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Habitat mapping in the European Seas - is it fit for purpose in the marine restoration agenda?

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ABSTRACT

As habitat mapping is crucially important for developing effective management and restoration plans, the aim of this work was to produce a census of available map resources at the European scale focusing on: a) key marine habitats; b) degraded habitats; c) human activities and pressures acting on degraded habitats, and d) the restoration potential of degraded habitats. Almost half of the 580 map records were derived from grey literature and web resources but contained no georeferenced files for download, thus limiting further use of the data. Biogeographical heterogeneity was observed and varied between the type and quality of information provided. This variability was mainly related to differences in research efforts and stakeholder focus. Habitat degradation was assessed in only 28% of the map records and was mostly carried out in a qualitative manner. Less than half of the map records included assessments on the recovery/restoration potential of the degraded habitats, with passive restoration by removal of human activities being the most commonly recommended measure. The current work has identified several gaps and challenges both in the thematic and geographic coverage of the available map resources, as well as in the approaches implemented for the harmonized assessment of habitat degradation. These should guide future mapping initiatives in order to more comprehensively support and advise the marine habitat restoration agenda for better meeting the objectives set in relevant policy documents and legislative acts in Europe.

Keywords:

Habitat mapping

Habitat degradation

Restoration

Management

Pressures

Introduction

Worldwide, we are observing widespread habitat loss and degradation in estuarine, coastal and marine systems (Lotze et al. 2006) as a result of multiple human activities and pressures (Halpern et al. 2008; Claudet and Fraschetti 2010; Halpern et al. 2015) and a lack of efficient conservation measures at large scales (Fiorentino et al. 2017). This significantly impacts upon the health of ecosystems, resulting in unpredictable changes in the provisioning of ecosystem goods and services (Worm et al. 2006) with a reduction of the resilience of ecosystems to pressures such as climate change (Folke et al. 2004; Hughes et al. 2017a,b). A number of global and regional targets have been established to catalyse conservation efforts in an attempt to prevent and mitigate habitat loss, and to restore degraded habitats. For example, the Convention on Biological Diversity (CBD 2014) identified restoration as a key action for delivering essential ecosystem services (Aichi Biodiversity Target 14), with the global target of restoring at least 15% of degraded ecosystems by 2020 (Aichi Target 15; CBD 2014). Within Europe, the 2020 headline target of the European Union's (EU) Biodiversity Strategy to 2020 states that "*Halting the loss of biodiversity and the degradation of ecosystem services in the EU by 2020, and restoring them in so far as feasible, while stepping up the EU contribution to averting global biodiversity loss*" with explicit target of "*restoring at least 15% of degraded ecosystems*" (European Union 2011). As the degradation of land and marine ecosystems undermines the well-being of 3.2 billion people, the recent (1/3/2019) UN Decade on Ecosystem Restoration 2021-2030 aims to massively scale up the restoration of degraded and destroyed ecosystems as a measure to fight climate change and biodiversity loss and to enhance food security.

To reach the above targets it is essential to both quantify the spatial extent of key habitats (e.g. habitats of conservation interest) as well as to identify their status and trends. Within Europe, several legislative acts at the pan-European (e.g. the EU Habitats Directive) and national/regional levels have resulted in multiple projects targeting habitat mapping on extensive sea areas (Boero et al. 2016). In order to store, process, and disseminate this information the "European Marine Observation and Data Network" (EMODnet) have produced a broad scale online map viewer by assembling point datasets and habitat distribution models from different sources (www.emodnet.eu/seabed-habitats). Its usefulness lies in its total coverage for the European Seas and the standardisation of habitat classification, which is in accordance with the European Nature Information System (EUNIS). EMODnet is also working on a thematic portal on human activities (http://www.emodnet.eu/human-activities) to collate georeferenced data which might be helpful as a proxy for where degraded habitats may occur. In a recent census of mapped resources of human activities and pressures acting on key European marine habitats, Dailianis et al. (2018) reported the existence of a multitude of available maps, however lacking standardization, sufficient spatial resolution, accuracy and potential for synthesis.

