat would all benefit from more frequent monitoring and the development of a standardised condition metric (as with SSSI assessments) across the South West. In the absence of more robust data, trawl intensity over soft and hard benthic habitats provides a useful proxy data source. Until baseline surveys and repeat condition assessments using applied methods are available, there remains a level of uncertainty in the Biodiversity: Habitat scores. Standardised survey protocols for key indicator sites are currently in development by Natural England's marine evidence team which could provide more robust data for future OHI South West assessments.

Biodiversity: Species

Conservation status of species

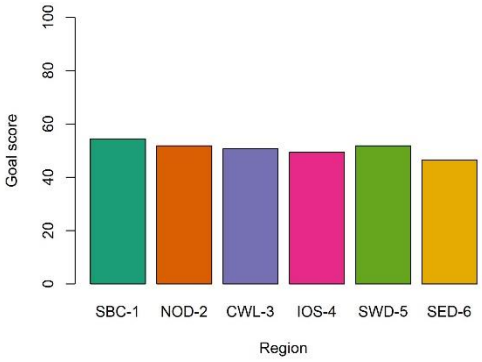


Figure 38. Species sub-goal scores.

This sub-goal tracks the conservation status of key indicator species in South West England. All regions perform relatively poorly for the Species sub-goal (Figure 38), with little inter-regional variation. This suggests the majority of species included are considered to have an unfavorable conservation status. All regions had lower final goal scores than current status scores (Table 12) due to the likely future status calculations indicating that the assessed species are predicted to see future declines. These predicted declines can be attributed to high pressures (Appendix 4), low resilience (Appendix 5) and negative population trends for many of the species.

Summary

The Species sub-goal is heavily adapted from the methods used in the Global OHI and was developed in iterations, with input from a range of stakeholders. The Global methodology uses marine species listed on the International Union for the Conservation of Nature's Red list. Issues were identified with this method relating to model sensitivity and data resolution. With nearly 700 IUCN listed marine species occurring across the South West, a significant number would need to record annual changes in condition for the OHI assessment to register discernible changes. Coupled with long gaps between IUCN species assessments, it was felt the model was lacking in sensitivity to measure change at the South West level. IUCN species distribution maps were also considered too coarse to allow much variation between OHI South West regions and often resulted in the inclusion of species that were not considered to occur in any significant numbers across the South West. Finally, stakeholders raised concerns regarding coastal species (notably bird species) being excluded from the analysis by using IUCN marine filters.

As a result, a decision was made to generate a targeted subset of key species, similar to that used in the Global OHI Sense of Place: Iconic Species sub-goal. Through an iterative process a list of 40 species representing a variety of taxonomic groups was produced, with Cornwall (CWL-3) experiencing the highest number of species' distributions intersecting its waters (39 of 40 species) and the Severn Estuary and Bristol Channel (SBC-1) the lowest (27 of 40).

This process relied on extensive literature and policy reviews and validated through consultation with stakeholders from conservation, policy and research backgrounds (see Section 2: Project Governance for details). The new methodology contained a range of species considered to represent each taxonomic group, whilst restricting the number included to allow changes in individual species' status to be reflected in goal scores. To further reflect local variation in species distribution and condition, IUCN data were replaced where possible with national and local population assessments and distribution records. This allowed a greater level of inter-regional variation than the IUCN data and increased the frequency of condition assessments. Additional condition and distribution data sets to the final source (Appendix 1) were considered for many species. Decisions over selecting data were generally driven by spatial coverage of the data across the South West, regular time series and standardisation between species within taxonomic groupings.

Table 12. Species. Current status, trend, pressures, resilience, future and sub-goal score.

REGION	STATUS	TREND	PRESSURES	RESILIENCE	FUTURE	GOAL SCORE
SBC-1	59	-0.3	71	81	50	55
NOD-2	56	-0.3	60	77	47	52
CWL-3	57	-0.3	82	77	44	51
IOS-4	56	-0.3	77	79	43	49
SWD-5	58	-0.3	82	79	46	52
SED-6	53	-0.3	81	78	40	47

Data sources and reference points

(Appendix 1, 2 & 3 for metadata)

The following datasets were used for this sub-goal:

- *List of marine species* [1] *(2019)*
- *Species distribution ranges* [2-7]
- *Population status* [8-11] *(IUCN: 2003-2018, Natural England: 2012-2019, CEFAS stock assessment: 2017, BoCC: 2015)*
- *Population trend* [12] *(2003-2018)*

A regional species list was developed from Marine Management Organisation policy statements and distribution ranges were sourced from a variety of technical reports and on-line resources. Data sources included DEFRA, NBN, The Shark Trust, IUCN, JNCC and BTO. This list comprised:

1) Species explicitly named in any MMO policy statements.
2) Species that were known to occur in South West England belonging to key groups (e.g. 'wading birds') referenced by MMO policy statements.
3) Species that were known to occur in South West England listed in any national and international conventions (e.g. OSPAR) referenced by MMO policy statements.

This list was apportioned into eight taxonomic groupings (marine mammals, sessile benthic organisms, crustacea, elasmobranchs, fish, breeding seabirds, non-breeding seabirds and wading birds). To enable analysis to be sensitive to change over time it was deemed appropriate to restrict the number of species within each taxonomic group. It was also considered necessary to assess species where robust condition data were available. As such, data availability and local relevance were introduced as further selection criterion:

1) A maximum of five species for eight taxonomic groupings (marine mammals, sessile benthic organisms, crustacea, elasmobranchs, fish, breeding seabirds, non-breeding seabirds and wading birds) to allow sensitivity to change.
2) Species with regular, time series condition data prioritised over species without.
3) Species with condition data available for all relevant OHI+ regions (those that overlap species distributions) prioritised over species with partial spatial coverage.
4) Breeding species, species that were resident or occurring in significant numbers prioritised over migratory and locally rare species.
5) Species that were considered high priority/conservation concern (IUCN, BOCC, BAP, OSPAR, W&C act, NGO lists) prioritised.
6) Non-commercially targeted species prioritised over commercial species due to coverage under the Food Provision – Wild Caught Fisheries goal.

With reference to the region-specific species list condition data for were obtained from multiple sources and scaled to 1 as follows:

1) Marine mammals, elasmobranchs and fish. IUCN extinction risk categories were ranked 0-1 where 'LC' = 1, 'NT' = 0.8, 'CD' = 0.7, 'VU' = 0.6, 'EN' = 0.4, 'CR' = 0.2, 'EX' = 0.
2) Sessile benthic organisms. MCZ management categories (Natural England) were ranked 0-1 where sites designated as 'maintain in favourable condition' = 1, 'recover to favourable condition' = 0.5. As species were listed over multiple sites and regions ranked categories were aggregated (mean) by species and region.
3) Crustacea. Regional stock assessment data were used to calculate B/B_{MSY} scores. These were then rescaled to 1 using the maximum species-specific B/B_{MSY} value.

4) Seabirds and wading birds. Birds of Conservation Concern (BoCC) rankings were rescaled such that: 'green' = 1, 'amber' = 0.5 and 'red' = 0.

Population status data were aggregated (mean) to provide region-specific species health scores and rescaled to 100.

Species were evaluated using target reference points, this being a combination of categorical ratings 0 (low) to 1 (high), and rescaled (0-1) B/B_{MSY} values. A 100% status score would indicate that regionally, all species are at minimum conservation concern.

Interpretation

Biodiversity Species status scores were relatively uniform across regions (Figure 39). This is due to low variation in species occurrence between regions. Individual species were on average found to occur in five of the six OHI SW regions. No regions had a unique species occurring and only one species (Manx Shearwaters (*Puffinus puffinus*) under the 'breeding seabird' category) occurred in less than three regions. Whilst Cornwall experienced the highest number of species' distributions intersecting its waters (38 of 40 species) and the Severn Estuary and Bristol Channel the lowest (26 of 40), the other regions were closer to the average 33 species. These low levels of variation partly occur due to the coarse resolution of available species distribution models, but also due to the small geographic scale of the South West assessment area relative to the large ranges of most marine species assessed. This was notably true for highly mobile species such as birds, marine mammals and fish, many of which have distributions spanning the North Atlantic.

Intermittent condition assessments of species at a South West England, national or global level, meant a time series of trend data were not often available. As such, species trend was derived from a single indicator value (often sourced from the IUCN), describing the predicted positive, negative or stable population dynamics.

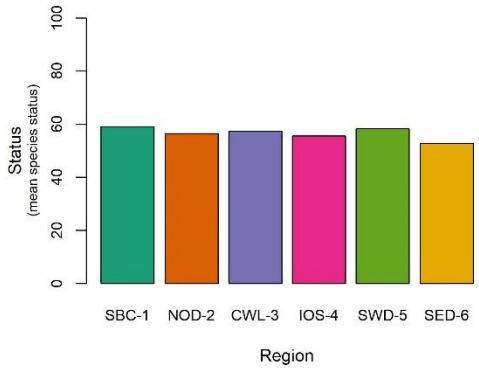


Figure 39. Marine species status.

Recommendations and limitations

Retaining the species listed in this assessment in future OHI South West assessments will ensure temporal comparisons in scores and allow the conservation status of these key species to be tracked through time. It is however recommended that future OHI South West assessments undergo a similar process of stakeholder consultation and literature review. It is likely that through human activities and natural variation, other species may become more relevant in the future. Repeating the validation exercises detailed here will ensure the model is measuring species considered a priority within their relevant taxonomic groupings.

This goal would benefit greatly from the standardisation and increased reporting of species condition assessments and monitoring strategies. Good Environmental Status ranks in the Marine Strategy Framework Directive suggests efforts to generate standardised metrics are being made. However, to date these initiatives rely on data considered too coarse for the OHI+ South West resolution and are likely to show long term trends (decadal), rather than inter-annual variation. Developing a comparable condition assessment methodology across sessile benthic organisms, mobile marine mammals or fish and seabirds is therefore unlikely in the short term. Other conservation status data used in this study, even if derived from UK surveys, such as the Birds of Conservation Concern, are likely to mask local variance in population trends. Local citizen science monitoring groups, such as the Cornwall Seal Group research Trust (South West coverage), could provide high resolution localised data. As these comprehensive datasets are currently only available for a small subset of species, preference was given applying data from a single data source for each taxonomic grouping where possible. This allowed easier comparison between similar species and between regions. In future OHI South West assessments exploring the availability of localised surveys and investment in coordinated monitoring of conservation concern and known indicator species should be prioritised in marine spatial planning and other management measures.

Coastal Systems: Coastal Protection

Coastal habitats with shoreline protection

The Coastal Protection sub-goal addresses natural coastal defense against sea level rise or storm surges. This goal contributes to the Coastal Systems goal, which measures the condition and monitoring of habitats that provide ecosystem services to South West England. Regional scores are variable for the sub-goal, with the Isles of Scilly (IOS-4) scoring highest (78). Negative trend and modelled declining future status for all regions are concerning indicators of both deteriorating health and reduced monitoring of habitats that provide important natural coastal defences.

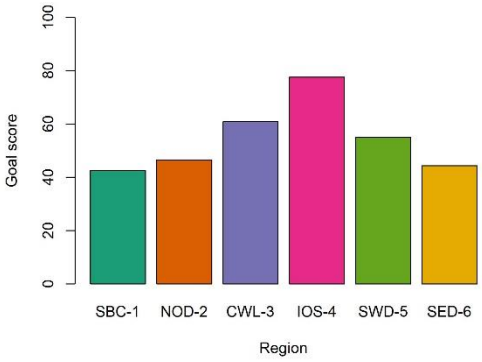


Figure 40. Coastal Protection sub-goal scores.

Summary

The Isles of Scilly (IOS-4) performs best for this sub-goal (score 78; Figure 40, Table 13). Seagrass sites in the Isles of Scilly are deemed to be in a moderate condition with high monitoring scores and, unlike other regions, sand dunes are generally assessed to be in favourable condition (although they have not been surveyed since 2012). The Severn Estuary and Bristol Channel (SBC-1) is the lowest scoring region (43), with saltmarsh, mudflat and sand dune habitats assessed as in an unfavourable condition or unmonitored in the six-year statuatory window for monitoring, and no seagrass habitat present. North Devon (NOD-2) experiences similar issues as it contains no monitored seagrass sites and an extensive sand dune system (11.4 km^2) with 85% of SSSI units in an unfavourable condition. South West Devon (SWD-6) also scores poorly, despite having seagrass sites believed to be in good condition. All sand dune associated habitats are in unfavourable condition, although they are limited in extent, and whilst the majority of its saltmarsh and mudflat sites are favourable, they have not been assessed for eight to ten years. All regions see negative trends and low modelled likely future status. This reflects the increasing lack of monitoring occurring across the South West for these habitats.

Table 13. Coastal Protection. Current status, trend, pressures, resilience, future and goal score.

REGION	STATUS	TREND	PRESSURES	RESILIENCE	FUTURE	GOAL SCORE
SBC-1	54	-0.6	82	78	31	43
NOD-2	52	-0.4	57	75	41	47
CWL-3	69	-0.4	71	76	53	61
IOS-4	79	-0.2	54	77	76	78
SWD-5	64	-0.5	65	78	46	55
SED-6	54	-0.6	72	75	35	44

Data sources and reference points

(Appendix 1, 2 & 3 for metadata)

The following datasets were used for this sub-goal:

- Seagrass extent [1] (1985-2015)
- Seagrass condition [2] and monitoring [2] (2012-2019)
- Saltmarsh/mudflats/sand dune extent [3] (2013)
- Saltmarsh/mudflats/sand dune condition [4] and monitoring [4] (2003-2016)

Saltmarsh, mudflat and sand dune condition data were sourced from Natural England's Designated Sites database. All habitat condition data were scaled 0-1 using a categorical rank where: favourable = 1, unfavourable recovering/unfavourable no change = 0.5 and unfavourable declining/destroyed = 0. Seagrass condition data were sourced on an ad hoc basis from Natural England survey reports. Appropriate survey data relating to seagrass health and extent were extracted from reports and standardised to a 0-1 scale. Monitoring data for saltmarsh/mudflats, seagrass and sand dunes were similarly scaled where sites that had not been assessed for 6 years or more scored 0, and less than 6 years scored 1. A mean 'relative health score' for each site and habitat type was calculated from condition and monitoring scores. Site-specific scores were aggregated (mean) by habitat type to provide region-specific health scores by year. Region-specific habitat health scores were proportionalised by relevant area of habitat type to total habitat extent, summed and rescaled to 100 to give region-specific status scores (for seagrass, saltmarsh/mudflats, and sand dunes combined).

Coastal Protection habitats were evaluated using a target reference point reflecting desirable management goals rather than being compared to previous years. A 100% status score indicates that regionally, all habitats are in 'favourable' condition and have been monitored within the assessment 5-year timeframe.

Interpretation

A time series on seagrass condition data were unavailable for the majority of sites (Figure 41), with the exception of the Isles of Scilly where Project Seagrass and Natural England provided standardised surveys annually. Many regions lacked repeat assessments or standardisation of methods between surveys. Whilst seagrass sites within the Isles of Scilly had reliable, time series condition data, their geographic isolation made extrapolation to gap fill trend values for all South West regions difficult. A trend estimate, based on a literature review of regional and global seagrass studies, was therefore applied as a proxy. Seagrass status scores were therefore derived from a single indicator value rather than annual status values as with other data. All regions with assessed seagrass habitat scored highly. These scores are however influenced by the monitoring metric, with all identified sites currently falling within the 6-year assessment window. These high monitoring rates do potentially mask the OHI+'s ability to detect declines in the actual condition of seagrass beds across the South West. For example, data from the Isles of Scilly suggest a recent decline in seagrass health. Leaf infection scores (used as an indicator of wasting disease) that contribute to the OHI+ condition score have more than doubled between 2014 and 2015 (Figure 41b, where 5 indicates high levels of infection and zero no infection recorded). In future iterations of the OHI+ excluding the monitoring metric could provide a clearer indicator of seagrass health if desired.

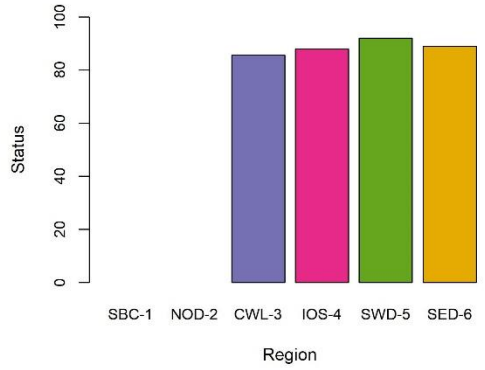


Figure 41a. Seagrass condition and monitoring status.

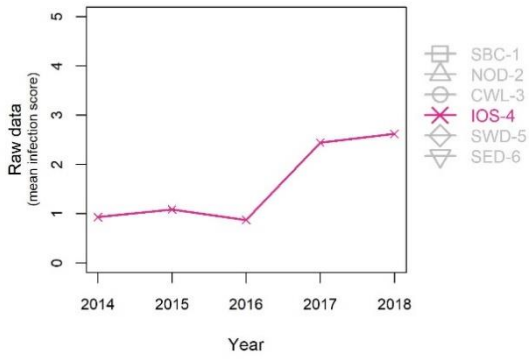


Figure 41b. Isles of Scilly (IOS-4) seagrass mean infection scores from annual surveys.

All regions show a negative trend for saltmarsh and mudflat status scores (Figure 42a). This was primarily driven by the lack of site monitoring in recent years (Figure 42b), as opposed to declines in condition. Without the monitoring metric all regions would have scored very highly, receiving status score of 80 or above, based on the current condition data ranking most sites as being in 'favorable'

condition (Figure 42c). However, given the limited number of sites monitored since 2010 (Figure 42b), the confidence in these assessments ranks is low. The Isles of Scilly have a small number of designated SSSI sites to sample from, so changes in the condition status of these sites are likely to have a more noticeable impact on status and trend than in other OHI South West regions, where changes to individual sites may be buffered. This may explain the sharp negative trend between 2014 and 2015.

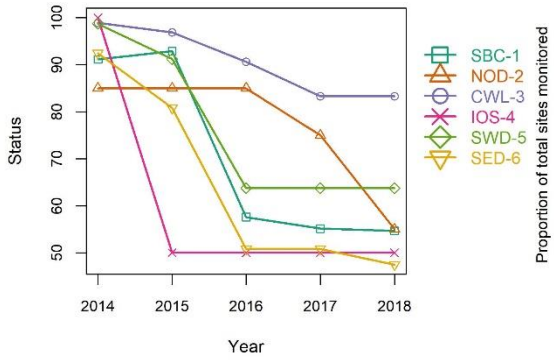


Figure 42a. Saltmarsh and mudflat condition and monitoring status.

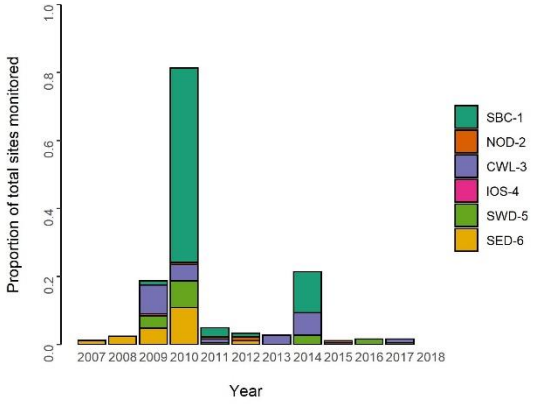


Figure 42b. Monitoring of SSSI saltmarsh and mudflat sites by year.

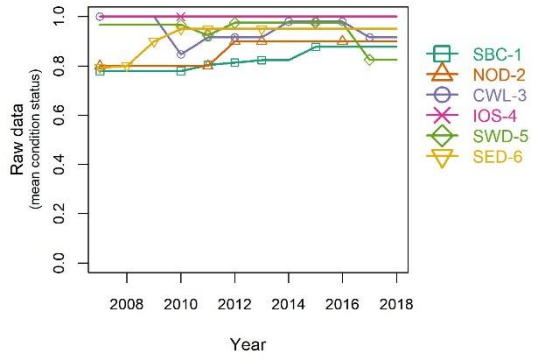


Figure 42c. Saltmarsh and mudflat condition (scaled 0 -1).

Sand dune habitats followed a similar declining trend to saltmarsh and mudflats (Figure 43). Lack of monitoring in recent years was likely the main driver of negative status scores between 2014 and 2018. Until 2014, a significant number of dune units were assessed annually, however since 2014 no new site assessments have been conducted across any OHI South West regions. In addition, a far greater number of sand dune SSSI sites are considered to be in an unfavourable condition than either mudflats or saltmarsh sites. This results in many regions performing particularly poorly for sand dune status and trend.

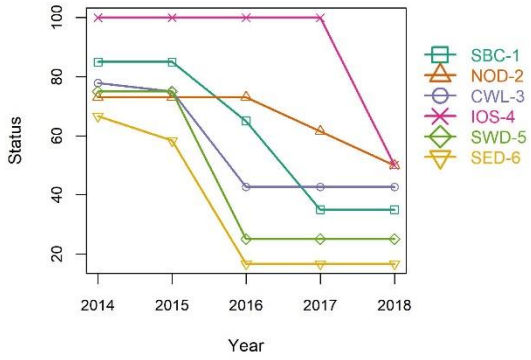


Figure 43. Sand dune condition and monitoring status.