While several efforts are currently being carried out to combine the existing information about habitat mapping and to standardize habitat classification (e.g. Evans et al. 2016), our knowledge about habitat status is still very limited, despite this being required for the "Good Environmental Status" (GES) biodiversity and seafloor integrity assessments (Descriptors 1 and 6, respectively) under the Marine Strategy Framework Directive (MSFD). Although commonly agreed (e.g. by Member States for EU directives) thresholds do not exist on the acceptable extent of adverse effects or the extent of loss, common definitions of "degraded habitats" include those habitats that have lost – to some extent – ecosystem structure, function and service provision (Abelson et al. 2016a). This could be either based on comparisons with reference areas featured by undisturbed habitats or with past states (e.g. historical data) but the line is often arbitrary without any knowledge of baselines, clear cut assessment criteria and thresholds and uncertainties related to describing the reference ecosystem (e.g. functions, processes, extent) (Keith et al. 2013; Abelson et al. 2016b). The lack of habitat-specific sensitivity thresholds and concise degradation status classification limits the linking between habitat distribution and existing human activities and pressures thus impeding decisions for management and restoration initiatives (Dailianis et al. 2018). This particularly applies to ecosystems where significant data gaps remain such as those of the deep-sea (Danovaro et al. 2017a).

The aim of this work is to assess: a) map availability for European key marine habitats and seabed geomorphological features supporting assemblages of high conservation interest, b) sources of degraded habitat maps by regional sea and habitat type, c) records of corresponding human activities and pressures from those degraded habitat sources, and d) associated recommended actions towards reversing degradation, recovery and habitat restoration. This is an attempt to provide a baseline for future data collection, in support of conservation, restoration and maritime spatial planning activities at the European scale.

Methodology

Our search focused on fifteen key marine benthic habitats and seabed features supporting assemblages of conservation interest according to the European and other international legislation, namely the EU Habitats Directive (92/43/EEC), the Convention for the Protection of the Marine Environment of the North-East Atlantic – OSPAR (1992), the Convention on the Protection of the Marine Environment of the Baltic Sea Area (Helsinki, 1992) and the "Protocol for Specially Protected Areas and Biological Diversity in the Mediterranean" of the Barcelona Convention (2013). The habitats considered in this study were:

Sublittoral soft-bottom:

- Seagrass beds (*Posidonia* spp., *Zostera* spp., and other seagrasses)
- Other sublittoral soft-bottom habitats

Sublittoral hard-bottom:

- Maërl beds
- Coralligenous formations
- Gorgonian forests and sponge beds
- Macroalgal forests/beds (*Cystoseira*, kelp or other canopy-forming algae)
- Other sublittoral hard-bottom habitats

Deep-sea (>200 m depth):

- Coral gardens
- Sponge aggregations
- Mixed coral/sponge aggregations
- Seamounts
- Hydrothermal vents
- Carbonate mounds
- Canyons
- Other deep-sea habitats

The geographic extent of our study involved all European sea basins according to the MSFD regions (and their sub-regions), as well as Norwegian and international waters in the North-East Atlantic Ocean, not included in the MSFD categories. Our study focused mainly on map resources published within the last three decades, covering large geographic areas (e.g. sea basins, MSFD regions and national waters).

A standard web search was performed, supplemented with queries in two research databases (ISI Web of Science and Scopus) in order to ensure maximum coverage of the published evidence. Keywords included “map”, “marine”, the examined benthic habitats/seabed features (e.g. maërl, coralligenous, *Posidonia*, *Zostera*, corals, sponges, canyon, etc.), or more general terms (deep sea, seagrass, etc.), and several geographic areas (Europe or the four MSFD regions, i.e. Baltic Sea; North-East Atlantic, Mediterranean Sea and Black Sea). The same search was applied adding the keyword “degraded” for each habitat/feature separately, to identify potential map resources for degraded habitats. The first 100 results per search were scanned, a) in order of relevance and b) ranked by year from 1990 to date (end of 2016).

The cut-off point for the first 100 results was internally defined based on the fact that irrelevant publications generally started to dominate after around first 50 search results. All keyword search results were carefully screened for their relevance to the geographic and thematic scope of our initiative. Sources providing maps for the distribution of a specific feature in several sub-regions were catalogued as multiple records. Synthetic maps and multi-layered viewers including maps on various habitat types and seabed features which were catalogued under the category "Broad scale". In addition, resources of national/international organizations, commissions and agencies dealing with marine habitats, conservation and management (i.e. EEA: European Environment Agency; FAO: Food and Agriculture Organization; HELCOM: Baltic Marine Environment Protection Commission; IUCN: International Union for Conservation of Nature; MarLIN: Marine Life Information Network; OCEANA; OSPAR; RAC/SPA: Regional Activity Centre for Specially Protected Areas) and all the European projects registered in the European Marine Spatial Planning platform (http://www.msp-platform.eu/), were also reviewed. We added these resources to enhance the coverage of our work. However, we aware that a search of grey literature cannot be complete since: 1) it depends on the subjective knowledge of the experts, 2) it is not indexed in Web of Science or Scopus, 3) it has low standard of repeatability, 4) it is not necessarily in English, and 5) it is not necessarily available on the Internet. Information that was not instantly available for download was considered as not available in general.

Acknowledging the variability with regard to the characterization of a given habitat as "degraded", all map records for the examined degraded habitats were reviewed and classified as:

- *Assessed*: degradation status formally assessed under well-defined criteria using habitat-specific methodology, undertaken by expert groups under international organizations and commissions (e.g. IUCN European Red List of Habitats, HELCOM

Red List Biotope Information Sheets, European Environmental Agency, Reports under the Article 17 of the Habitats Directive, and OSPAR Commission).

- *Observed*: degradation status observed at the case study level by individual field studies using various response variables (e.g. decline in coverage, loss of habitat-forming key species, etc.).
- *Modelled*: degradation status modelled in studies developing or applying cumulative impact assessments.
- *Assumed*: some level of degradation was assumed or expected to exist due to the presence of specific activities and pressures which potentially cause habitat degradation.

Furthermore, in an effort to link the reported degradation with activities and pressures acting on habitats, all records for degraded habitat maps were annotated with the activities and pressures present. The list of activities, endogenous (i.e. those emanating from within the system and are directly manageable) and exogenous pressures (i.e. those emanating from outside the system and cannot be directly managed) was derived from Smith et al. (2016) and is described in detail in Dailianis et al. (2018). Additional information on the extent of degradation (quantitative or qualitative), the recovery/restoration potential (positive or low/poor) and, where available, the suggested ecological restoration practice (i.e. active restoration/assisted regeneration approaches, passive restoration/unassisted natural regeneration by removal of activities, or combination, *sensu* McDonald et al. 2016) were also reported for each degraded habitat map record.

Results

Key marine habitat and degraded habitat map sources

A total of 580 map records were identified, 379 for key marine habitats and 201 for degraded habitats, containing maps from all European sea basins as well as global scale maps (Supplementary online material). A considerable proportion of the habitat map records (58%) were derived from grey literature sources (mainly project reports, online resources and websites), while peer-reviewed papers were the main source for degraded habitats maps (67% - Fig. 1). However, in both cases, most resources provided only images of maps (84% in total), while accessible georeferenced layers (e.g. GIS) and online web viewers accounted for small percentages (<10%).

Habitat map records covered the Mediterranean Sea (43%) and the North-East Atlantic (33%), followed by the Baltic Sea (11%) and a small percentage (3%) from the Black Sea (Fig. 2). In addition, 10% were from non-EU regional seas or global maps. Within the two dominant regions, the Western Mediterranean Sea and North Sea sub-regions were represented by the highest numbers of habitat map records, while the Central Mediterranean Sea and Macaronesia sub-regions were covered by the smallest numbers of records.

A high percentage of the identified map records related to a specific habitat (79%) (Fig. 3), with sublittoral soft substrate (28%) and deep-sea habitats (26%) dominating, followed by sublittoral hard substrate habitats (23%) and broad scale maps (21%) (i.e. synthetic maps and multi-layered viewers including maps on various habitat types and seabed features). *Zostera* seagrass meadows, deep-sea coral assemblages (also known as cold-water corals), and macroalgal beds (e.g. *Cystoseira* spp. and kelp) were the most highly represented habitats of the above-mentioned major habitat categories.