Recommendations and limitations

The Coastal Systems goal is an amalgamation of two goals from the OHI Global methodology, Carbon Storage and Coastal Protection. Whilst describing two distinct ecosystems services (the ability of coastal habitats to sequestrate carbon emission and provide natural defence from sea level rise and storm events), when applied to South West England there is a high level of overlap in the data used in the two goals. In the Global methodology, there exists a greater diversity of habitats, making each Goal distinct enough to warrant separation. Across the South West assessment area there exist only a limited number of habitats that provide these ecosystem services and only a subset have comprehensive data available for use in the OHI+ assessment, meaning that saltmarsh and mudflats and seagrass data would be used for both goals. Some of these data are further used in the Biodiversity Habitats sub-goal. To avoid a small number of datasets exerting a high level of influence over OHI+ South West regional and overall assessment scores, Carbon Storage and Coastal Protection were combined into a single goal named Coastal Systems. The goal retained two sub-goals as each have distinct considerations and implications.

The Coastal Protection sub-goal currently assumes that all habitat types and locations across the South West provide equal benefit and are of equal need to coastal communities. It is likely that certain OHI+ South West regions are more reliant on coastal systems than others, and that larger connected networks of service-providing habitats confer greater benefits than smaller, isolated sites. Digital terrain models (DTMs) to identify coverage and condition of relevant habitats in low lying land, DTMs for the proportion of low lying land within each region, and mapping locations of 'hard engineering' coastal defences that may be contributing to coastal squeeze were all considered in early iterations of the assessment. However, available open source DTMs often lack the spatial resolution to overlay

against fine scale habitat data derived from surveys, resulting in a high level of uncertainty. In future assessments, this sub-goal could benefit from the development of a more robust model of natural defences in low lying or vulnerable land. This could also inform management and habitat restoration efforts.

As with the Biodiversity Habitats sub-goal, the monitoring rate metric had a significant impact on scores for this sub-goal. The high number of SSSI units ranked as being in favourable condition, particularly littoral sediment associated habitats, has the potential to produce high OHI scores based on surveys that are potentially >10 years old. In consultation with the project steering group and other key stakeholders, a decision to use a monitoring frequency score was taken, reflecting the uncertainty in the condition data available. The six-year window for condition assessments was partially informed by the Common Standards for Monitoring Designated Sites reporting cycles (https://hub.jncc.gov.uk/assets/0450edfd-a56b-4f65-aff6-3ef66187dc81), requiring surveys every six years on progress made towards maintaining and restoring a favourable conservation status for key habitat types. Whilst this metric provides a useful indicator of uncertainty in unassessed sites, it can, in effect, reward sites that are in poor condition or declining just for being monitored. This is demonstrated by seagrass sites in the Isles of Scilly experiencing increased levels of leaf infection between 2014 and 2018, yet still scoring highly as the sites are being monitored. In future assessments the monitoring metric should be removed or incorporated into pressures and resilience calculations if more regular assessment were to enable greater confidence in the condition data.

Coastal Systems: Carbon Storage

Coastal habitats with carbon storage potential

The Carbon storage sub-goal measures sequestration of carbon and contributes to the Coastal System goal. The Isles of Scilly (IOS-4) and Cornwall (CWL-3) regions score highly for the Carbon Storage sub-goal, with 85 and 78 respectively. All other regions score below 56. Negative historic trend and declining likely future status for the majority of regions, indictes the deteriorating health and/or declining investment in monitoring of seagrass, saltmarsh, mudflat and maerl habitats that together contribute to the removal of carbon and buffering of human driven climate change.

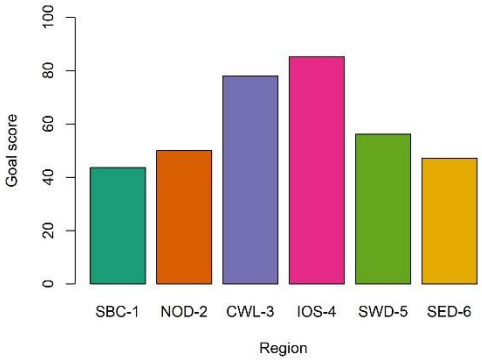


Figure 44. Carbon Storage sub-goal scores.

Summary

The Isles of Scilly (IOS-4) and Cornwall (CWL-3) are the top performing regions for the Carbon Storage sub-goal (Figure 44, Table 14). With only a single SSSI site containing littoral sediment (St. Martin's Sedimentary Shore), seagrass represents the primary carbon sequestering habitat by area (km^2) across the Isles of Scilly occurring within the considered habitat types. Whilst seagrass sites in IOS-4 experience fluctuations in variables such as wasting disease and epiphyte cover, in 2018 they remain in moderate condition and, as they are regularly monitored, the region scores highly (85). The future status score also suggests the Isles of Scilly to be the only region likely to experience improvements into the future. Cornwall's saltmarsh and mudflats are generally in favourable condition (92%), with the majority of sites (75%) surveyed within the last six years. It was also the only region with mapped and assessed maerl habitat.

The Severn Estuary and Bristol Channel (SBC-1) was the lowest scoring region (44), followed by South East Devon (SWD-5) (47), North Devon (NOD-2) and South West Devon (SWD-5) (56). These regions all have saltmarsh and mudflat believed to be in favourable condition, but with very few sites monitored in the legally underpinned six-year window resulting in reduced OHI+ scores. North Devon and the Severn Estuary and Bristol Channel have no mapped seagrass or maerl habitats, so scores directly reflect the condition and monitoring of their saltmarsh and mudflats.

Table 14. Carbon Storage. Current status, trend, pressures, resilience, future and goal score.

REGION	STATUS	TREND	PRESSURES	RESILIENCE	FUTURE	GOAL SCORE
SBC-1	55	-0.6	76	78	33	44
NOD-2	55	-0.4	46	75	45	50
CWL-3	79	-0.1	60	76	77	78
IOS-4	84	-0.1	47	77	86	85
SWD-5	64	-0.5	54	78	48	56
SED-6	56	-0.5	61	75	39	47

Data sources and reference points

(Appendix 1, 2 & 3 for metadata)

The following datasets were used for this sub-goal:

- *Seagrass extent* [1] *(1985-2015)*
- *Seagrass condition* [2] *and monitoring* [2] *(2012-2019)*
- *Saltmarsh/mudflats extent* [3] *(2013)*
- *Saltmarsh/mudflats condition* [4] *and monitoring* [4] *(2003-2016)*
- *Maerl extent* [5] *(2009)*
- *Maerl condition* [6] *(2013)*

Saltmarsh and mudflat condition data were sourced from Natural England's Designated Sites database. All habitat condition data were scaled 0-1 using a categorical rank where: favourable = 1, unfavourable recovering/unfavourable no change = 0.5 and unfavourable declining/destroyed = 0. Seagrass and maerl condition data were sourced on an ad hoc basis from Natural England survey reports. Appropriate survey data relating to seagrass health and extent were extracted from reports and standardised to a 0-1 scale. Monitoring data for saltmarsh/mudflats, seagrass and maerl were similarly scaled, where sites that had not been assessed for 6 years or more scored 0, and less than 6 years scored 1. A mean 'relative health score' for each site and habitat type was calculated from condition and monitoring scores. Site-specific scores were aggregated (mean) by habitat type to provide region-specific health scores by year. Region-specific habitat health scores were proportionalised by relevant area of habitat type to total habitat extent, summed and rescaled to 100 to give region-specific status scores (for seagrass, saltmarsh/mudflats and maerl combined).

Carbon Storage habitats were evaluated using a target reference point, with the target being a score of 1 (high). A 100% status score would indicate that regionally, all habitats are in 'favourable' condition and have been monitored within a 5-year timeframe.

Interpretation

Time series data of seagrass condition were unavailable for the majority of sites (Figure 45), with the exception of the Isles of Scilly where Project Seagrass and Natural England provided annual standardised surveys. Many regions lacked repeat assessments or standardisation of methods between surveys. Whilst seagrass sites within the Isles of Scilly had reliable, time series condition data, their geographic isolation made extrapolation to gap fill trend values for all South West regions difficult. A trend estimate, based on a literature review of regional and global seagrass studies, was therefore applied as a proxy. This estimate was derived from a single indicator value rather than annual status values as with other data. All regions with assessed seagrass habitat scored highly. These scores are however influenced by the monitoring metric, with all identified sites currently falling within the 6-year assessment window. These high monitoring rates do potentially mask the OHI+'s ability to detect declines in the actual condition of seagrass beds across the South West. For example, data from the Isles of Scilly suggest a recent decline in seagrass health. Leaf infection scores (used as an indicator of wasting disease) that contribute to the OHI+ condition score have more than doubled between 2014 and 2015 (Figure 45b, where 5 indicates high levels of infection and zero no infection recorded). In future iterations of the OHI+ excluding the monitoring metric could provide a clearer indicator of seagrass health if desired.

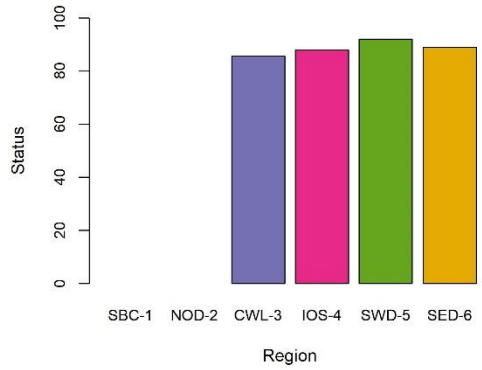


Figure 45a. Seagrass condition and monitoring status.

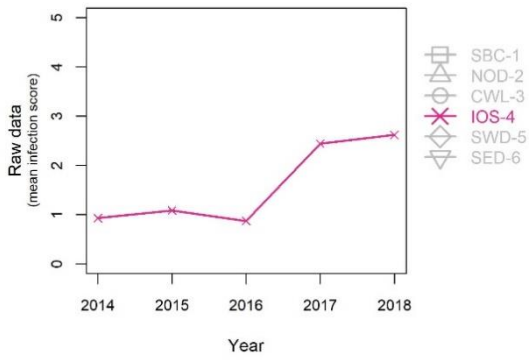


Figure 45b. Isles of Scilly (IOS-4) seagrass mean infection scores from annual surveys.

All regions show a negative trend for saltmarsh and mudflat status scores (Figure 46a). This was primarily driven by the lack of site monitoring in recent years (Figure 46b), as opposed to declines in condition. Without the monitoring metric all regions would have scored very highly, receiving status score of 80 or above, based on the current condition data ranking most sites as being in 'favorable' condition (Figure 46c). However, given the limited number of sites monitored since 2010 (Figure 46b),

the confidence in these assessments ranks is low. The Isles of Scilly have a small number of designated SSSI sites to sample from. Changes in the condition status of these sites are likely to have a more noticeable impact on status and trend than in other OHI South West regions, where changes to individual sites may be buffered. This caused the sharp negative trend between 2014 and 2015.

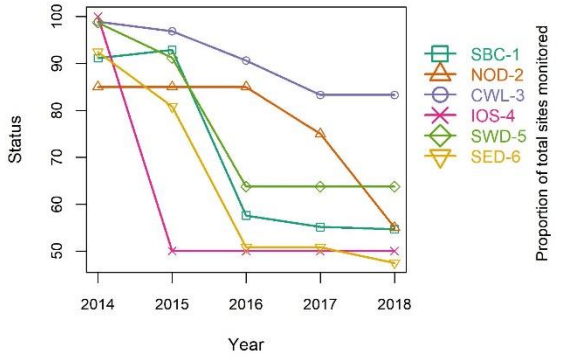


Figure 46a. Saltmarsh and mudflat condition and monitoring status.

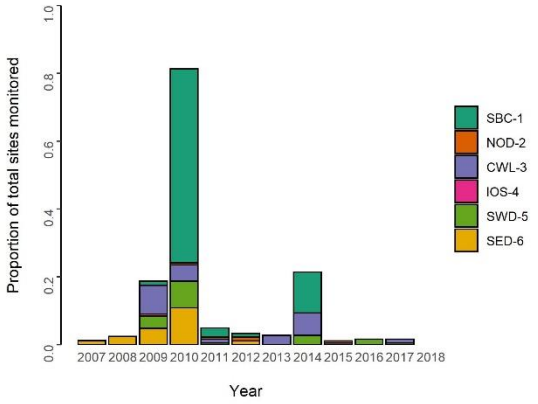


Figure 46b. Monitoring of SSSI saltmarsh and mudflat sites by year.

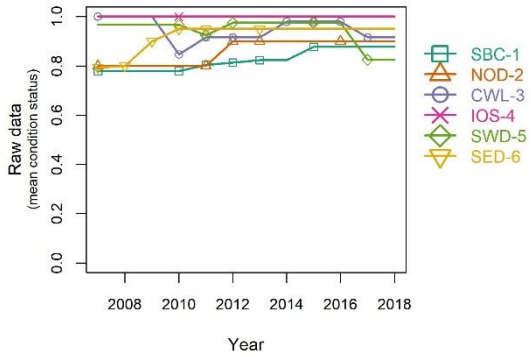


Figure 46c. Saltmarsh and mudflat condition (scaled 0 -1).

Maerl habitat is only recorded in Cornish waters. All other regions are assigned NA values with no impact on their goal scores (Figure 47). As with the seagrass data, maerl sites are generally lacking standardised time series data to apply as a trend. A similar method to that of seagrass was applied to derive a single indicator value from peer-reviewed and grey literature.

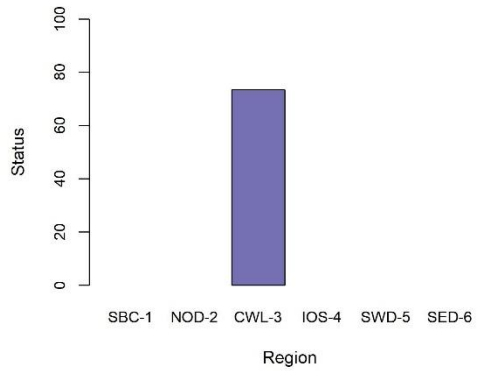


Figure 47. Maerl condition.

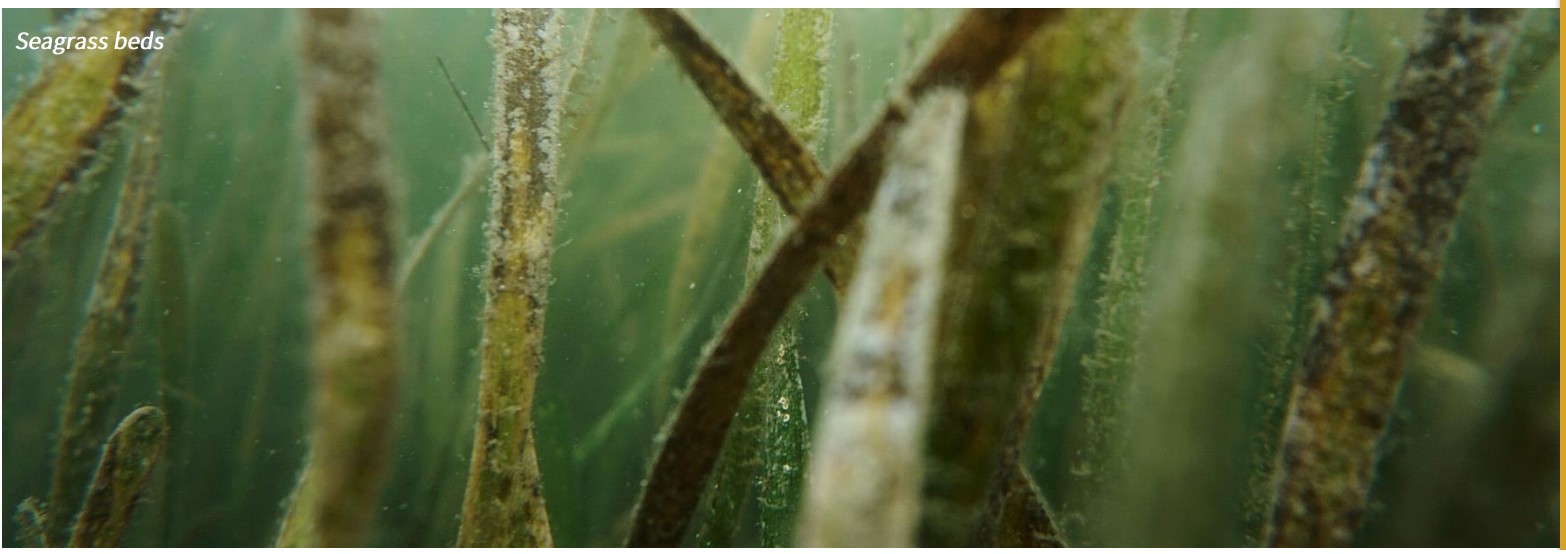
Recommendations and limitations

Natural carbon sequestration budgets are generally calculated by combining known sequestration rates (tonnes CO_2) of certain habitats by the total area (km^2). Ideally the Carbon Sequestration sub-goal would include a metric of this kind. This would allow inter-regional comparison of sequestration rates and track changes through time either due to habitat declines or restoration efforts. This metric would be reliant on fine-scale, regularly updated extent data, currently unavailable in the South West. Trend data on saltmarsh, mudflat, seagrass and maerl extent were either unavailable or lacked standardised survey methods. Whilst SSSI assessments (saltmarsh and mudflats) do account for declines in area, they do not provide data on rates of change (km^2). Recent seagrass and maerl surveys do provide more comprehensive understanding of habitat area but are yet to be conducted on a regular basis. Without regularly updated extent data and a historical baseline to compare against, measuring the fine-scale expansion or contraction of carbon sequestering habitats becomes impossible. In future, if standardised, repeat surveys providing comparable extent data becomes more available, the Carbon Storage sub-goal could benefit from further adaption in this manner.

The inclusion of renewable energy installations in the OHI South West was considered under the Carbon Storage sub-goal. Whilst the development of offshore wind facilities are not reliant on healthy ocean systems, they themselves can contribute to a net reduction of carbon emissions and the subsequent impacts in ocean warming, acidification and sea level rise. Presently, there are no sites in commercial operation in the South West England assessment area. Data on offshore renewable energy production could become an inclusion in future OHI South West iterations should sites be commissioned or if the OHI model were to be expanded to a UK level.

Kelp forests were also considered for inclusion in the Carbon Storage sub-goal, due to their prevalence around the South West and known carbon sequestration potential. Whilst extent data

exist for kelp habitat, condition data were lacking. Natural England condition reports were available for selected sites, however many lacked repeat assessments and there was high variation in survey coverage between OHI South West regions.



Seagrass beds

3.2. South West England OHI+ scores

Calculating OHI+ assessment scores

Region-specific goal scores were aggregated (using an equally weighted average) to provide a cumulative index score for each region. Where a goal comprised of sub-goals: Food Provision, Livelihoods and Economies, Designated Areas, Biodiversity, and Coastal Services, sub-goal scores were first aggregated using an unweighted mean (Livelihoods and Economies, Designated Areas, Biodiversity, and Coastal Services) or weighted mean (Food Provision). These region-specific outputs were then further aggregated (using a weighted mean) to provide overall goal scores and central index score for the South West England assessment area (Figure 48). Weights were derived from region-specific sea areas (km^2) from coast (mean high water) to 12 nm offshore. This enabled regions with more expansive marine spatial coverage to have greater leverage on the final overall OHI+ assessment scores.

Region-specific assessment scores

Aggregating region-specific goal scores (Figure 49) revealed that the highest scoring region was South West Devon (69 (sd 14.49)). Livelihoods and Economies (Economic Productivity), Artisanal Fisheries and Food Provision (Mariculture) all scored highly (> 90). The lowest cumulative index score occurred in the west of the region; Isles of Scilly (57 (sd 16.89)). The Isles of Scilly also had the greatest mean negative status score trend (-0.2 (sd 0.17)). Within the Isle of Scilly scores were greatest for Coastal Services (Coastal Protection and Carbon Storage) and Food Provision (Fisheries. The cumulative index score was negatively impacted by low goal scores for Designated Areas (Valued Landscapes and Ecological Features), Biodiversity (Habitats and Species), Livelihoods and Economies (Economic Productivity and Marine Wages and Jobs) and Artisanal Fisheries. The Severn Estuary and Bristol Channel, Cornwall, Isles of Scilly, South West and South East Devon all had mean negative status score trends (-0.15, -0.03 -0.2, -0.04 and -0.14 respectively). North Devon had a mean status score trend of zero. South East Devon had the greatest variance in aggregated goal scores (66.62 (min 18.9, max 85.92)), South West Devon had least variance in aggregated goal scores (44.74 (min 47.96, max 92.70)) (Appendix 11).

South West England assessment scores

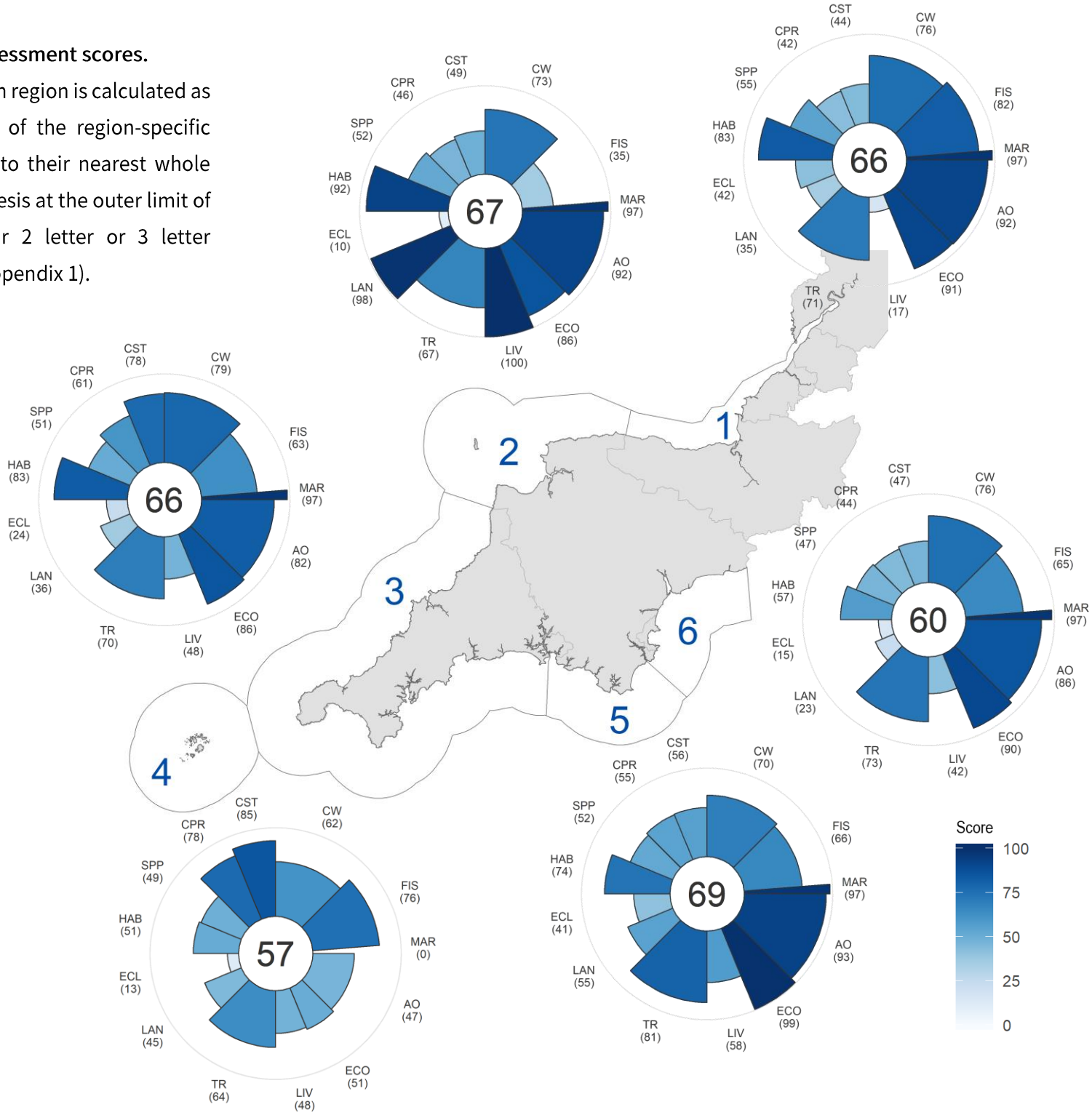
The highest scoring goals/sub goals for the South West England assessment (disregarding Mariculture) were, Economies and Livelihoods (Economic Productivity), Artisanal Fisheries and Biodiversity (Habitats), scoring: 82, 80 and 77, respectively. Lowest scoring were Designated Areas

(Ecological Features and Valued Landscapes), and Biodiversity (Species), scoring: 21, 49 and 51 respectively.

Figure 48. South West England assessment score. Overall goal scores and central index score for South West England. Individual goal/sub goal scores can range from 0 to 100. Scores, rounded to their nearest whole number, are shown in parenthesis at the outer limit of the petal together with their 2 letter or 3 letter goal/sub-goal acronym (see Appendix 1). The petal is shaded using a light to dark blue colour ramp as detailed in the figure legend. The overall goal scores and central index score for South West England are calculated as the area weighted average (mean) of region-specific outputs, weights are derived from region-specific sea areas (km^2) from coast (mean high water) to 12 nm offshore.

Figure 49. Region-specific assessment scores.

The central index score for each region is calculated as an equally weighted average of the region-specific goal scores. Scores, rounded to their nearest whole number, are shown in parenthesis at the outer limit of the petal together with their 2 letter or 3 letter goal/sub-goal acronym (see Appendix 1).



4. Regional summaries

4.1 Severn Estuary & Bristol Channel (SBC-1)

Summary

The Severn Estuary & Bristol Channel region (SBC-4; final score 66) was the equal third best performing region within the assessment (Figure 50a). The region showed relatively high variation from the South West central index for a variety of goals (Figure 50b). This likely reflects the region's distinct geography, ecology, population and settlements (large, clustered), and small marine area (903 km^2). The region scored notably highly for the Designated Areas: Ecological Features and Fisheries sub-goals, but poorly for Livelihoods and Carbon Storage (Table 15).

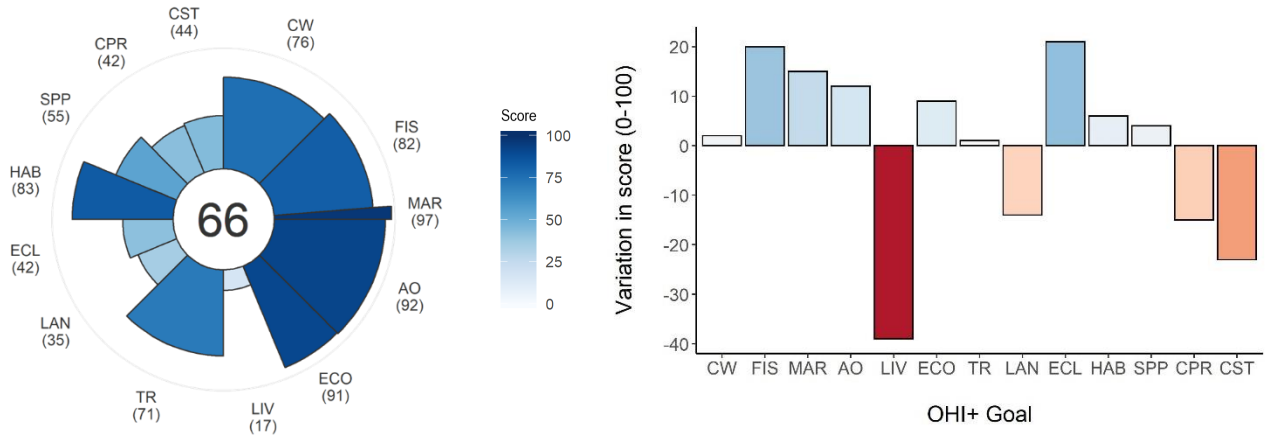


Figure 50a. Severn Estuary & Bristol Channel goal and central score and Figure 50b. variation from the South West OHI+ central index score by goal. CW (clean waters); FIS (fisheries), MAR (mariculture), AO (Artisanal Opportunities), ECO (Economy), LIV (Livelihoods), TR (Tourism), LAN (Landscapes), ECL (Ecological Features), HAB (Habitats), SPP (Species), CPR (Coastal Protection), CST (Carbon Storage).

High scoring goals and datasets

Designated Areas. The Severn Estuary scored 42 for Designated Areas: *Ecological Features* sub-goal (Table 15); twice that of the south west assessment area mean average. This high score was in part influenced by the region's small geographic area and the presence of the Severn Estuary SAC covering 51% of its marine area. This score contrasts with the *Landscapes* sub-goal, measuring designated areas for cultural and aesthetic reasons, which scored (35) lower than the South West average.

Fisheries. The Severn Estuary & Bristol Channel scored 82 for the Food Provision: Fisheries sub-goal. The region has limited fishing activity, with landings of 430 kg in 2018 comprised exclusively of crab

and European lobster (*Homarus gammarus*) stocks, considered relatively sustainable. As all landings were attributed to under ten-metre vessels the Artisanal Opportunities goal also received a high goal score.

Low scoring goals and datasets

Livelihoods & Economies. The Severn Estuary and Bristol Channel scored 17 for the Livelihoods sub-goal. The next lowest scoring region was South East Devon with 33, and a South West average of 56. The low score for the region is a result of wages in the region not increasing in line with the national Consumer Price Index (CPI) and coupled with a year-on-year decline in marine-related jobs (i.e. boat building and repair, fish processing). This decline was the largest decline of any region, with a 50% reduction between 2014 (n=182 jobs) and 2018 (n=90 jobs). Available data represent a best estimate of marine-related jobs from registered employees and certain marine industries (see Marine Wages & Jobs), so may not capture the entire workforce.

Coastal Systems. The region performed poorly for the Coastal Systems sub-goals (Table 15). No seagrass or maerl sites occur within the region's boundaries, making the *Carbon Storage* sub-goal a direct measure of SSSI designated saltmarsh and mudflats. As much of the region is estuarine it contains extensive habitats with high carbon sequestration value. This makes the region's low score for the Carbon Storage sub-goal concerning. Only 22% sites were monitored within the last six years (2013 - 2018) and almost 20% (20 of 102 sites) assessed as being in an unfavourable condition. Extensive monitoring of these sites was conducted in 2010 but since this time monitoring has been limited, with a maximum of 22 sites monitored in a single year (2014).

Recommendations and limitation

Given the importance and size (58 km^2) of the Severn Estuary's mudflat habitats, the lack of monitoring in recent years is cause for concern. The region's SSSI littoral sediment sites should be considered a priority for future monitoring and management. In future, OHI+ assesments involving a more hollistic measure of carbon sequestration would be benecifial. The Severn Estuary region would likely see a susbtantial increase in its status score if the sub-goal directly measured the carbon sequestration budgets of each region (combining known sequestration rates (tonnes CO_2) of habitats by the total area (km^2)).

The region had limited data to inform several goals including the *Artisanal Opportunities* goal and the *Food Provision: Fisheries* sub-goal. Data scarcity likely reflects the low level of fishing effort in the region rather than missing data. Limited landings (430 kg in 2018) were only recorded at a single port, Bridgewater, and only during certain years (2017 and 2018). These low levels of fishing activity need

acknowledging when comparing against other regions such as Cornwall which landed in excess of 18,600 tonnes.

Table 15. Severn Estuary & Bristol Channel best (green) and worst (red) performing goals compared to the OHI+ SW central index score.

GOAL	STATUS	TREND	PRESS.	RES.	FUTURE	SCORE	SW SCORE	DIFF.
Ecological Feat.	41	0	79	92	42	42	21	**21**
Fisheries	77	NA	38	76	87	82	62	**20**
Mariculture	94	1	81	81	100	97	82	**15**
Coastal Protection	54	-0.6	82	78	31	43	58	**-15**
Carbon Storage	55	-0.6	76	78	33	44	67	**-23**
Clean Waters	25	-1	57	69	9	17	56	**-39**

4.2 North Devon (NOD-2)

Summary

North Devon (NOD-2; score 67) was the second highest performing region in the assessment (Figure 51a). The region had the largest proportion of its inshore area designated for the conservation of sites with cultural, aesthetic or recreational value (Table 16). It was also the only region in the South West to experience an increase in marine-related jobs and wages in recent years (2014 to 2018). North Devon's fisheries were estimated to be the least sustainable of any OHI+ region (Figure 51b; score 35), due to landings dominated by species considered particularly vulnerable to over-exploitation.

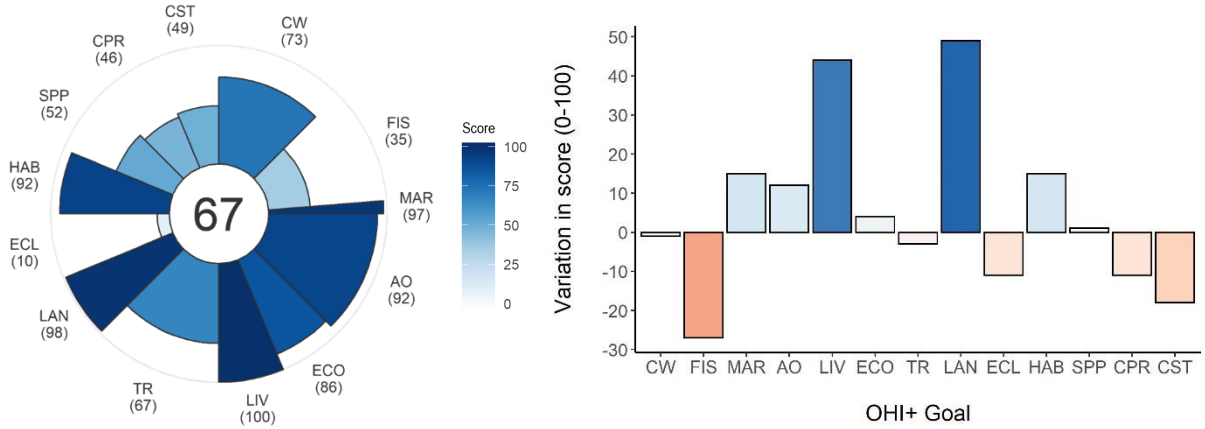


Figure 51a Severn Estuary & Bristol Channel goal and central score and Figure 51b variation from the South West OHI+ central index score by goal. CW (clean waters); FIS (fisheries), MAR (mariculture), AO (Artisanal Opportunities), ECO (Economy), LIV (Livelihoods), TR (Tourism), LAN (Landscapes), ECL (Ecological Features), HAB (Habitats), SPP (Species), CPR (Coastal Protection), CST (Carbon Storage).

High scoring goals and datasets

Landscapes. North Devon currently has approximately 96% of its inshore area (1 km inshore to 3 nm offshore) designation for the purpose of protecting areas valued for aesthetics, culture and recreation. This is primarily due to the North Devon Biosphere (142 km^2), which accounts for 94% of the inshore zone.

Habitats: North Devon scored highly (92) for the Habitats sub-goal. The region's soft and hard benthic habitats are estimated to have experienced some of the lowest disturbance from bottom towed gears (used as a proxy for condition) in the South West, averaging 0.44 and 0.017 fishing hours per km^2 per year respectively. However, this dataset only accounts for AIS instrumented vessels (required on vessels larger than 15 meters in length) and may exclude smaller vessels deploying bottom towed gears.

Livelihoods. North Devon is one of two regions in the South West estimated to have achieved a net increase in marine-related jobs (i.e. boat building, fish processing) by 2018, and the only region with wages increases that keep pace with the Consumer Price Index (CPI). This resulted in a maximum score of 100 for the Livelihoods sub-goal.

Low scoring goals and datasets

Fisheries. North Devon received the lowest OHI+ score for the *Fisheries* sub-goal (35). The region's landings were mostly limited to three stocks, with 81% of the 789 mt landed in 2018 dominated by whelks (*Buccinidae*), dogfish (*Squalidae*) or skate and ray species (*Rajiformes*). All three stocks are considered vulnerable to fishing pressure, either due to life-history traits (i.e. low reproductive rates) making them sensitive to overfishing or historical population declines, and therefore received a low sustainability ranking in the OHI+.

Carbon Storage . The Carbon Storage sub-goal scored (49) poorly for the region. No seagrass or maerl sites occur within the region's boundaries, making the sub-goal a direct measure of saltmarsh and mudflats. The region had four sites with littoral sediment as the main habitat type covering 11 km^2, with three in 'Favourable' condition and the remaining site categorised as 'Unfavourable, no change', although it was the smallest site by area (0.61 km^2). Only one of the region's Sites of Special Scientific Interest (SSSI) sites was recently surveyed (2015) to confirm these condition rankings, with the second largest by site by area, the Braunton Burrows SSSI, unassessed since 2006 (as of 2018).

Ecological Features. North Devon scored highly (98) for spatial designation of culturally important areas but was the worst-performing region for ecological designations, with just 7% coverage of the inshore zone (1 km inland and 12 nm) as of 2018. The region would benefit from the identification and designation of new ecologically important sites if appropriate.

Recommendations and limitation

Fisheries. The OHI+ would greatly benefit from an increase in B/BMSY (Biomass Maximum Sustainable Yield) assessments for commonly landed species. Over 90% of North Devon's 789 landed tonnes in 2018 had no BBMSY assessment available, making it heavily reliant on Marine Conservation Society Good Fish Guide recommendations. Although most regions had greater BBMSY coverage of stocks, the availability and standardisation of BBMSY metrics for all stocks would improve confidence and comparability in the Fisheries goal score.

Coastal Systems. North Devon's neighbouring region, the Severn Estuary and Bristol Channel (SEB-1), scored similarly (48 and 43) for the Coastal Systems goal. Both regions had some of the lowest

monitoring rates in the assessment. The South West's north coast should be considered a priority area for future survey efforts of important coastal habitats.

Table 16. North Devon best (green) and worst (red) performing goals compared to the OHI+ central Index score.

GOAL	STATUS	TREND	PRESS.	RES.	FUTURE	SCORE	SW SCORE	DIFF.
Landscapes	96	0	59	92	100	98	49	**49**
Livelihoods	100	0.3	54	42	100	100	56	**44**
Habitats	85	0.5	33	75	100	92	77	**15**
Ecological Feat.	7	1	48	92	13	10	21	**-11**
Carbon Storage	55	-0.4	46	75	45	49	67	**-18**
Fisheries	35	-0.2	24	71	36	35	62	**-27**

4.3 Cornwall (CWL-3)

Summary

Cornwall was the joint third highest performing region in the OHI+ assessment (66; Fig. 52a). Nine of fourteen assessed goals for Cornwall scored above the OHI+ South West central index score (Figure 52b). Cornwall has relatively healthy fisheries (63) and artisanal fishing opportunities (82), and intact coastal habitats (83). Cornwall was one of the only regions supporting coastal habitats providing carbon sequestration ecosystem services that scored above the assessment average and were subject to monitoring above the regional average frequency (75% sites monitored between 2013 and 2018). Cornwall scored poorly for the Landscapes sub-goal (36; Table 17), which measured total area designated to protect valued aesthetic, cultural and recreational landscapes. The stability and growth of the region's marine-related jobs and wages were below the South West assessment index score.

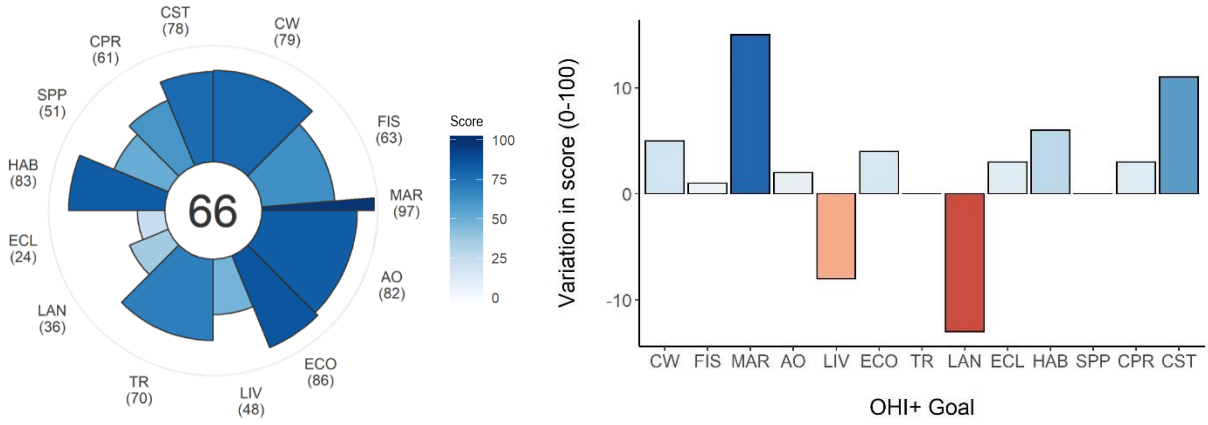


Figure 52a Cornwall goal and central score and Figure 52b variation from the South West OHI+ central index score by goal. CW (clean waters); FIS (fisheries), MAR (mariculture), AO (Artisanal Opportunities), ECO (Economy), LIV (Livelihoods), TR (Tourism), LAN (Landscapes), ECL (Ecological Features), HAB (Habitats), SPP (Species), CPR (Coastal Protection), CST (Carbon Storage).

High scoring goals and datasets

Carbon Storage. This sub-goal, measuring the condition, extent and monitoring of coastal habitats such as saltmarsh and mudflats that provide carbon sequestration services, was scored highly (78) for the region. Over 90% of assessed saltmarsh and mudflat habitats were considered to be in 'Favourable' status. Unlike most regions in the OHI+ assessment, 75% of these sites were surveyed at least once in the past six years (2013 - 2018).

Fisheries (FIS). The Fisheries sub-goal score for Cornwall (63) was above the South West average score (62). Landings in Cornwall (2018) were by far the largest of any of the assessment regions (>18,600 tonnes), making it a key region of interest for the sub-goal. While the score reveals scope for improvement, it shows Cornwall's landings were mostly comprised of stocks fished within (or at least close to) biological limits or were 'recommended' species by the Marine Conservation Society.

Low scoring goals and datasets

Landscapes (Designated Areas). The lowest score for Cornwall relative to the South West average was the Designated Areas: Landscapes sub-goal (Figure 52b; 36). The region has approximately 35% of its inshore area (1 km inshore to 3 nm offshore) designated for the purpose of protecting areas valued for aesthetic, cultural and recreational reasons. This is the third lowest proportion of total area of any OHI+ region. Cornwall is however the largest region in the assessment, with a coastal area of 2584 km2 and the longest coastline (1082 km using mean high water), so its total designated area of 898 km2 represents the largest actual area in the South West.

Livelihoods. Cornwall performed poorly compared to the South West average for the Livelihoods sub-goal (Table 17). Cornwall's marine-related jobs (e.g. boat building and repair, fish processing) are estimated to have peaked in 2015 (for years 2014 – 2018) and subsequently contracted by 4.4% as of 2018. This recent decline, coupled with the region's per capita mean annual wage increases in 2018 falling below the yearly mean Consumer Price Index (CPI) of 2.5%, resulted in the low score for the sub-goal.

Recommendations and limitation

Designated Areas. Cornwall scores below the South West average for designating culturally important sites (LAN), and above average (21) but below accepted policy targets (30% coverage) for areas protecting ecological features (ECL). The expansion of Cornwall's marine protected area network should therefore be considered.

Livelihoods. Despite recent (2015 – 2018) declines in marine-related jobs, the long-term trend reveals Cornwall's marine-related jobs remain 6% higher than 2010 levels. This decline should therefore be closely monitored but may not be an immediate cause for concern.

Biodiversity: Habitats. Given the general favourable condition and recent surveying (2013 - 2018) of Cornwall's saltmarsh and mudflat habitats, a shift in monitoring and restoration efforts to other habitat types may help to improve outcomes. Of the total coastal sand dune sites under SSSI designation in the region, only 24% are assessed as being in 'Favourable' condition and 29% monitored in the six year prior to the OHI+ assessment year (2018). Regular, standardised monitoring

of marine habitats (i.e. seagrass, maerl and kelp) would also be beneficial for building a more comprehensive picture of the state of Cornwall's sub-tidal habitats of key biodiversity importance.

Mariculture. The Mariculture sub-goal was hindered by a lack of data and the scores were considered a weak indicator of the state of the industry. Cornwall has the largest total area licensed for mariculture in the South West (>100 km^2 in 2019). As the industry develops and open-source production data become available, the OHI+ could be adapted to better understand the industry.

Table 17. Cornwall best (green) and worst (red) performing goals compared to the OHI+ central Index score.

GOAL	STATUS	TREND	PRESS.	RES.	FUTURE	SCORE	SW SCORE	DIFF.
Mariculture	94	1	83	81	100	97	82	**15**
Carbon Storage	79	-0.1	60	76	77	78	67	**11**
Habitats	83	0	69	76	83	83	77	**6**
Species	57	-0.3	82	77	44	51	51	**0**
Livelihoods	50	0	72	44	45	48	56	**-8**
Landscapes	35	0	68	92	37	36	49	**-13**

4.4 Isles of Scilly (IOS-4)

Summary

The Isles of Scilly (IOS-4) scored in 57 in in OHI+ assessment using data for the period 2014 - 2018 (Figure 53a). The Isles of Scilly achieved low scores for Mariculture, Artisanal Opportunities and Economies when compared to the South West average (Figure 53b). Three goals scored above the South West average (Figure 53b), including fisheries, coastal protection and coastal systems. The region experienced a decline in status for many datasets used during the assessment period, resulting in a low overall score. These low scores were in part driven by the within-region benchmarking approach adopted by the assessment.

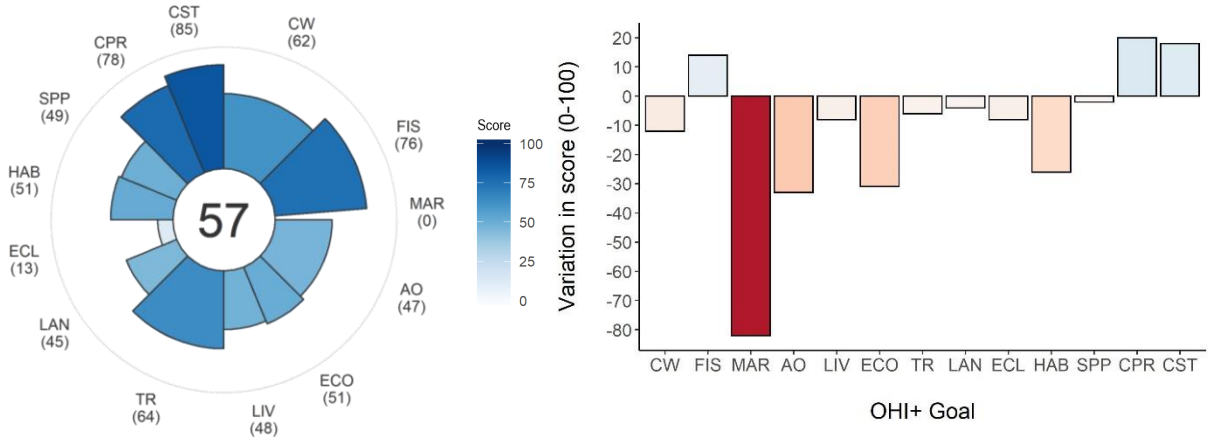


Figure 53a Isles of Scilly goal and central score and Figure 53b variation from the South West OHI+ central index score by goal. CW (clean waters); FIS (fisheries), MAR (mariculture), AO (Artisanal Opportunities), ECO (Economy), LIV (Livelihoods), TR (Tourism), LAN (Landscapes), ECL (Ecological Features), HAB (Habitats), SPP (Species), CPR (Coastal Protection), CST (Carbon Storage).

High scoring goals and datasets

Coastal Systems. The Isles of Scilly scored highly for both Coastal Systems sub-goals, which include habitats providing natural Coastal Protection (78) and Carbon Storage (85; Table 18). The Coastal Protection goal relies on habitat condition data relating to seagrass, sand dune and saltmarsh/mudflats, and implements a metric to penalise regions that fail to conduct regular (surveyed at least once every six years) monitoring of these habitats. The Isles of Scilly have a limited number of SSSI sites and small total area for sand dune and saltmarsh and mudflat habitat types. Despite their limited area, both dunes and littoral sediment habitats were assessed to be in favourable condition, although they have not been surveyed since 2012 or 2009 respectively. Seagrass in the Isles of Scilly is assessed as being in declining condition (increased levels of leaf infection), but when

combined with the monitoring metric achieves relatively high OHI+ status scores as they are one of the few sites across the South West to have interannual surveys.

Fisheries. The region was also the highest scoring (Table 18) for the Fisheries sub-goal (excluding the Severn Estuary region which recorded low or zero landings each year). The high score is attributed to the majority (97 of 107 tonnes) of landings in 2018 arising from lobster and crab stocks that are considered close to BBMSY or have Marine Conservation Society 'recommended' stock status. The region was also the only one to have a positive trend for fisheries, indicating landings were sustainable during the assessment period.

Low scoring goals and datasets

Mariculture. The lack of mariculture sites reflects the exposed and isolated nature of the islands, with no sheltered estuaries, which are often preferred for benthic shellfish aquaculture.

Economies and Artisanal Opportunities. Data informing the Economies sub-goal revealed a 37% decrease in per capita Gross Value Added (the value generated by any unit engaged in the production of goods and services) since 2012 and the Artisanal Opportunities 'landings to port' dataset a 60% decrease in the proportion of landings from under ten-metre vessels recorded as since 2014. The region experiences the largest share of its' landing from the under ten-metre fleet and the equal highest GVA per capita for marine related industries when compared to all other OHI+ regions. However, as the OHI+ currently measures a regions current status against its recent past to determine scores for these goals, declines during the reporting period result in low scores compared to regions that see stability or increases over time.

Recommendations and limitation

The Isles of Scilly was one of the top performing regions when interrogating source data on water clarity (suspended detrital matter), proportion of landings by under ten-metre vessels and trawl intensity over soft-bottom benthic habitats. However, these datasets experienced declines over the five years assessment period and as such the region scored poorly. Early iterations of the OHI+ explored using reference points that compared all regions' status against each other, with the best performing region becoming the benchmark (score of 100). Using this approach would result in the Isles of Scilly becoming the 3rd highest scoring region, with notable increases to certain goals (i.e. the Clean Waters increased from 62 to 88). These 'across region' reference points however have limitations (limited model sensitivity and potentially unconstructive comparisons across regions with distinct biogeography and socioeconomic characteristics). Tracking each region's performance over time was therefore considered preferable. The influence of benchmark reference points on OHI+

scores reveals the need for more defined management targets in the South West. This would aid clarity when designing effective management strategies and allow direct comparison between geographically distinct areas, likely resulting in higher OHI+ scores for the Isles of Scilly.

Table 18. Isles of Scilly best (green) and worst (red) performing goals compared to the OHI+ central Index score.

GOAL	STATUS	TREND	PRESS.	RES.	FUTURE	SCORE	SW SCORE	DIFF.
Coastal Protection	79	-0.2	54	77	76	78	58	**20**
Carbon Storage	84	-0.1	47	77	86	85	67	**18**
Fisheries	72	0.1	53	73	79	76	62	**14**
Economies	64	-0.5	81	58	38	51	82	**-31**
Artisanal Opp.	56	-0.5	76	71	38	47	80	**-33**
Mariculture	0	0	62	81	0	0	82	**-82**

4.5 South West Devon (SWD-5)

Summary

South West Devon (SWD-5) was the best performing region in the OHI+ assessment (69; Figure 54a). The region received high scores for Economies, Designated Areas: Ecological Features, Mariculture, Tourism & Recreation and Artisanal Opportunities. The region's coastal habitats providing carbon storage benefits (56) were the only area to fall noticeably below the South West average (67), however the other habitats based sub-goals also scored slightly below average.

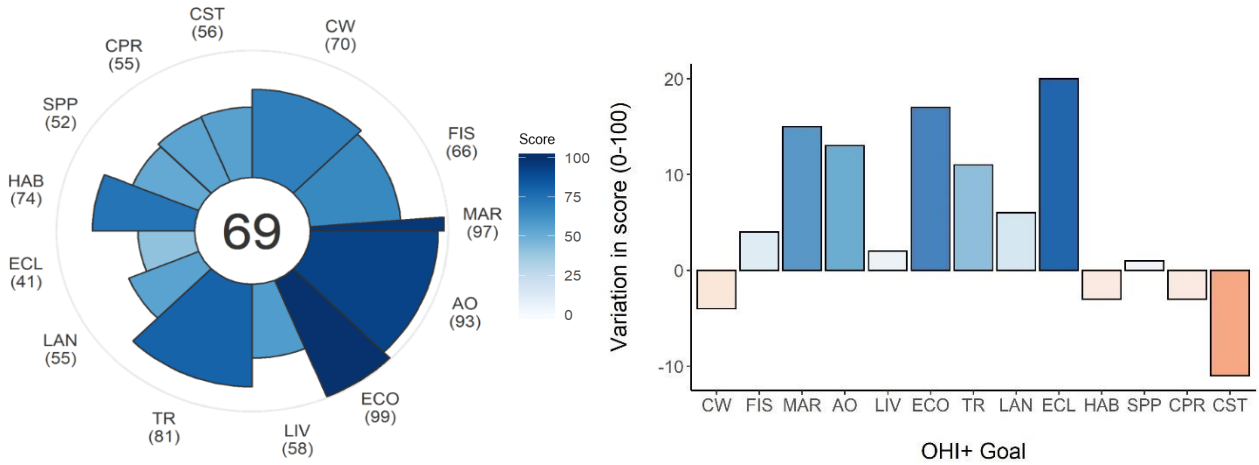


Figure 54a South West Devon goal and central score and Figure 54b variation from the South West OHI+ central index score by goal. CW (clean waters); FIS (fisheries), MAR (mariculture), AO (Artisanal Opportunities), ECO (Economy), LIV (Livelihoods), TR (Tourism), LAN (Landscapes), ECL (Ecological Features), HAB (Habitats), SPP (Species), CPR (Coastal Protection), CST (Carbon Storage).

High scoring goals and datasets

Ecological Features. A high proportion of coastal waters in South West Devon are designated for both cultural management and ecological conservation. With over 30% of the region's coastal area (1 km inshore to 12 nm offshore) within some form of relevant spatial designation, the Ecological Features sub-goal scored highly (41) compared to South West average (21). The score was influenced by two large sites; Start Point to Plymouth Sound and Eddystone SAC (249 km^2) and Skerries Bank and Surrounds MCZ (341 km^2). Further, a large proportion (53%) of the nearshore area (1 km inshore to 3 nm offshore) was also classified in this assessment as being designated for management for human enjoyment or cultural value.

Artisanal Opportunities. This goal captured the opportunities for small-scale fisheries, including the proportion of landings by under ten-metre vessels. The reference point for this dataset compares the region's current status against its recent (5 year) past due to a lack of suitable policy targets. The

region experienced a consistent increase in the proportional of fisheries catch from under-ten metre vessels since 2015, and as such scored highly. The region has the second lowest raw proportional catch attributed to the under ten fleet (2018; 19.1% of landings).

Economies . South West Devon was the only region to record stable Gross Value Added (GVA) per capita for marine-related industries (2011–2015). As such, economic productivity did not appear to follow the general negative trend for the South West (mean -6.7% decrease per year for other regions).

Low scoring goals and datasets

Carbon Storage. This sub-goal scored poorly for the region as less than half of SSSI sites identifying saltmarsh and mudflats as a designated feature were monitored within the last six years (as of 2018). Saltmarsh and mudflats within the Yealm Estuary SSSI were reported as being in particularly poor condition. Sites within the Tamar-Tavy and Salcombe to Kingsbridge Estuaries were assessed as more 'Favourable'.

Clean Waters. This goal score was negatively impacted by an increase in water pollution associated with high vessel density. The region experienced the highest density of vessels (tracked by the global AIS system) of any South West UK region for four of five years of the assessment period (2014 -2018), with a peak weekly mean 1500 vessels per 4 km^2 in 2018. Most other regions in the assessment experienced approximately 500 per 4 km^2 per week.

Recommendations and limitation

Ecological Features. At present the OHI+ doesn't measure effectiveness or monitoring of marine protected areas due to a lack of data. There is a pressing need to develop a standardised and repeatable monitoring framework to measure the effectiveness of marine protected areas in the South West. This would provide future OHI+ assessments with a more robust measure of how regions utilise spatial management for marine conservation.

Biodiversity: Habitats. A proxy of bottom towed fishing pressure was applied for the Habitats sub-goal due to the lack of survey data on benthic habitat condition. Without survey data to assess condition status (i.e. Favourable, Unfavourable), benthic condition was assessed relative to a region's past performance, with regions recording declines in trawl intensity receiving higher scores that those with increases. This method benefited South West Devon due to a decline in trawling over soft benthos between a maximum observed in 2016 and 2018. This metric however fails to account for South West Devon having some of the highest trawl intensity over its soft benthic habitats, with 10 hours effort per km^2 in 2018. Comparatively, the Isles of Scilly, with an average of 3 hours per km^2, recorded increases in trawling and was the lowest scoring region for soft benthic habitats. Collection of survey

data at index or reference sites should be prioritised to provide a more detailed understanding of the condition of important benthic habitats and would improve certainty in the OHI+ scores for the Biodiversity: Habitats goal.

Table 19. South West Devon best (green) and worst (red) performing goals compared to the OHI+ central Index score.

GOAL	STATUS	TREND	PRESS.	RES.	FUTURE	SCORE	SW SCORE	DIFF.
Ecological Feat.	30	1	79	92	52	41	21	**20**
Economies	98	0	41	58	100	99	82	**17**
Mariculture	94	1	81	81	100	97	82	**15**
Coastal Protection	64	-0.5	65	78	46	55	58	**-3**
Clean Waters	73	-0.1	100	92	66	70	74	**-4**
Carbon Storage	64	-0.5	54	78	48	56	67	**-11**

4.6 South East Devon (SED-6)

Summary

South East Devon was the lowest scoring mainland region in the OHI+ assessment (60; Figure 55a). The region scored below the South West main index for seven of 13 goals/sub-goals, notably Designated Areas, Biodiversity: Habitats, Carbon Storage and Coastal Protection. Aside from the Mariculture sub-goal, which was limited by data availability and has a minimal contribution the central score, the region scored marginally above the South West average for Economies, Clean Waters, Tourism and Recreation and Artisanal Opportunities a (Figure 55b).

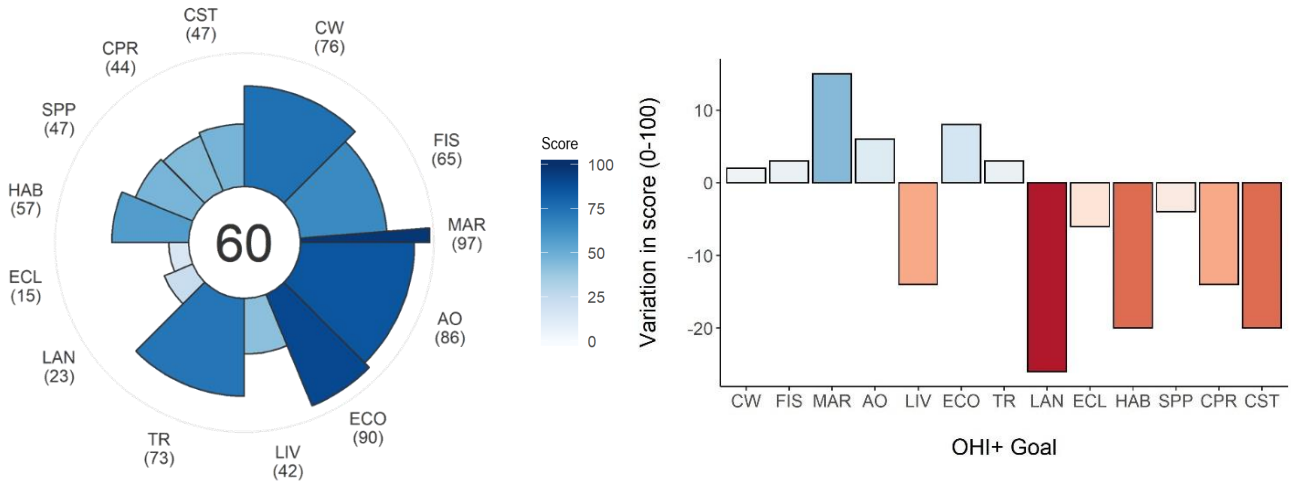


Figure 55a South East Devon goal and central score and Figure 55b variation from the South West OHI+ central index score by goal. CW (clean waters); FIS (fisheries), MAR (mariculture), AO (Artisanal Opportunities), ECO (Economy), LIV (Livelihoods), TR (Tourism), LAN (Landscapes), ECL (Ecological Features), HAB (Habitats), SPP (Species), CPR (Coastal Protection), CST (Carbon Storage).

High scoring goals and datasets

Artisanal Opportunities. This goal (86) scored above the South West average (Figure 55b), due to increases in the Catch Per Unit Effort (CPUE) of under ten-meter vessels between 2012 and 2016. The AO goal uses a 'within-region' benchmark; assessing the region's current status against its recent past performance. While improvements have occurred within the region, CPUE (0.07 tonnes per kilowatt day fished ('days at sea multiplied by engine power to give a total of kilowatt (KW) days of effort')) was the lowest across the assessment area and the region reported the lowest proportion of landings from the under ten vessels (8.9% of total catch) in 2018 when compared to other regions.

Tourism & Recreation. South East Devon experienced the highest visitor density of any region, resulting in an above average Tourism & Recreation goal score. This goal was, however, reliant on data

from 2014 due to limited data availability. The calculated score may not represent more recent patterns.

Mariculture. South East Devon's Mariculture sub-goal score was greater than the assessment average for south west England. The region has the third largest total area (34 km^2) licensed for mariculture production as of 2018. However, this goal experienced problems of limited data availability due to the small number of producers that means production data are not disaggregated by region.

Low scoring goals and datasets

Landscapes. South East Devon received particularly low scores for this goal, with only 11% of its inshore area designated for ecological protection and 22% for cultural, aesthetic or recreational purposes. Comparatively, neighbouring South West Devon is one of the better performing regions for these sub-goals, with 30% and 53% respectively.

Biodiversity: Habitats. Whilst the region's mudflats and saltmarsh are all considered to be in favourable or recovering condition, it has the poorest monitoring rates in the OHI+ assessment. As of 2018, none of the region's littoral or supralittoral sediment SSSI units had been assessed within six years, with several surveys 10 years old. Lack of timely monitoring reduces the certainty in the favourable condition assessments and the region consequently received reduced scores. South East Devon's soft benthic habitats also received low scores as the region is estimated to experience some of the highest levels of disturbance from bottom towed fishing gears in the assessment area. Trawl intensity, calculated from Global Fishing Watch data, increased from an average of 3 fishing hours per km^2 in 2014 rising to 8.9 hours per km^2 in 2018.

Recommendations and limitation

Fisheries: The OHI+ would greatly benefit from an increase in maximum sustainable yield (BBMSY) assessments for commonly landed species. Over 60% of South East Devon's 14,000 landed tonnes of seafood in 2018 came from species that had no BBMSY assessment available, making assessment of landings more reliant on sustainability criteria from the Marine Conservation Society. Although landings for most regions were comprised of a greater proportion of fish species with BBMSY assessments, the availability and standardisation of BBMSY metrics for an increasing number of stocks would improve confidence and comparability in the Fisheries goal score. These assessments could better assist management of Devon's biological stocks, including scallop species (king scallop (*Pecten maximus*), queen scallop (*Aequipecten opercularis*)) and common cuttlefish (*Sepia officinalis*), which represented 32% of the region's landings in 2018.

Designated Areas. South East Devon would benefit from the expansion of its network of protected areas to address the low coverage of 11%. The current extent of protected areas in South West Devon, which is greater (30%), may have been prioritised in Devon due to more conspicuous distribution of vulnerable habitats or species. However, improvements in coverage in SE Devon could help the management of seagrass sites, as well as saltmarsh and mudflats habitats that support rare wading and migratory birds and RAMSAR sites. These sites should be considered a priority for increased monitoring, with the region's SSSI littoral sediment sites not having been surveyed for over eight years (mean= 8.3 ±sd 0.92 years as of 2018).

Table 20. South East Devon best (green) and worst (red) performing goals compared to the OHI+ central Index score.

GOAL	STATUS	TREND	PRESS.	RES.	FUTURE	SCORE	SW SCORE	DIFF.
Mariculture	94	1	81	81	100	97	82	15
Economies	92	-0.1	49	49	89	90	82	8
Artisanal Opp.	83	-0.1	39	70	88	86	80	6
Habitats	66	-0.4	68	75	49	57	77	-20
Carbon Storage	56	-0.5	61	75	39	47	67	-20
Landscapes	22	0	68	92	24	23	49	-26

5. OHI+ and marine management

Mapping management policy against OHI+ goals

To evaluate the potential use of the OHI+ as a tool to assess progress of the UK Marine Management Organisation's (MMO) South West Marine Plan (SWMP) area, we examined the correspondence between OHI+ goals and SWMP policy statements.

The SWMP is an example of a marine spatial planning initiative that seeks to develop a holistic approach to marine management, encompassing all relevant economic, social and environmental aspects of our oceans. The development of policy statements underpinning the SWMP has included stakeholder involvement through a series of workshops enabling incorporation of local priorities (see: https://www.gov.uk/government/collections/south-west-marine-plan for details and summaries of each engagement iteration). By evaluating the OHI+ against SWMP's policies, we were able to ensure the OHI+ contains indicator data that are comprehensive and relevant.

OHI+ datasets were assessed against MMO SWMP draft policy statements (https://www.gov.uk/government/publications/marine-planning-iteration-3-engagement-for-the-north-east-north-west-south-east-and-south-west-marine-plan-areas), using version 3, the most recent available at the time of writing. The policy mapping exercise was validated by our project Steering Group, which comprised organisations with regionally relevant expertise, that were either data custodians or had mandates relevant to the successful delivery of the SWMP.

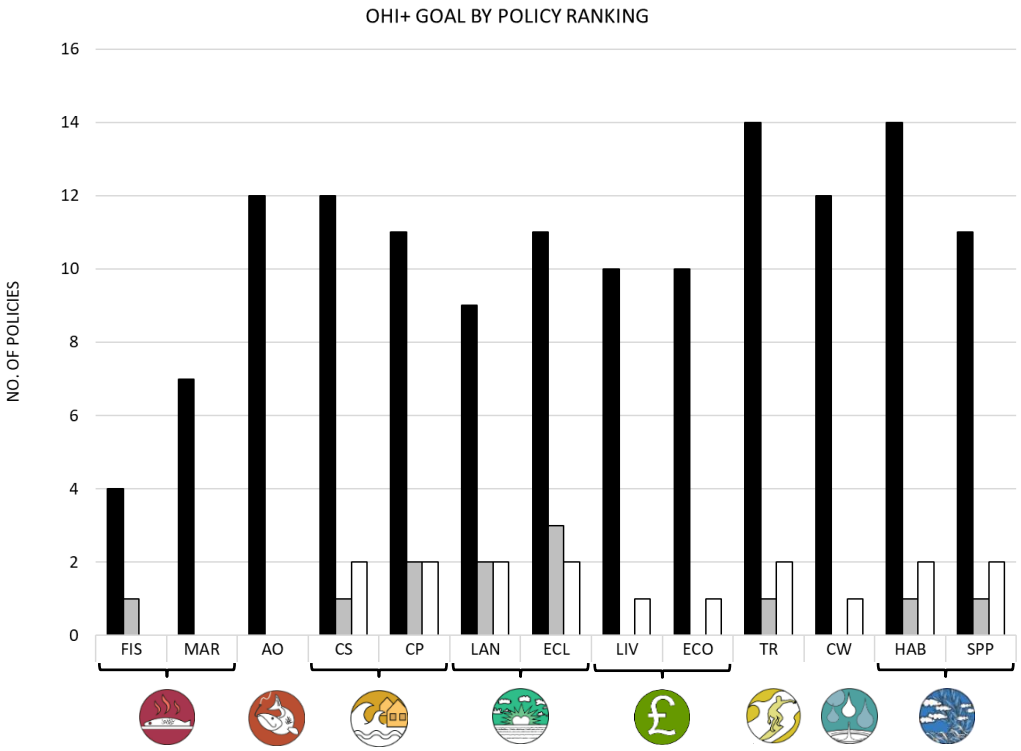
The SWMP draft document contained 74 policy statements, categorised into Environment (n = 33), Social (n = 19) and Economic (n = 22) sub-groups. Prior to this exercise, each policy statement was read and specific 'topic areas' identified (Appendix 12). Topic areas were highlighted if they contained key phrases, explicitly mentioning social, economic and environmental considerations (i.e. prominent industries, infrastructure, recreational activities, cultural considerations, threats, legislation, conventions, ecosystem services, habitats, species) relevant to the policy's objectives.

Each policy statement was assessed against the OHI+ using a decision tree to examine the capacity of the OHI+ assessment to reflect the breadth of issues covered in the SWMP (Appendix 13). Each statement was categorised based on how topic areas in the policy statements were explicitly represented by the data underpinning each of the goals, sub-goals, or pressures. Policies were categorised based on the following criteria:

- High: the majority of topic areas in the statement correspond explicitly to one or more OHI+ goal datasets AND the data were deemed an effective indicator of any future change in status to those topic areas.
- Medium: the majority of topic areas in the statement correspond to one or more OHI+ goal datasets BUT the data were deemed only moderately effective as an indicator of any future change to those topic areas.
- Low: only a minority of topic areas in the statement correspond to one or more OHI+ goal datasets OR if a policy statement did not correspond to any of the goal datasets but corresponded to one or more OHI+ pressure layer. Pressure data have a limited contribution to the OHI+ score calculations (8.25%) so any policies linked exclusively to pressure data were classed as 'low'.
- None: no topic areas in the statement corresponded to the goal datasets or pressure layers.

How well do OHI+ goals capture SWMP policy areas?

The extent to which the OHI+ assessment captures areas of relevance to the SWMP was assessed by counting the number of policy statements that were considered to be of 'high', 'medium' or 'low' relevance to each goal or sub-goal (Figure 56). This exercise recognised that each policy statement may be relevant to more than one OHI+ goal. There was a high level of commonality, with the majority of policy statements categorised as High. The mean number of policy statements categorised as 'high' for each goal or sub-goal was 10. Contributions to 'medium' and 'low' categorised policy statements were generally spread among goals with no clear outliers from a mean of 1 'medium' and 2 'low' contributions per goal or sub-goal.



	FIS	MAR	AO	CS	CP	LAN	ECL	LIV	ECO	TR	CW	HAB	SPP
High	4	7	12	12	11	9	11	10	10	14	12	14	11
Medium	1	0	0	1	2	2	3	0	0	1	0	1	1
Low	0	0	0	2	2	2	2	1	1	2	1	2	2

Figure 56. South West England OHI+ goal relevance to SWMP policies. Bar graph depicts the number of times a South West England OHI+ goal or sub-goal was categorised as 'high', 'medium', 'low' or 'none' against a SWMP policy.

Aggregating sub-goals together would produce contrasting results (e.g. the Biodiversity goal would become the top performing element of the OHI+ model with 23 'high' ranks). However, as sub-goal scores are averaged to produce the total goal score, it is more representative to view sub-goals independently.

The Tourism and Recreation goal and Biodiversity Habitats sub-goal both performed strongly in reflecting the policy statements of the SWMP, each relevant to 14 SWMP policies considered to be well represented in the OHI+ South West England assessment. The diverse range of habitats included in the Habitats sub-goal results in strong links to a wide variety of SWMP policy statements. These habitats support species, providing ecosystem services and are hotspots for recreational activities and designated areas. Similarly, Tourism and Recreation is associated with a variety of social and economic policies, so this goal performs well in the policy mapping. The Wild Caught Fisheries and

Mariculture sub-goals (together forming the Food Provision goal) contributed to the fewest 'high' rankings (4 and 7 respectively). Aside from spatial measures restricting fishing activity, fisheries management is generally considered outside the remit of UK marine spatial planning. As a result, the Fisheries sub-goal had limited links to SWMP policy statements. Whilst mariculture is often referenced in MMO policies, data availability meant the sub-goal's scope is currently limited to a coarse production metric. If available in the future, data on access and infrastructure (processing facilities, transport links, supply chains) would enable greater relevance of this goal to the SWMP. An access metric would also see improvements for the Artisanal Opportunities goal and further improve the Tourism and Recreation goal performance in the policy mapping since numerous policy statements note the importance of developing and maintaining coastal access points for both economic and recreational activities.

Relevance of SWMP policies to the South West England OHI+ assessment

Of the 74 SWMP policy statements, 35 were considered to have 'high' relevance to the OHI+ South West assessment model. Seven policy statements were moderately relevant ('medium'), 14 policy statements had 'low' representation and 18 did not overlap with any aspects of the OHI+ model framework. Given the lack of clear policies or priorities within marine plan policies, this is metric is considered the best available to evaluate them in a meaningful way at this time.

Of the 18 policy statements that had no link either to OHI+ goal datasets or pressure layers, 16 were in the MMO Economy category (Figure 571). This likely reflects the OHI+ focus on sustainable and renewable resources, rather than finite resources (aggregates) or activities that are independent of well management ocean (cable laying). The remain two policy statements with no discernible relationship to OHI+ data were both in the Society category. One of these was SW-DEF-1, relating to naval operations, and the other SW-GOV-1 relating to the selecting of dredge disposal sites, neither of which fall under the remit of the OHI in its current form.

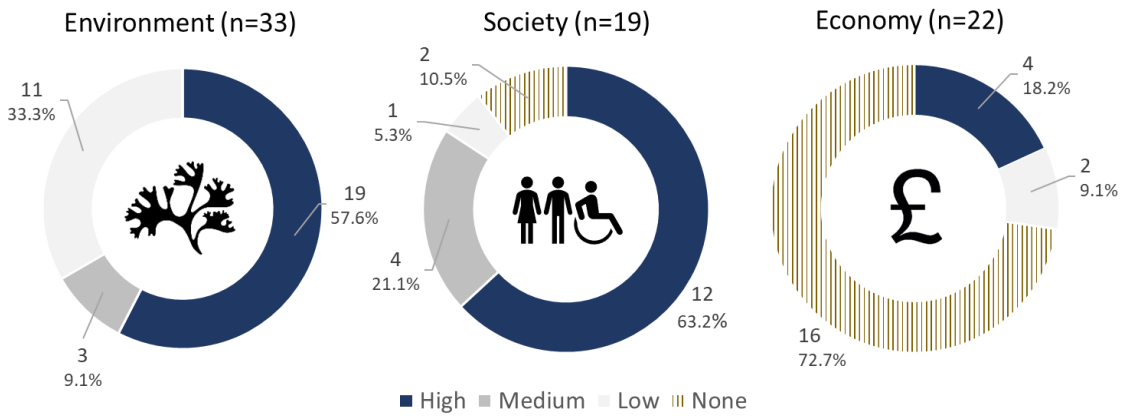


Figure 57. SWMP policy relevance to OHI+ datasets. Ring plots depict the number of SWMP policies were categorised as 'high', 'medium', 'low' and 'none' against South West England OHI+ assessment.

Both the Society and Environment categories had > 50% of their policies categorised as 'high', reflecting the OHI+ strength as a tool measuring the benefits society receives from a healthy ocean (i.e. ecosystem services, sustainable fisheries, clean beaches). Very few policies were categorised as 'medium' (n = 5). Of the 14 polices categorised as 'low', seven were represented in OHI+ goal data, but only to a limited extent. Some of these policies are unlikely to ever be directly measured in future OHI assessments due to their specific nature or the feasibility of collecting relevant data. SW-HAB-1, relating to deep sea habitats, is one such example. These deep-sea habitats are only present in the offshore zone of Cornwall (CWL-3), and the likelihood of comprehensive, time series condition data becoming available is unlikely. However, others could be targeted for more direct inclusion through the introduction of new datasets to OHI goals when reliable data become available. The remaining eight 'low' categorised policies were linked to pressures data only. Many of these policies should be reviewed when conducting any future OHI+ South West assessments. For example, policies including SW-CC-6, relating to carbon dioxide concentrations in seawater, could become direct metrics in the clean waters goal if reliable, time series data covering the entire South West England assessment area becomes available.

6. Discussion

What does the OHI+ assessment tell us?

We have established a baseline understanding of marine health and sustainable activity in the South West. By tailoring the global OHI indicator index metric, we quantitatively measured the benefits and services the South West waters provide and assess progress towards their sustainable management. Synthesising data on multiple socioeconomic and ecological variables into a standardised scoring system facilitates easy comparison of disparate datasets that are often viewed in isolation or only at small spatial scales. Whilst data gaps and challenges remain, the OHI+ has been successfully adapted from the global model and has the potential for replication in the future to track changes through time. Here we focus on key considerations arising from our results.

The first regional assessment using the OHI methodology in UK waters indicate that marine species, jobs, habitats providing coastal protection and protected areas all had comparatively low scores and should be prioritised for research and management (Figure 48). Conversely, the South West is assessed to have relatively clean waters, with many habitats in reasonable condition, high economic productivity and stable small-scale fisheries at the time of assessment in 2019. Certain regions achieved higher scores than others (Figure 49), with South West Devon (SWD-5) scoring particularly highly and the Isles of Scilly lowest. All regions however have potential to make considerable progress towards improved management of their marine environment to maximise the benefits they provide. A lack of transparent and repeatable marine habitat condition assessments, and supporting data-repositories, often hinder local management and reporting efforts. The results of this study have already informed reporting by local and regional stakeholder groups. This reflects the OHI+'s value in informing local management. The policy mapping exercise illustrates the high potential for the adapted OHI+ to contribute to measuring progress against policy targets. Whilst the OHI+ model was not designed to directly assess the South West Marine Plan; it provides a relevant management framework to compare the OHI+ model against, with all goals ranked as being highly matched to 11 or more policy statements.

Interpreting OHI+ scores

Whilst incorporating localised datasets is an important component of OHI+ assessments, the interpretation and use of data, and use of regionally and locally relevant reference points, have a major influence on OHI+ scores. The lack of defined quantitative targets relating to marine management in the South West proved challenging. In the absence of policy targets, within region comparisons (benchmarks) using a five-year time window were applied to compare a region's current performance against its recent past for several goals (see section 4 for details on setting reference points). Inter-regional comparison was also considered, where a maximum goal score of 100 would represent the top performing region, but comparing regions with distinct biogeography and socioeconomic priorities was considered inappropriate (e.g. direct comparison of the marine wages and employment levels between the Bristol Channel and Isles of Scilly). Whilst within-region benchmarks provided a useful measure in the absence of defined management targets and allows individual regions to assess their progress over time, the interpretation of scores can be complex. Regions with improvements in goal status over the five-year window will inevitably score highly, whilst regions that display declines in status will score poorly. Regions with lower status value in 2018 could therefore receive low OHI+ scores, even if they outperformed other regions in the raw data. Scores are therefore relative to each region's past performance but do not reflect their current performance in comparison to other regions. For example, a region whose status value has declined over time could have a lower OHI+ score than other regions, even if their most recent status outperformed those regions. The low total score for the Isles of Scilly is likely influenced in this manner for multiple goals. Acknowledging these caveats is important and exploring the trends in raw data for low scoring regions is necessary.

This interpretation issue is particularly relevant to the scores of two regions: the Severn Estuary and Bristol Channel (SBC-1) and the Isles of Scilly (IoS-4). The Isles of Scilly received the lowest score (57) of any region in the assessment. It was also the lowest scoring region in four of the five goal/sub goals (Mariculture, Artisanal Fishing Opportunity, Tourism and Recreation, Livelihoods and Economies) that used a within region benchmark. Comparatively, it received scores close to or above the regional average for the six goal/sub goals (Fisheries, Carbon Storage, Coastal Protection, Ecologically Designated Areas, Landscape Designated Areas and Species) that used a target reference point (Clean Waters and Habitats used a combination of targets and benchmarks due to data constraints).

Taking the Artisanal Opportunities goal as an example, we can see that the Isles of Scilly reveals a decline in landings and CPUE by its under ten-metre fleet in the last five years. These declines result in a low score of 47. However, it remains the most significant contribution by the small-scale fleet of

any region of any in the South West study area, with nearly 40% (Figure 17b) of its landings coming from under ten-metre vessels, compared to the regional average of 16% (excluding the Severn Estuary and Bristol Channel which has few active ports and no large vessels). Using an across-region reference point for 2018 data, the Isles of Scilly would have been the second ranked region for under ten-metre landings and would be among the top three regions for CPUE. Conversely, the Severn Estuary and Bristol Channel is the highest scoring region for these datasets, yet only has one active home port with just 0.43 tonnes landed in 2018. As the region's fleet is entirely comprised of under ten-metre vessels with a stable CPUE value, it scores very highly under the reference points which reward stability, regardless of raw data values. This example demonstrates the difficultly in comparing regions using a within-region benchmark reference point. The development of quantitative, achievable management targets in the South West is recommended to help managers set objectives, track trends and assess performance. For many of the goals, establishing policy targets is challenging and requires consideration of the potential synergies or trade-offs between different goals. For example, establishing the desired contribution of under ten-metre vessels in South West fisheries, the levels of tourism that are both socially and environmentally sustainable or to what extent should further development of mariculture be promoted. The OHI+ assessment serves as a basis for promoting dialogue and deliberation around these issues.

Adapting the global OHI to the local South West OHI+

Independent OHI+ assessments rely on the same model framework as the global assessment but allow for adaptation of data, goals and reference points to reflect local policy and management priorities. Goals can be localised using higher resolution data, alternative indicators and targets which produce scores better reflecting local realities. These assessments can therefore provide policy makers with relevant information on progress towards local management priorities at the spatial scale where decisions are made.

It is important to note that direct comparison between different OHI assessments is inappropriate as they may include different goals, rely on different data and set different reference points. However, qualitative comparison is possible if these caveats are correctly acknowledged. Applying the original datasets from the global assessment (2018), spatially cropped to the South West study area, we can see how local adaptations to the model impact OHI outputs. The central index score of 65 out of 100 for South West England OHI+ model is far lower than the 75 achieved using the global methods and datasets (Figure 58). This variation was even more prominent for some individual goals. Variation in goal and central index scores between the Global and South West assessments reveals the benefit of incorporating local datasets and setting regionally relevant reference points. Understanding of the

local context and data also resulted in the incorporation of that additional checks that may have lowered the scores (e.g. the monitoring frequency of habitats). Whilst the core OHI framework has been retained, the scores presented in this study more accurately reflect the specific circumstances of the South West and better identify areas for targeted management than would be possible using the global model.

Challenges with sourcing region-specific data and data gaps

Whilst regular time-series data covering the entire South West assessment area were available for many goals, some data gaps and methodological constraints were identified. Certain goals, such as the Clean Waters goals, were data-rich with additional dataset available for inclusion if desired. Other goals lacked suitable data or data were difficult to attribute to regions. Data-poor goals would benefit from increased monitoring and tailored data collection in the future. The full recommendations and limitations of each goal are detailed in section 4.

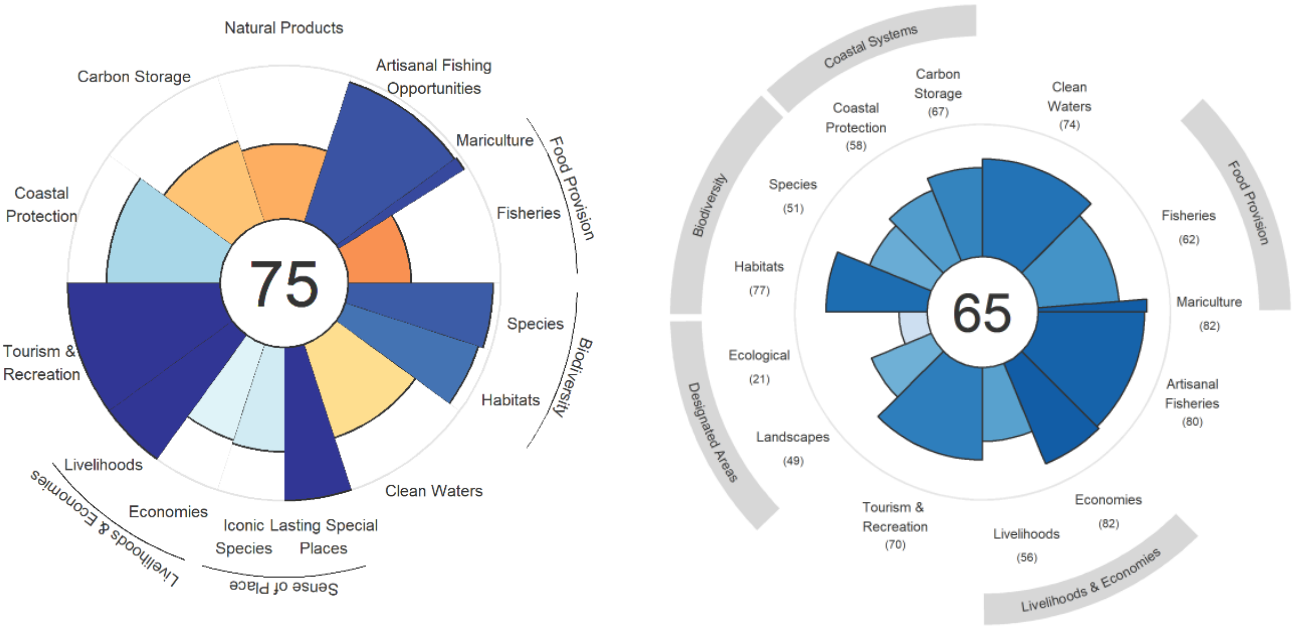


Figure 58. Comparison of overall goal scores and central index scores for South West England. (A) Global data and methods and (B) OHI+ SW data and methods (note different symbology used for each assessment).

The OHI framework relies on existing, open-source data, rather than the collection of new data to specifically inform goals. Data gaps identified during the assessment can therefore help identify specific goals or regions requiring improved data-collection in the future. Time-series data at a region

level were available for most OHI+ goals in the South West. The OHI+ study used local (local, SW regional, National or <European level) data for 89% of the 56 goal status data layers examined, with only 6 data layers drawn from global OHI data. Region specific data were available for all goals, except for two datasets under the Clean Waters goal and the Livelihoods and Economies: Marine Wages & Job sub-goal for the Isles of Scilly (IoS-4) region, where Cornish data had to be used as a 'nearest neighbor' proxy.

Despite this, several areas lacking comprehensive data were identified. Goals relating to developing industries, including the global natural products goal and mariculture sub-goal, were notably data poor. This was partly due to data privacy laws preventing the open-source publication of data below a national or South West regional level. As these industries develop, region specific time series data should become available for future OHI+ South West assessments. The assessment would also benefit from a wider variety of marine social science data being incorporated. For example, the social and cultural benefits of South West fisheries, notably the small-scale fleet, are rarely monitored. Key marine social science research themes have already been identified for the sector, including issues of access and equity relating to marine and coastal resources (McKinley et al., 2020). Regular time series social data covering these topics would all greatly enhance the Artisanal Opportunities and other OHI+ goals, providing a more holistic OHI+ assessment. Goals covering marine habitats and species were also found to lack regular, standardised data. Whilst coastal habitats and species were better represented, likely reflecting the reduced costs collecting shore-based data, the South West lacks systematic mapping and monitoring surveys for its marine habitats and species. The Isles of Scilly seagrass voluntary monitoring program represents the only example of an inter-annual, standardised survey for a non-coastal habitat. Proposed monitoring schemes at sentinel marine sites by Natural England present an opportunity for improved habitat data in the future. The development of standardised condition assessments should be prioritized in these surveys to allow easier comparison between habitat types and help inform regions requiring targeted management.

Other goals revealed issues of data attribution to a regional level. Biodiversity: Species was an example of a goal where numerous datasets were excluded due the localised or ad-hoc nature of their collection. Species surveys covering all OHI+ regions with long-term trends were only available for a subset of species. National species monitoring and assessment programs, such as the Small Cetaceans in European Atlantic waters and the North Sea (SCANS), represent attempts to build robust population assessments of marine indicator species in the UK. However, these schemes are designed at large spatial scales and often contain limited sample sizes when disaggregated to a local level. Similarly, annual survey data on recreational activity and blue space use were excluded from the

Tourism and Recreational goal due to small sample sizes when analysis the data below a South West scale.

A lack of historical baseline data also prevented the setting of ambitious reference points for certain OHI goals. Coastal and marine habitats notably lacked historical extent data to compare current extent and condition against. UK Seagrass beds for example have seen declines of between 25% and 49% in the last 25 years (Jones and Unsworth, 2015). More substantial declines have occurred in the last century, with the emergence of wasting disease in the 1920s. Without these baselines, the OHI+ relies on current data, potentially setting reference points representing degraded ecosystems with reduced extents and encouraging shifting baselines between future OHI+ assessments. Developing modeled layers of historical extent or setting recovery targets (i.e. annual increases in area) would encourage restoration efforts and allow OHI+ reference points to better reflect naturally occurring ecosystem health.

Repeat assessments of the OHI+

The OHI model is intended to be transparent, open source and easily replicated. The OHI+ South West assessment was designed to maximise these benefits, allowing future repetition to track changes through time, or adaption to a large assessment scale if desired. For this reason, datasets with national coverage and those most likely to persist as long-term data were prioritised for inclusion.

Application at small spatial scales

The South West assessment represents one of the smaller applications of the OHI framework. The global OHI assessment assigned 174 regions based on all coastal states EEZs. Subsequent OHI+ assessments generally focus on large regions (e.g. the Baltic OHI) or entire countries (e.g. Brazil, Fiji). Sub-country assessments are rare, and generally focus on large geographic areas (e.g. British Colombia, USA West Coast). Successful application to a more local level reveals the versatility of the OHI framework. English county level regions were considered the optimal report unit for this assessment as they reflect defined political units and many open-source datasets are aggregated to a county level. The decision to divide Devon into three sub-regions reflected management boundaries (South West Marine Plan boundaries) and distinct biogeography between the north and south coasts (see section 3). This decision was possible due to the availability of data at a sub–Devon County resolution for most OHI+ goals, likely because Devon contains multiple local authorities. Application of the OHI+ model to smaller spatial scales than those used in this project is therefore possible. However, disaggregation of data reported at the county level was required for certain datasets (i.e. domestic and international overnight stays in the Tourism & Recreation goal). These are detailed

under the relevant goal sections in this report. The lack of data availability reporting at a sub-county scale (i.e. town parish councils or local authorities) in Cornwall and the Isles of Scilly would likely result in data attribution issues should the assessment require expansion of sub-county regions. Below the local authority scale even data-rich goals may require further adaptation and data-gaps become more frequent.

Future assessments

The results presented in this report are the first to comprehensively assess regional ocean health and sustainable management in South West England. As such, they offer an essential baseline against which marine management efforts can be measured in the future. The OHI+ baseline scores will have increased impact if the assessment is repeated, allowing comparison of OHI+ scores through space and time. This is evident in the Global OHI assessment, conducted annually since 2012. Whilst Global OHI scores have displayed limited inter-annual change (http://www.oceanhealthindex.org/region-scores/annual-scores-and-rankings), individual goal and region scores fluctuate from year to year (Halpern et al., 2015b).

One of the advantages of the OHI+ model is that any replication will be far less time and effort intensive than the original assessment. Without the need to define regions, source relevant local datasets and validate outputs with stakeholders, repeat assessments only require data to be updated each year. Inevitably certain datasets may become obsolete in the future. This may occur due to recording schemes losing funding, shifting management priorities or because new issues become prominent. However, as the majority of datasets used in this study are drawn from well-established recording schemes they are likely to have longevity. The majority of datasets in a repeat SW assessment would therefore only require updating, rather than replacing. Additionally, all OHI+ data and programming code is available open access online (https://github.com/OHI-Science/esw) and replies exclusively on open-source software (see section 1). This ensures all data is documented and future assessments can easily replicate the methods.

When considering repeat OHI+ assessments, the optimal time gap requires establishing. Not all datasets used in this study report annually. Others may report regularly, but exhibit low sensitivity to change. For example, there is often a temporal lag between declines in species abundance being reflected in conservation assessment rankings. This results in limited inter-annual variation in datasets and would likely result in OHI+ scores being similar year to year. To address this issue repeat assessments are likely to have maximum value if conducted every two to three years.

National application

The OHI+ model is also adaptable to larger geographic scales. As the OHI+ SW study prioritised datasets from national repositories, the current model can be easily applied to alternative English regions (i.e. an English Channel assessment) or as a quantitative tool to support national marine management. The MMO regional marine plans are an example of existing management units, with well-defined boundaries informed by known biogeographic, cultural and economic characteristics, that could easily be applied to the OHI model. The datasets detailed in our study are nationally available, some adaptations would be necessary before conducting a national assessment. There is the possibility that goals may need some adaption to reflect national priorities. For example, the development of offshore wind and other renewable energy generation, whilst not currently prominent in the South West, could be incorporated into national assessments if desired.

Summary

This report represents the first application of the OHI+ framework to the United Kingdom and the first attempt to holistically assess ocean health in the South West. The results provide a baseline understanding of the condition of the marine environment and the coastal communities that rely on a healthy ocean to provide livelihoods, food and enjoyment. The OHI+ assessment was able to draw on a variety of data repositories and long-term monitoring projects to effectively adapt the global framework to the South West region. This project also benefitted greatly from the input of local stakeholders, the OHI global team and the project Steering Group that has provided oversight and support throughout the project lifecycle. Whilst the South West UK is considered a relatively data-rich, this report also highlights key knowledge gaps that require addressing to improve our certainty in OHI+ scores and allow policy makers to make informed and effective decisions. Replication of this assessment in the future can address some of these gaps and provide a measure of management effectiveness through time. We hope the results presented here will be of value to a variety of marine management groups now and in the future.

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Appendices

Appendix 1: Status metadata describing goal/sub goal, data description, units, available temporal resolution, spatial resolution as applied to OHI+ assessment, data type and source.

Goal	Sub goal	Dataset	Units	Temporal res.	Spatial res.	Data type: Observed (O) Product (P) Modelled (M) Classification (C)	Source (see Appendix 2 for source data urls)
Clean Waters (CW)		Bathing Water classification	Ranked category	1997-2017	Region-specific	C	Environment Agency
		Water clarity: gelbstoff (coloured dissolved organic matter) & detrital material	Light absorption due to gelbstoff and detritus at 442 nmi (m^{-1})	2003-2017	Region-specific	O	NASA
		Beach clean data	Litter items m^{-1}	2018	Region-specific	O	MCS
		Run-off from urban-suburban built areas modelled from UK monthly rainfall data & land classification	mm/km^2	2005-2015	Region-specific	P	CEH: Centre for Ecology & Hydrology
		Pollution from vessels (data extracted to 3nm of coast)	Vessel density (2 km^{-2})	2011-2015	Region-specific	O	MMO
		Nutrients: fertiliser use (national data regionally apportioned by land use)	Tonnes (total tonnes per region)	2002-2016	National: apportioned by region	P	FAO
		Pesticide use (national data regionally apportioned by land use)	kg/ha	1990-2016	National: apportioned by region	P	FAO
		Land cover (for data extraction)	Area: km^2	2015	Region-specific	O	CEH: Centre for Ecology & Hydrology
Food Provision (FP)	**Fisheries (FIS)**	B/B_{MSY} data (regional) derived from regional (CEFAS) stock assessments	Ratio: popn. biomass /MSY biomass	2017	Regional (South West England)	P	CEFAS
		B/B_{MSY} data (global) derived from global (RAM legacy) stock assessments	Ratio: popn. biomass /MSY biomass	2001-2015	Global	P	ramlegacy.org
		Marine Conservation Society sustainable seafood	Ranked category	2020	National	C	Marine Conservation Society
		UK and foreign vessels landings by UK ports	Tonnes	2014-2018	Port specific	O	gov.uk
	Mariculture (MAR)	Mariculture production data	Tonnes	2012-2016	National: apportioned by region	O	CEFAS
		Mariculture production sites	km^2	2019	Region-specific	O	CEFAS
Artisanal Opportunities (AO)		UK and foreign vessels landings by UK ports	Tonnes	2014-2018	Port specific	O	gov.uk
		Catch per unit (vessel) effort	Ratio: tonnes/hour	2012-2016	Port specific	P	MMO
		Marine diesel price	Cost: £/litre	2010-2017	National	P	gov.uk

Goal	Sub goal	Dataset	Units	Temporal res.	Spatial res.	Data type: Observed (O)	Source (Appendix 2 for urls)

						Product (P) Modelled (M) Classification (C)	
Coastal Livelihoods & Economies (LE)	**Livelihoods (LIV)**	Employed marine workforce	n (number of jobs [full-time equivalent])	2010-2018	Unitary/district authority	O	ONS
		Per capita (median) annual wage	£	2002-2018	Unitary/district authority	O	ONS
		Consumer Price Index	% rate of increase/decrease	2018	National	P	ONS
	Economies (ECO)	Regional GVA by local authority	£	1997-2015	Unitary/district authority	O	ONS
		Employed marine workforce & total workforce	n (number of jobs [full-time equivalent])	2010-2018	Unitary/district authority	O	ONS
Tourism & Recreation (TR)		Domestic overnight tourist stays	n (overnight stays)	2010-2014	Unitary/district authority	O	Visit England
		International overnight tourist stays	n (overnight stays)	2010-2014	Unitary/district authority	O	Visit England
		Accommodation (hotels, campsites, B&B)	n (accommodation units)	2019	Regional (South West England)	O	©OpenStreetMap contributors
		Viewshed (land with sea views) 1 km inland of coast	Proportion	2014	Region-specific	M	MMO
		Modelled marine recreation potential (MMO 1064) (clipped to 3 km of coast [mean high water])	Proportion	2014	Region-specific	M	MMO
Designated Areas (DA)	**Landscapes (LAN)**	World Heritage Site (WHS) Local Nature Reserve (LNR) Important Bird and Biodiversity Area (IBA) Biosphere Reserve (BR) Heritage Coast (HC) RSPB Reserve (RSPBR) Area of Outstanding Natural Beauty (AONB) Protected Wrecks (PW) National Parks (NP)	km^2	2001-2006 1973-2011 2007-2015 1976 1974-1992 1994-2016 1957-1995 1973-2014 1954	Region-specific data clipped to 1 km inland & 3 nmi from coast (mean high water)	O	various
	Ecological (ECL)	Special Area of Conservation (SAC) Special Protected Area (SPA) Marine Conservation Zone (MCZ) Site of Special Scientific Interest (SSSI) RAMSAR sites	km^2	2005-2017 1992-2017 2013-2016 1983-2009 1991-2001	Region-specific data clipped to 1 km inland & 12 nmi from coast (mean high water)	O	various

Goal	Sub goal	Dataset	Units	Temporal res.	Spatial res.	Data type: Observed (O) Product (P) Modelled (M) Classification (C)	Source (Appendix 2 for urls)
Biodiversity (BD)	**Habitat (HAB)**	Seagrass extent	km^2	1985-2015	Region-specific	O	EMODnet
		Seagrass condition & monitoring	Ranked category	2012-2019	Region-specific	C	Natural England
		Saltmarsh/mudflats extent	km^2	2013	Region-specific	O	Natural England
		Saltmarsh/mudflats condition & monitoring	Ranked category	2003-2016	Region-specific	C	Natural England
		Maerl extent	km^2	2009	Region-specific	O	DEFRA
		Maerl condition	Ranked category	2013	Region-specific	C	Natural England
		Soft & hard bottom extent	km^2	2019	Region-specific	O	EMODnet
		Soft & hard bottom condition (GFW trawl intensity)	Fishing hours day^{-1}	2012-2018	Region-specific	O	global fishing watch
	Species (SPP)	MMO policy statements derived marine species list	None	2019	SW Marine Plan Area	O	MMO
		NBN Atlas	Region Id	2019	Region-specific	O	NBN
		DEFRA MB0102	Region Id	2010	Region-specific	O	DEFRA
		The Shark Trust	Region Id	2010	Region-specific	O	The Shark Trust
		IUCN	Region Id	2011-2012	Region-specific	O	IUCN
		Seabird Monitoring Programme	Region Id	1985-2018	Region-specific	O	JNCC
		Breeding Bird Survey	Region Id	2013-2018	Region-specific	O	BTO
		MCZ feature condition	Ranked category	2012-2019	Region-specific	C	Natural England
		B/B_{MSY} data	Ratio	2017	Regional (South West England)	P	CEFAS
		BoCC rank	Ranked category	2015	National	C	BTO
		IUCN Redlist (extinction risk)	Ranked category	2003-2018	Global	C	IUCN
		IUCN Redlist (population trend)	Ranked category	2003-2018	Global	C	IUCN
Coastal Systems (CS)	**Coastal Protection (CPR)**	Seagrass extent	km^2	1985-2015	Region-specific	O	EMODnet
		Seagrass condition & monitoring	Ranked category	2012-2019	Region-specific	C	Natural England
		Saltmarsh/mudflats extent	km^2	2013	Region-specific	O	Natural England
		Saltmarsh/mudflats condition & monitoring	Ranked category	2003-2016	Region-specific	C	Natural England
		Sand dune extent	km^2	1985-2015	Region-specific	O	Natural England
		Sand dune condition & monitoring	Ranked category	2007-2017	Region-specific	C	Natural England
	Carbon Storage (CST)	Seagrass extent	km^2	1985-2015	Region-specific	O	EMODnet
		Seagrass condition & monitoring	Ranked category	2012-2019	Region-specific	C	Natural England
		Saltmarsh/mudflats extent	km^2	2013	Region-specific	O	Natural England
		Saltmarsh/mudflats condition & monitoring	Ranked category	2003-2016	Region-specific	C	Natural England
		Maerl extent	km^2	2009	Region-specific	O	DEFRA
		Maerl condition	Ranked category	2013	Region-specific	C	Natural England

Appendix 2: Sources of status data.

Goal	Sub-goal	Data	Superscript	url
CW		Bathing water classifications	4	https://environment.data.gov.uk/bwq/profiles/data-download.html?country=England
		Water clarity	5	https://oceancolor.gsfc.nasa.gov/cgi/l3
		Beach clean data	7	No url – data request made to the Marine Conservation Society
		Urban run-off	3	https://catalogue.ceh.ac.uk/datastore/eidchub/33604ea0-c238-4488-813d-0ad9ab7c51ca/GB/monthly/
		Pollution from vessels	6	https://environment.data.gov.uk/ds/catalogue/index.jsp#/catalogue
		Nutrients	1	http://www.fao.org/faostat/en/#data/RFN
		Pesticides	2	http://www.fao.org/faostat/en/#data/EP/visualize
		Land cover	8	https://digimap.edina.ac.uk/roam/download/environment
FP	FIS	CEFAS stock assessment (B/B_{MSY} data (regional))	1	http://data.cefas.co.uk/#/View/18741
		RAM stock assessment (B/B_{MSY} data (global))	2	https://www.ramlegacy.org/database
		Marine Conservation Society sustainable seafood guide	3	https://www.mcsuk.org/goodfishguide/search
		Landings to port	4	https://www.gov.uk/government/statistical-data-sets/uk-and-foreign-vessels-landings-by-uk-port-and-uk-vessel-landings-abroad
	MAR	Mariculture production data	1	No url – data request made to CEFAS
		Mariculture production sites	2	http://data.cefas.co.uk/#/View/79
AO		Landings to port	1	https://www.gov.uk/government/statistical-data-sets/uk-and-foreign-vessels-landings-by-uk-port-and-uk-vessel-landings-abroad
		Catch per unit (vessel) effort	2	https://data.gov.uk/search?filters%5Bpublisher%5D=Marine+Management+Organisation
		Marine diesel price	3	https://www.gov.uk/government/statistical-data-sets/oil-and-petroleum-products-monthly-statistics
LE	LIV	Workforce & annual wages	1	https://www.nomisweb.co.uk
		Consumer Price Index	2	https://www.ons.gov.uk/economy/inflationandpriceindices/timeseries/d7g7/mm23
	ECO	Revenue (GVA)	1	https://www.ons.gov.uk/economy/grossvalueaddedgva/datasets/regionalgvaibylocalauthorityintheuk
		Workforce (total & marine)	2	https://www.nomisweb.co.uk
TR		Domestic overnight stays	1	https://www.visitbritain.org/archive-great-britain-tourism-survey-overnight-data
		International overnight stays	2	https://www.visitbritain.org/nation-region-county-data
		Accommodation	3	https://overpass-turbo.eu
		Viewshed	4	https://environment.data.gov.uk/DefraDataDownload/?mapService=MMO/LandWithSeaViews&Mode=spatial
		Recreational potential	5	https://environment.data.gov.uk/ds/catalogue/index.jsp#/catalogue
DA	LAN	WHS extent & designations	1	WHS: https://data.gov.uk/dataset/3ac5c299-6805-476b-af9b-90aadec5e7b4/world-heritage-sites-gis-data
		LNR extent & designations	2	LNR: https://data.gov.uk/dataset/acdf4a9e-a115-41fb-bbe9-603c819aa7f7/local-nature-reserves-england
		IBA extent & designations	3	IBA: http://datazone.birdlife.org/site/requestgis
		Biosphere Reserves extent & designations	4	Biosphere reserves: https://data.gov.uk/dataset/4ceee25f-ed74-4419-921f-5d25f5ae3c5c/biosphere-reserves-england
		Heritage Coast extent & designations	5	Heritage Coasts: https://naturalengland-defra.opendata.arcgis.com/datasets/d9557885721d483dac138bdd0ab08c3e_0/data
		RSPBR extent & designations	6	RSPB reserves: https://opendata-rspb.opendata.arcgis.com/datasets/rspb-reserves/data
		AONB extent & designations	7	AONB: http://naturalengland-defra.opendata.arcgis.com/datasets/areas-of-outstanding-natural-beauty-england/data
		Protected Wrecks extent & designations	8	Protected Wrecks: https://services.historicengland.org.uk/NMRDataDownload/SecurePages/Download.aspx
		National Parks extent & designations	9	National parks: https://data.gov.uk/dataset/334e1b27-e193-4ef5-b14e-696b58bb7e95/national-parks-england
	ECL	SAC, SPA, RAMSAR site extent & designations	1	SAC, SPA, Ramsar: http://jncc.defra.gov.uk/protectedsites/SACselection/gis_data/terms_conditions.asp
		MCZ extent & designations	2	MCZ: https://naturalengland-defra.opendata.arcgis.com/datasets/marine-conservation-zones-england
		SSSI extent & designations	3	SSSI: https://naturalengland-defra.opendata.arcgis.com/datasets/sites-of-special-scientific-interest-units-england

Goal	Sub-goal	Data	Superscript	url
BD	HAB	Seagrass extent	1	https://www.emodnet-seabedhabitats.eu/access-data/download-data/
		Seagrass condition & monitoring	2	Seagrass condition: sourced from various reports and years
		Saltmarsh/mudflats extent	3	https://naturalengland-defra.opendata.arcgis.com/datasets/priority-habitat-inventory-england-south/data
		Saltmarsh/mudflats condition & monitoring	4	https://designatedsites.naturalengland.org.uk/SiteSearch.aspx - and data request from Natural England
		Maerl extent	5	https://data.gov.uk/dataset/c530a017-94f1-4e09-96de-13b4d1874250/2009-defra-mb0102-2c-distribution-of-maerl-beds-from-polygon-data-in-the-united-kingdom-and-isle-of-man
		Maerl condition	6	https://data.gov.uk/dataset/22842939-102d-4b2b-a3d7-d72dfa008b82/2013-natural-england-fal-and-helford-sac-maerl-drop-down-video-and-dive-survey
		Soft & hard benthic habitats extent	7	https://www.emodnet-seabedhabitats.eu/access-data/download-data/
		Soft & hard benthic habitats condition	8	https://globalfishingwatch.force.com/gfw/s/data-download
	SPP	List of marine species	1	https://www.gov.uk/government/publications/marine-planning-iteration-3-engagement-for-the-north-east-north-west-south-east-and-south-west-marine-plan-areas
		Species distribution ranges	2	https://nbnatlas.org/
		Species distribution ranges	3	https://data.gov.uk/search?q=DEFRA+MB0102
		Species distribution ranges	4	https://www.sharktrust.org/Pages/FAQs/Category/british-sharks
		Species distribution ranges	5	https://www.iucnredlist.org/search (distribution)
		Species distribution ranges	6	http://archive.jncc.gov.uk/smp/sitesMain.aspx
		Species distribution ranges	7	https://www.bto.org/our-science/projects/bbs/latest-results/species-lists/county-species-lists
		Species status	8	https://www.gov.uk/government/collections/marine-conservation-zone-designations-in-england
		Species status	9	http://data.cefas.co.uk/#/View/18741
		Species status	10	https://www.bto.org/our-science/publications/psob
		Species status	11	https://www.iucnredlist.org/search (status)
		Population trend	12	https://www.iucnredlist.org/search (trend)
CS	CPR	Seagrass extent	1	https://www.emodnet-seabedhabitats.eu/access-data/download-data/
		Seagrass condition & monitoring	2	No url – data request made to Natural England
		Saltmarsh/mudflats/sand dune extent	3	https://naturalengland-defra.opendata.arcgis.com/datasets/priority-habitat-inventory-england-south/data
		Saltmarsh/mudflats/sand dune condition & monitoring	4	https://designatedsites.naturalengland.org.uk/SiteSearch.aspx - and data request from Natural England
	CST	Seagrass extent	1	https://www.emodnet-seabedhabitats.eu/access-data/download-data/
		Seagrass condition & monitoring	2	No url – data request made to Natural England
		Saltmarsh/mudflats extent	3	https://naturalengland-defra.opendata.arcgis.com/datasets/priority-habitat-inventory-england-south/data
		Saltmarsh/mudflats condition & monitoring	4	https://designatedsites.naturalengland.org.uk/SiteSearch.aspx - and data request from Natural England
		Maerl extent	5	https://data.gov.uk/dataset/c530a017-94f1-4e09-96de-13b4d1874250/2009-defra-mb0102-2c-distribution-of-maerl-beds-from-polygon-data-in-the-united-kingdom-and-isle-of-man
		Maerl condition	6	https://data.gov.uk/dataset/22842939-102d-4b2b-a3d7-d72dfa008b82/2013-natural-england-fal-and-helford-sac-maerl-drop-down-video-and-dive-survey

Appendix 3: Status data availability described by goal/sub goal, data description, available years and OHI assessment year.

Goal	Sub-goal	Data	Data year if prior to 2001	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
CW		Bathing water classification																		X			
		Water clarity																		X			
		Beach clean data																					
		Urban run-off																X					
		Pollution from vessels																X					
		Fertiliser use																	X				
		Pesticide use																	X				
		Land cover (for data extraction)																X					
FP	FIS	CEFAS stock assessment (B/B_{MSY} data (regional))																		X			
		RAM stock assessment (B/B_{MSY} data (global))																X					
		Marine Conservation Society sustainable seafood guide																					
		Landings to port																			X		
	MAR	Mariculture production data																			X		
		Mariculture production sites																				X	
AO		Landings to port																			X		
		Catch per unit (vessel) effort																	X				
		Marine diesel price																			X		
LE	LIV	Employed marine workforce																			X		
		Per capita (median) annual wage																			X		
		Consumer Price Index																			X		
	ECO	Regional GVA by local authority in the UK																X					
		Employed marine workforce & total workforce																			X		
TR		Domestic overnight stays															X						
		International overnight stays															X						
		Accommodation (hotels, campsites, B&B)																				X	
		Viewshed (land with sea views)															X						
		Modelled marine recreation potential															X						
DA	LAN	World Heritage Site (WHS) extent & designation							X													!	
		Local Nature Reserve (LNR) extent & designation												X								!	
		Important Bird and Biodiversity Area (IBA) extent & designation																X				!	
		Biosphere Reserve (BR) extent & designation	X 1976																			!	
		Heritage Coast (HC) extent & designation	X 1992																			!	
		RSPB Reserve (RSPBR) extent & designation																	X			!	
		Area of Outstanding Natural Beauty (AONB) extent & designation	X 1995																			!	
		Protected Wrecks (PW) extent & designation															X					!	
		National Parks (NP) extent & designation	X 1954																			!	
	EC	Special Area of Conservation (SAC) extent & designation																		X		!	
		Special Protected Area (SPA) extent & designation																		X		!	
		Marine Conservation Zone (MCZ) extent & designation																	X			!	
		Site of Special Scientific Interest (SSSI) extent & designation										X										!	
		RAMSAR extent		X																		!	

! data current at 2019

available data

X 2018 assessment data

Goal	Sub-goal	Data	Data year if prior to 2001	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
BD	HAB	Seagrass extent																X					
		Seagrass condition																		Rgn 3	Rgn 4/5	Rn 6	
		Seagrass monitoring													Rgn 5			Rgn 3	Rgn 4	Rgn 6			
		Littoral sediment extent														X							
		Littoral sediment condition & monitoring																			X		
		Maerl extent										X											
		Maerl condition														X							
		Soft and hard bottom extent																	X				
		Soft and hard bottom condition (GFW trawl intensity)																				X	
	SPP	Species list (MMO policy statements)																				X	
		NBN Atlas (species distributions)																					
		DEFRA MB0102 (species distributions)																					
		The Shark Trust (species distributions)																					
		IUCN (species distributions)																					
		Seabird Monitoring Programme (species distributions)																					
		Breeding Bird Survey (species distributions)																					
		MCZ feature condition (species status)																				X	
		B/BMSY data (species status)																		X			
		BoCC rank (species status)																X					
		IUCN Redlist (extinction risk: species status) #																					
		IUCN Redlist (population trend: status trend) #																					
CS	CPR	Seagrass extent																X					
		Seagrass condition																		Rgn 3	Rgn 4/5	Rn 6	
		Seagrass monitoring													Rgn 5			Rgn 3	Rgn 4	Rgn 6			
		Saltmarsh/mudflats extent														X							
		Saltmarsh/mudflats condition & monitoring																			X		
		Sand dune extent																X					
		Sand dune condition & monitoring																			X		
	CST	Seagrass extent																X					
		Seagrass condition																		Rgn 3	Rgn 4/5	Rn 6	
		Seagrass monitoring													Rgn 5			Rgn 3	Rgn 4	Rgn 6			
		Saltmarsh/mudflats extent														X							
		Saltmarsh/mudflats condition & monitoring																			X		
		Maerl extent										X											
		Maerl condition														X							

data year dependent on IUCN assessment year

available data

X 2018 assessment data

Appendix 4: Pressure data described by stressor name, category and sub-category, region specific data, data type and goal/sub goal application.

Stressor	Category	Sub-category	Region specific	Data type: Observed (O) Product (P) Modelled (M)	Goal or sub goal and element																				
					CW	FIS	MAR	AO	LIV	ECO	TR	LAN	ECL	HAB: SM*	HAB: SG*	HAB: M*	HAB: SB*	HAB: HB*	SPP	CP: SM*	CP: SG*	CP: SD*	CS: SM*	CS: SG*	CS: M*
Invasive species	Ecological	Alien species	No	M		1		1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1
Genetic escapes	Ecological	Alien species	No	M		1			1	1									1						
Ocean acidification	Ecological	Climate change	No	M											1	2			1		1			1	2
Sea level rise	Ecological	Climate change	Yes	P			1		2	2	2	1	1	2	2					3	3	3	2	2	
Sea surface temperature	Ecological	Climate change	Yes	P											2	1			1		2			2	1
Ultraviolet radiation	Ecological	Climate change	No	M															1						
Fisheries pressure (inshore) dredging	Ecological	Fishing pressure	Yes	P		3		2	1						3	3	3	3	3		3			3	3
Fisheries pressure (inshore) lining	Ecological	Fishing pressure	Yes	P		2		1	1										1						
Fisheries pressure (inshore) netting	Ecological	Fishing pressure	Yes	P		2		1	1						2		2	2	3		2			2	
Fisheries pressure (inshore) potting	Ecological	Fishing pressure	Yes	P		2		1	1						2		1	1	1		2			2	
Fisheries pressure (inshore) trawling	Ecological	Fishing pressure	Yes	P		3		3	1						3	3	3	3	3		3			3	3
Fisheries pressure (offshore) fixed gear	Ecological	Fishing pressure	Yes	P		2		2	1								1	1	2						
Fisheries pressure (offshore) longlines	Ecological	Fishing pressure	Yes	P		2		2	1										2						
Fisheries pressure (offshore) trawls	Ecological	Fishing pressure	Yes	P		3		2	1								3	3	2						
Intertidal habitat destruction	Ecological	Habitat destruction	Yes	O		1		1	1	1			3	3	3				2	3	3	3	3	3	
Subtidal hard bottom habitat destruction	Ecological	Habitat destruction	Yes	P		2		2	2	2			2					3	2						
Subtidal soft bottom habitat destruction	Ecological	Habitat destruction	Yes	P		2		2	2	2			2				3		2						
Industrial sprawl	Ecological	Pollution	Yes	O	1			1			3	2	2	2					2	2		2	2		
Urban sprawl	Ecological	Pollution	Yes	O	1			1			3	2	2	2					2	2		2	2		
Chemical input within coast to 12 nmi offshore	Ecological	Pollution	Yes	O | P | M		1	2		3	3									2						
Chemical input within coast to 3 nmi offshore	Ecological	Pollution	Yes	O | P | M	3		3	1			3	2	2	1	2	1	2	2	3	1	2	1	1	2	1
Nutrient input within coast to 12 nmi offshore	Ecological	Pollution	Yes	M		1			1	1									3						
Nutrient input within coast to 3 nmi offshore	Ecological	Pollution	Yes	M	3		3	1	3	3	3	2	2	2	3	2	2	2	2	2	3	2	2	3	2
River pollution	Ecological	Pollution	Yes	O	3		3	1			3	2	2	1	2	1	2	2	3	1	2	1	1	2	1
Pathogens within coastal waters	Ecological	Pollution	No	O	3				3	3	3														
Plastic pollution within coast to 12 nmi offshore	Ecological	Pollution	Yes	M	3				3	3	3	3	3						1						
Underwater noise within coast to 12 nmi offshore	Ecological	Pollution	Yes	O															3						
Recreational pressure	Ecological	Pollution	Yes	M	2						2			2	2	2			2	2	2	2	2	2	2
Social deprivation	Social	Social	Yes	O				2	3	3	3														

O: Observed - a recorded value
P: Product - a derived unit from multiple 'observed' data sets (e.g. kg/m^2)
M: Modelled - data not observed but derived from a modelling algorithm

* SM – saltmarsh, SG – seagrass, SD – sand dunes, M – maerl, SB – soft bottom benthic substrata, HB – hard bottom benthic

Appendix 5: Resilience data described by layer name, category and category type, region specific data, data type, weight, and goal/sub goal application.

Layer	Category	Category type	Region specific	Data type: Observed (O) Product (P) Modelled (M)	Weight	Goal or sub goal and element																				
						CW	FIS	MAR	AO	LIV	ECO	TR	LAN	ECL	HAB: SM*	HAB: SG*	HAB: M*	HAB: SB*	HAB: HB*	SPP	CP: SM*	CP: SG*	CP: SD*	CS: SM*	CS: SG*	CS: M*
Measure of ecological integrity	Ecological	Ecosystem	Yes	O	1		X		X						X	X	X	X	X		X	X	X	X	X	X
Management of nonindigenous species	Ecological	Regulatory	No	O	1			X							X	X	X	X	X	X	X	X	X	X	X	X
CITES signatories	Ecological	Regulatory	No	O	0.5															X						
Management of habitat to protect fisheries biodiversity	Ecological	Regulatory	No	O	1		X		X									X	X	X						
Commercial fishing management	Ecological	Regulatory	No	O	1		X		X									X	X	X						
Artisanal fisheries management effectiveness	Ecological	Regulatory	No	O	1		X													X						
Nearshore & estuarine fisheries byelaws	Ecological	Regulatory	Yes	O	1				X																	
Management of habitat to protect habitat biodiversity	Ecological	Regulatory		O	1		X		X				X	X	X	X	X	X	X	X	X	X	X	X	X	X
Coastal protected marine areas	Ecological	Regulatory	Yes	O	1		X		X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X
EEZ protected marine areas	Ecological	Regulatory	Yes	O	1		X		X	X	X							X	X	X						
Management of mariculture to preserve biodiversity	Ecological	Regulatory	No	O	1			X							X	X	X	X	X	X						
Mariculture sustainability index	Ecological	Regulatory	No	O	1			X																		
Management of tourism to preserve biodiversity	Ecological	Regulatory	No	O	1										X	X	X	X	X	X						
Management of waters to preserve biodiversity	Ecological	Regulatory	No	O	1	X		X				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Global Competitiveness Index (GCI) scores	Social	Social	No	P	1					X	X															
Strength of governance	Social	Social	No	P	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Social Progress Index	Social	Social	No	P	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

O: Observed - a recorded value
P: Product - a derived unit from multiple 'observed' data sets (e.g. kg/m^2)
M: Modelled - data not observed but derived from a modelling algorithm

* SM – saltmarsh, SG – seagrass, SD – sand dunes, M – maerl, SB – soft bottom benthic substrata, HB – hard bottom benthic substrata

Appendix 6: Pressure and resilience data sources.

Data	Description	Pressure or Resilience	url
nvasive species	Modelled impact from harmful invasive marine species	pressure	https://github.com/OHI-Science/ohi-global/blob/draft/eez/layers/sp_alien.csv
Genetic escapes	Modelled impact from introduced mariculture species	pressure	https://github.com/OHI-Science/ohi-global/blob/draft/eez/layers/sp_genetic.csv
Ocean acidification	Modelled change in ocean acidity	pressure	https://github.com/OHI-Science/ohi-global/blob/draft/eez/layers/cc_acid.csv
Sea level rise	Sea surface height anomalies	pressure	https://github.com/OHI-Science/ohi-global/blob/draft/eez/layers/cc_slr.csv
Sea surface temperature	Sea surface temperature anomalies	pressure	https://github.com/OHI-Science/ohi-global/blob/draft/eez/layers/cc_sst.csv
Ultraviolet radiation	Modelled UV radiation anomalies	pressure	https://github.com/OHI-Science/ohi-global/blob/draft/eez/layers/cc_uv.csv
Fisheries pressure (inshore) dredging	Modelled inshore fishing activities intensity	pressure	http://data.cefas.co.uk/#/View/3277
Fisheries pressure (inshore) lining	Modelled inshore fishing activities intensity	pressure	http://data.cefas.co.uk/#/View/3277
Fisheries pressure (inshore) netting	Modelled inshore fishing activities intensity	pressure	http://data.cefas.co.uk/#/View/3277
Fisheries pressure (inshore) potting	Modelled inshore fishing activities intensity	pressure	http://data.cefas.co.uk/#/View/3277
Fisheries pressure (inshore) trawling	Modelled inshore fishing activities intensity	pressure	http://data.cefas.co.uk/#/View/3277
Fisheries pressure (offshore) fixed gear	Fishing effort and vessel presence	pressure	https://globalfishingwatch.force.com/gfw/s/data-download
Fisheries pressure (offshore) longlines	Fishing effort and vessel presence	pressure	https://globalfishingwatch.force.com/gfw/s/data-download
Fisheries pressure (offshore) trawls	Fishing effort and vessel presence	pressure	https://globalfishingwatch.force.com/gfw/s/data-download
Intertidal habitat destruction	Resident population within 5 km of coast	pressure	https://catalogue.ceh.ac.uk/documents/0995e94d-6d42-40c1-8ed4-5090d82471e1
Subtidal hard bottom habitat destruction	Fishing effort over hard bottom benthic substrata	pressure	https://globalfishingwatch.force.com/gfw/s/data-download
Subtidal soft bottom habitat destruction	Fishing effort over soft bottom benthic substrata	pressure	https://globalfishingwatch.force.com/gfw/s/data-download
Industrial sprawl	Area (km^2) change in industrial built environment between 1965 and 2014	pressure	https://uk-nationaltrust.opendata.arcgis.com/datasets/64c3e911034f40829d288e1cd908415a_0 https://uk-nationaltrust.opendata.arcgis.com/datasets/ab9ac11913e042dfa55f51df440fd0ac_0
Urban sprawl	Area (km^2) change in urban built environment between 1965 and 2014	pressure	https://uk-nationaltrust.opendata.arcgis.com/datasets/64c3e911034f40829d288e1cd908415a_0 https://uk-nationaltrust.opendata.arcgis.com/datasets/ab9ac11913e042dfa55f51df440fd0ac_0
Chemical input within coast to 12 nmi offshore	Agricultural pesticide pollution	pressure	https://github.com/OHI-Science/ohi-global/blob/draft/eez/layers/po_chemicals.csv
Chemical input within coast to 12 nmi offshore	Pollution from vessels	pressure	https://environment.data.gov.uk/ds/catalogue/index.jsp#/catalogue
Chemical input within coast to 12 nmi offshore	Urban run-off	pressure	https://catalogue.ceh.ac.uk/datastore/eidchub/33604ea0-c238-4488-813d-0ad9ab7c51ca/GB/monthly/
Chemical input within coast to 3 nmi offshore	Agricultural pesticide pollution	pressure	https://github.com/OHI-Science/ohi-global/blob/draft/eez/layers/po_chemicals.csv
Chemical input within coast to 3 nmi offshore	Pollution from vessels	pressure	https://environment.data.gov.uk/ds/catalogue/index.jsp#/catalogue
Chemical input within coast to 3 nmi offshore	Urban run-off	pressure	https://catalogue.ceh.ac.uk/datastore/eidchub/33604ea0-c238-4488-813d-0ad9ab7c51ca/GB/monthly/
Nutrient input within coast to 12 nmi offshore	Agricultural fertiliser pollution	pressure	https://github.com/OHI-Science/ohi-global/blob/draft/eez/layers/po_nutrients.csv
Nutrient input within cast to 3 nmi offshore	Agricultural fertiliser pollution	pressure	https://github.com/OHI-Science/ohi-global/blob/draft/eez/layers/po_nutrients.csv
River pollution	Water framework directive violations	pressure	https://environment.data.gov.uk/catchment-planning/data-download/
Pathogens within coastal waters	Population without access to improved sanitation facilities	pressure	https://github.com/OHI-Science/ohi-global/blob/draft/eez/layers/po_pathogens.csv
Plastic pollution within coast to 12 nmi offshore	Modelled floating marine plastics (density & distribution)	pressure	https://github.com/OHI-Science/ohi-global/blob/draft/eez/layers/po_trash.csv
Underwater noise within coast to 12 nmi offshore	Vessel density	pressure	https://environment.data.gov.uk/ds/catalogue/index.jsp#/catalogue
Recreational pressure	Recreational activity (coast to 3 nmi offshore)	pressure	https://environment.data.gov.uk/ds/catalogue/index.jsp#/catalogue
Social deprivation	Carstairs index within 5 km coast	pressure	https://census.ukdataservice.ac.uk/get-data/related/deprivation.aspx
Measure of ecological integrity	Marine species condition (species sub-goal status score) calculated for all of EEZ (to 12 nmi offshore) as a proxy for ecological integrity	resilience	data as per BD: SPP sub-goal
Management of nonindigenous species	Survey responses by country to the Convention on Biological Diversity (CBD) Third National Report: invasive species related questions	resilience	https://github.com/OHI-Science/ohi-global/blob/draft/eez/layers/sp_alien_species.csv
CITES signatories	Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) signatories	resilience	https://github.com/OHI-Science/ohi-global/blob/draft/eez/layers/g_cites.csv
Management of habitat to protect fisheries biodiversity	Survey responses by country to the Convention on Biological Diversity (CBD) Third National Report: habitat related questions	resilience	https://github.com/OHI-Science/ohi-global/blob/draft/eez/layers/fp_habitat.csv

Data	Description	Pressure or Resilience	url
Commercial fishing management	Regulations and management of commercial fishing	resilience	https://github.com/OHI-Science/ohi-global/blob/draft/eez/layers/fp_mora.csv
Artisanal fisheries management effectiveness	Quality of management of small-scale fishing for artisanal and recreational purposes (expert opinion survey)	resilience	https://github.com/OHI-Science/ohi-global/blob/draft/eez/layers/fp_mora_artisanal.csv
Nearshore & estuarine fisheries byelaws	Direct & supportive MPA measures	resilience	http://www.association-ifca.org.uk/map/
Management of habitat to protect habitat biodiversity	Survey responses by country to the Convention on Biological Diversity (CBD) Third National Report: habitat related questions	resilience	https://github.com/OHI-Science/ohi-global/blob/draft/eez/layers/hd_habitat.csv
Coastal protected marine areas	Percentage marine areas protected from bottom towed gear within 3 nmi of coastline	resilience	https://www.mcsuk.org/mpa/reality-check

EEZ protected marine areas	Percentage marine areas protected from bottom towed gear within 12 nmi of coastline	resilience	https://www.mcsuk.org/mpa/reality-check
Management of mariculture to preserve biodiversity	Survey responses by country to the Convention on Biological Diversity (CBD) Third National Report: mariculture related questions	resilience	https://github.com/OHI-Science/ohi-global/blob/draft/eez/layers/g_mariculture.csv
Mariculture sustainability index	Mariculture practice assessment criteria from the Mariculture Sustainability Index (MSI)	resilience	https://github.com/OHI-Science/ohi-global/blob/draft/eez/layers/g_msi_gov.csv
Management of tourism to preserve biodiversity	Survey responses by country to the Convention on Biological Diversity (CBD) Third National Report: tourism related questions	resilience	https://github.com/OHI-Science/ohi-global/blob/draft/eez/layers/g_tourism.csv
Management of waters to preserve biodiversity	Survey responses by country to the Convention on Biological Diversity (CBD) Third National Report: tourism related questions	resilience	https://github.com/OHI-Science/ohi-global/blob/draft/eez/layers/po_water.csv
Global Competitiveness Index (GCI) scores	Competitiveness in achieving sustained economic prosperity	resilience	https://github.com/OHI-Science/ohi-global/blob/draft/eez/layers/li_gci.csv
Strength of governance	World Governance Indicators (WGI) six combined scores	resilience	https://github.com/OHI-Science/ohi-global/blob/draft/eez/layers/wgi_all.csv
Social Progress Index	Social Progress Index scores	resilience	https://github.com/OHI-Science/ohi-global/blob/draft/eez/layers/res_spi.csv

Appendix 7: Goal dataset reference points.

Goal	Sub-goal	Data	Reference type
CW		Nutrients, pesticides, urban run-off, water clarity & pollution from vessels	Benchmark: within region maxima during most recent 5 years
		Beach clean data	Benchmark: maximum regional value
		Bathing water classifications	Target: categorical rank 0-1
FP	FIS	CEFAS/RAM stock assessment (B/B_{MSY} data [regional/global])	Target: $B/B_{MSY} = 1$
	MAR	Mariculture production data	Benchmark: within region maxima during most recent 5 years
AO		Under 10 m fishing fleet proportion of catch & catch per unit (vessel) effort	Benchmark: within region maxima during most recent 5 years
		Marine diesel price	Benchmark: maximum in most recent 5 years
LE	LIV	Workforce & annual wages	Benchmark: within region temporal comparison
	ECO	Revenue (GVA) & workforce	Benchmark: within region maxima during most recent 5 years
TR		Domestic & international overnight stays	Benchmark: within region maxima during most recent 5 years
		Viewshed	Benchmark: proportion of total area
		Recreational potential	Benchmark: maximum gridded value
DA	LAN	WHS, LNR, IBA, Biosphere Reserves, Heritage Coast, RSPBR, AONB, Protected Wrecks, National Parks extent & designations	Target: proportion of total area
	ECL	SAC, SPA, RAMSAR, MCZ & SSSI site extent & designations	Target: proportion of total area
BD	HAB	Seagrass, saltmarsh/mudflats condition & monitoring	Target: categorical rank 0-1
		Maerl condition	Target: categorical rank 0-1
		Soft & hard benthic habitats condition	Benchmark: within region maxima during most recent 5 years
	SPP	Marine species status	Target: categorical rank 0-1 & $B/B_{MSY} = 1$
CS	CST	Seagrass, saltmarsh/mudflats condition & monitoring	Target: categorical rank 0-1
		Maerl condition	Target: categorical rank 0-1
	CPR	Seagrass, saltmarsh/mudflats & sand dune condition & monitoring	Target: categorical rank 0-1

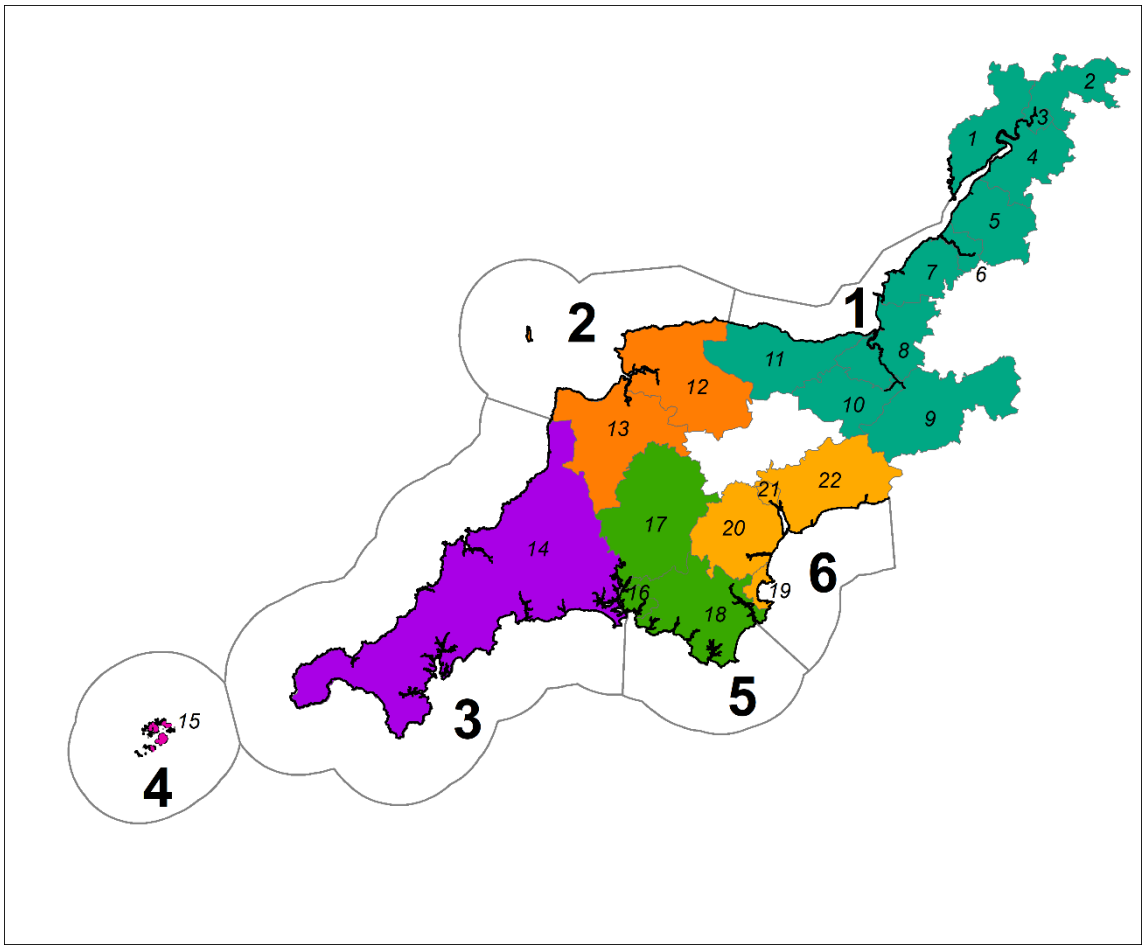
Appendix 8: Status data trend calculations.

Goal	Sub-goal	Data	Trend
CW		Nutrients, pesticides, urban run-off, water clarity, pollution from vessels & bathing water classifications	Region-specific trend calculated from the most recent 5 years of data for nutrients, pesticides, urban run-off, suspended detrital matter, coastal pathogens and pollution from vessels
		Beach clean data	Marine debris trends were estimated using a secondary dataset describing the amount of improperly disposed of plastics (Halpern et al., 2012, 2017; Jambeck et al., 2015)
FP	FIS	CEFAS/RAM stock assessment (B/B_{MSY} data [regional/global])	Region-specific trend calculated from the most recent 5 years of data
	MAR	Mariculture production data	Region-specific trend calculated from the most recent 5 years of data
AO		Under 10 m fishing fleet proportion of catch & catch per unit (vessel) effort	Region-specific trend calculated from the most recent 5 years of data for proportion of catch and CPUE
		Marine diesel price	National trend calculated for marine diesel
LE	LIV	Workforce & annual wages	Region-specific trend calculated from the most recent 5 years of data.
	ECO	Revenue (GVA) & workforce	Region-specific trend calculated from the most recent 5 years of data.
TR		Domestic & international overnight stays	Region-specific trend calculated from the most recent 5 years of data.
DA	LAN	WHS, LNR, IBA, Biosphere Reserves, Heritage Coast, RSPBR, AONB, Protected Wrecks, National Parks extent & designations	Region-specific trend calculated from the most recent 5 years of data
	ECL	SAC, SPA, RAMSAR, MCZ & SSSI site extent & designations	Region-specific trend calculated from the most recent 5 years of data
BD	HAB	Saltmarsh/mudflats, soft & hard benthic habitats	Region-specific trend calculated from the most recent 5 years of data for saltmarsh and benthic sub-littoral habitats
		Seagrass & maerl	Time-series data for seagrass and maerl were not available, as such a yearly trend of -0.07 (Jones and Unsworth, 2016) for seagrass and -0.006 (Gubbay et al, 2016) for maerl were used
	SPP	Marine species status	Species-specific population trend data were source from the IUCN Red List. Population trend categories were re-ranked 'decreasing' = -0.5, 'stable' = 0 and 'increasing' = 0.5 (Halpern et al., 2012, 2017) and aggregated (mean) to provide region-specific population trends
CS	CST	Seagrass, saltmarsh/mudflats & maerl	Region-specific trend calculated from the most recent 5 years of data for saltmarsh. Time-series data for seagrass and maerl were not available, as such a yearly trend of -0.07 (Jones and Unsworth, 2016) for seagrass and -0.006 (IUCN 2016) for maerl were used
	CPR	Seagrass, saltmarsh/mudflats & sand dune	Region-specific trend calculated from the most recent 5 years of data for saltmarsh and sand dunes. Time-series data for seagrass not available, as such a yearly trend of -0.07 (Jones and Unsworth, 2016) was used

Appendix 9: Standard Industrial Classification (SIC) codes and related marine industries.

SIC code	Industry
03110	Marine fishing
03210	Marine aquaculture
10200	Processing and preserving of fish, crustaceans and molluscs
30110	Building of ships and floating structures
30120	Building of pleasure and sporting boats
33150	Repair and maintenance of ships and boats
46380	Wholesale of other food, including fish, crustaceans and molluscs
47230	Retail sale of fish, crustaceans and molluscs in specialised stores
50100	Sea and coastal passenger water transport
50200	Sea and coastal freight water transport
52101	Operation of warehousing and storage facilities for water transport activities
52220	Service activities incidental to water transportation
52241	Cargo handling for water transport activities
77341	Renting and leasing of passenger water transport equipment
77342	Renting and leasing of freight water transport equipment

Appendix 10: Local authorities with coastal/estuarine tidal waters.



Region	Id	Authority
1	1	Forest of Dean
1	2	Tewkesbury
1	3	Gloucester
1	4	Stroud
1	5	South Gloucestershire
1	6	City of Bristol
1	7	North Somerset
1	8	Sedgemoor
1	9	South Somerset
1	10	Taunton Deane
1	11	West Somerset
2	12	North Devon
2	13	Torridge
3	14	Cornwall
4	15	Isles of Scilly
5	16	Plymouth
5	17	West Devon
5	18	South Hams
6	19	Torbay
6	20	Teignbridge
6	21	Exeter
6	22	East Devon

Appendix 11: Region-specific Status, Trend, Pressures, Resilience, Future and Goal scores described by aggregated mean and standard deviation, minimum, maximum values and difference.

Region	Status	Trend	Pressures	Resilience	Future	Goal	Metric
1	66	-0.15	68	83	65	66	mean
1	17	0.37	31	8	22	19	sd
1	33	-0.61	38	75	32	38	minimum
1	87	0.50	100	92	97	92	maximum
1	54	1.11	62	16	66	54	difference
2	67	0.00	64	77	66	67	mean
2	20	0.29	37	13	22	20	sd
2	35	-0.41	27	67	36	35	minimum
2	95	0.50	100	92	100	93	maximum
2	61	0.91	73	24	64	58	difference
3	68	-0.03	77	78	64	66	mean
3	18	0.23	21	12	14	16	sd
3	26	-0.25	58	70	34	30	minimum
3	81	0.50	100	92	83	82	maximum
3	55	0.75	42	22	50	52	difference
4	61	-0.20	89	81	54	57	mean
4	17	0.17	13	10	19	17	sd
4	27	-0.45	76	71	30	29	minimum
4	82	0.05	100	92	81	81	maximum
4	54	0.50	24	20	51	53	difference
5	69	-0.04	58	83	69	69	mean
5	13	0.31	37	8	18	14	sd
5	42	-0.49	33	76	47	48	minimum
5	85	0.50	100	92	100	93	maximum
5	44	0.99	67	16	53	45	difference
6	63	-0.14	63	78	57	60	mean
6	21	0.31	32	12	22	21	sd
6	17	-0.54	39	70	21	19	minimum
6	83	0.50	100	92	88	86	maximum
6	66	1.04	61	22	67	67	difference

Appendix 12: Example of key 'topic areas' identification from SWMP policies. Example shows page 1 of draft policy SW-WQ-1. Sample of key areas identified for mapping against South West England OHI+ data include but are not limited to oil, sediment, sewage, nutrients, heavy metals and thermal pollution.

Policy drafting template SW-WQ-1

HLMO	Living within environmental limits	**Sub bullet(s)**	Healthy marine and coastal habitats occur across their natural range and are able to support strong, biodiverse biological communities and the functioning of healthy, resilient and adaptable marine ecosystems.
Grouping	Water quality	**Code**	SW-WQ-1

Policy

SW-WQ-1
Proposals that may have significant adverse impacts upon water quality, including upon habitats and species beneficial to water quality, must demonstrate that they will, in order of preference:
a) avoid
b) minimise
c) mitigate significant adverse impacts

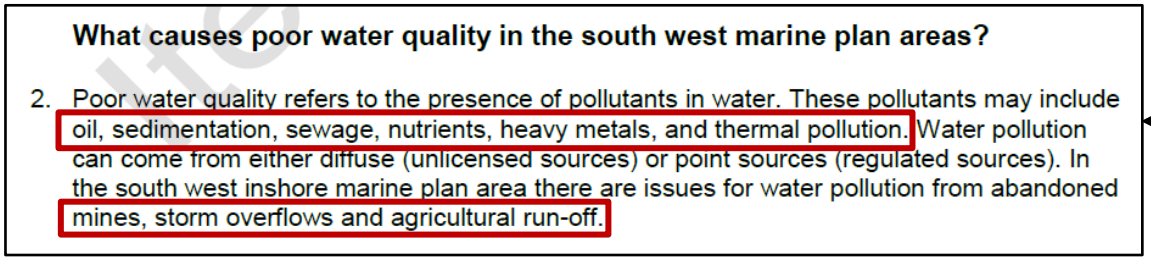
What is water quality?

1. Water quality is a measure of the condition of water and its suitability to sustain a range of uses for both biotic and human benefits. Good water quality is important in meeting the UK government's vision for clean, healthy, safe, productive and biologically diverse seas and oceans (Marine Policy Statement). Water quality in respect of the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 is defined by specific biological, physico-chemical and hydromorphological criteria. The objectives of the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 to protect and improve water quality, set ambitious environmental goals and actions which are implemented by River Basin Management Plans. This policy seeks to complement these objectives and River Basin Management Plan implementation.

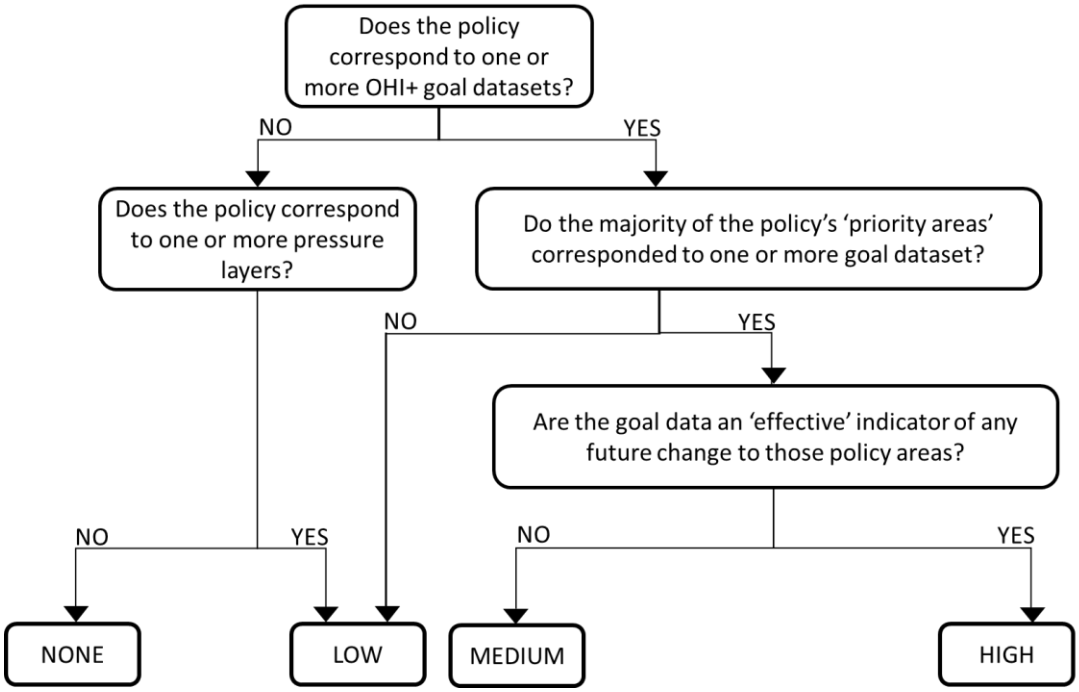
What causes poor water quality in the south west marine plan areas?

2. Poor water quality refers to the presence of pollutants in water. These pollutants may include oil, sedimentation, sewage, nutrients, heavy metals, and thermal pollution. Water pollution can come from either diffuse (unlicensed sources) or point sources (regulated sources). In the south west inshore marine plan area there are issues for water pollution from abandoned mines, storm overflows and agricultural run-off.

3. Water quality is also affected by:
   - physical modifications to water ways
   - changes to the natural flow and level of water
   - negative effects of invasive non-native species
   - resuspension of sediment
   - extreme weather such as drought followed by intense rainfall
   - seasonal population variation



Appendix 13: Decision tree used to map SWMP policies against South West England OHI+ goal datasets and assign ranks to draft policies.



Appendix 14: Goal weighting

Isles of Scilly data used as an exploratory case study

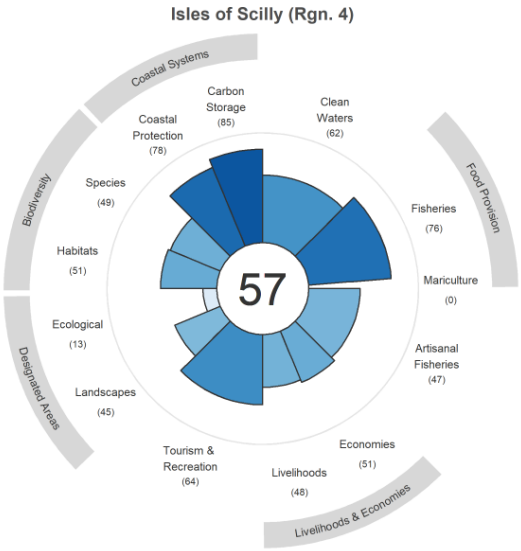
Classification	Natural products	Food	Fishing communities	Carbon storage	Coastal protection	Culture & identity	Livelihoods & economy	Tourism & recreation	Clean waters	Biodiversity	Energy	Education & Science
Very important	37	66	66	53	65	41	61	61	93	80	48	66
Moderately important	33	31	33	26	32	43	37	36	15	23	41	29
Slightly important	34	9	9	7	10	20	13	13	0	3	17	16
Not at all important	4	7	5	2	0	1	1	2	1	1	1	0
Don't Know	2	0	1	19	3	5	0	0	3	5	4	1
(blank)	9	6	5	12	9	9	7	7	7	7	8	7
Applicable OHI Goal		FIS & MAR	AO	CST	CPR	ECL & LAN	LIV & ECO	TR	CW	SPP & HAB		

Raw survey data

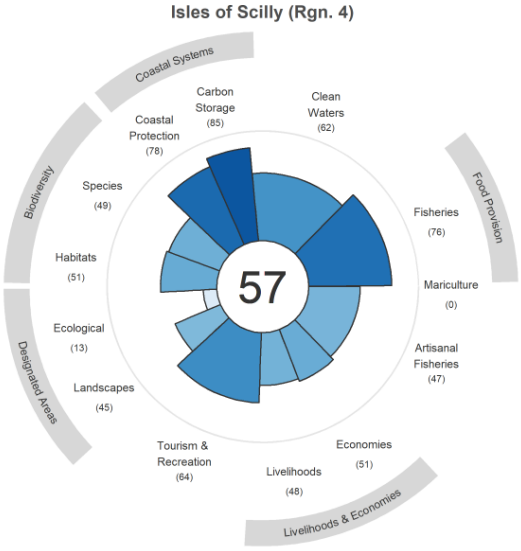
- each classification assigned a score (1 [not at all important] to 4 [Very important])
- multiplied number of respondents by ranked score for each 'goal'
- calculated an aggregated score (sum) for each 'goal'
- then proportionalised these aggregated scores as a total of all goal scores
- where a survey category comprised 2 sub-goals (e.g. livelihoods & economies) the proportion would have been divided between the goals equally (except for 'Food' which I divided between FIS and MAR using the wild caught weight proportion)

Final weights

Goal	Name	Weight
MAR	Mariculture	0.011042
FIS	Fisheries	1.001213
CW	Clean Waters	1.107652
CST	Carbon Storage	0.405432
CPR	Coastal Protection	0.498178
SPP	Species	0.524677
HAB	Habitats	0.524677
ECL	Ecologically Important Areas	0.442531
LAN	Valued Landscapes	0.442531
TR	Tourism & Recreation	1.006956
LIV	Livelihoods	0.506128
ECO	Economies	0.506128
AO	Artisanal Fisheries	1.022855



Unweighted: index score 57.20



Weighted: index score 57.23

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