Similarly, the majority of degraded habitat maps covered the Mediterranean Sea (46%) and the North-East Atlantic (30%), and to a lesser extent the Baltic (16%) and Black seas (2%) (Fig. 4). Sublittoral habitats again dominated, with 32% and 25% of the records for hard and soft substrates, respectively, followed by deep-sea habitats (20%) (Fig. 5). The most commonly reported degraded habitats were macroalgal beds, *Zostera* seagrass meadows and deep-sea coral assemblages.

Assessment status and extent of habitat degradation

In the majority of map records for degraded habitats (48%), the status of degradation was inferred by the presence of some form of negative impacts (e.g. shift from *Cystoseira* to barrens or turf) or a decline / loss of habitat-forming key species. Whilst in 28% of records degradation was directly assessed, 11% were predicted from modelled cumulative impact scores / assessments. In most map records, assessed habitats (91%) were reported to be in an "Unfavourable/Sub-GES" environmental status. The manner by which degradation was evaluated varied spatially, with the North East Atlantic having a larger percentage of records in which degradation was assessed while Baltic and Mediterranean had a large percentage of records in which degradation was "observed" (Fig. 6). Degradation status was predominately "observed" in sublittoral habitat types, while in the deep sea it was largely assessed and assumed (Fig. 6).

In most degraded habitat map records, information relating to the extent of degradation was absent or descriptive and qualitative in nature (37% each) while numerical/quantitative information was present in only 25% of the records – predominately in sublittoral soft and hard substrate habitats of the Mediterranean Sea, where it was usually expressed as a percentage of habitat loss. However, in a few cases different case-specific metrics were used, such as decrease in seagrass biomass, shoot density or density of gorgonians at a given site.

Activities and pressures reported on degraded marine habitats

Extraction of living resources was the most reported activity in the three major habitat types investigated (Fig. 7). Unspecified activities leading to eutrophication was the most common threat in broad scale maps. Interestingly, research activities were identified as a potential threat for deep-sea habitats, along with extraction of non-living resources (e.g. oil, gas and mining) (>10 records each).

The most frequently reported types of endogenous pressure differed between habitats, with changes in siltation and light along with abrasion mainly reported on sublittoral soft and hard substrates (about 20 records each) (Fig. 8). Nutrient enrichment and organic matter inputs were the most highly reported pressure types in broad scale map records. Thermal regime change, and climate change were the most frequently reported types of exogenous pressure in most examined map records (Fig. 9).

Recovery/restoration potential of degraded marine habitats and suggested actions

Less than half (40%) of the map records for degraded habitats included information on their recovery/restoration potential. Of these 40% indicated that there is potential for restoration/recovery, based on experts' opinion or quantitative assessments; another 14% indicated a low/poor potential for recovery/restoration. The latter was mostly reported for deep-sea habitats, including cold-water coral reefs and sponge assemblages in the North-East Atlantic.

The majority of map records (72%) did not suggest specific restoration actions for the reported degraded habitats (Fig. 10). Of those that did, the most frequent was passive restoration by removal of activities causing degradation (20%), such as the adoption of restrictions to fishing activities (e.g. bottom trawling) or the establishment of Marine Protected Areas. Active restoration was suggested as a measure in only 6% of records, with 2% suggesting a combination of passive restoration/removal of activities and active restoration.

Discussion

A fundamental requirement for managing and restoring degraded habitats is their identification, classification and mapping along with their status. This study highlights the availability of map resources describing the distribution of key habitats and their degree of degradation within European Seas and identifies gaps in our knowledge. Whilst considerable effort has been invested to collect, standardise and disseminate such information, the results are often difficult to access. In addition, the information is spatially fragmented and based on different methodologies, thereby hindering effective and efficient conservation and management activities. Marine ecosystem restoration is shaped by various motivations and uncertainties, for example incomplete knowledge and unpredictability (Ounanian et al. 2018). However, efforts to narrow information gaps are essential to help identifying habitats requiring restorative actions, and to inform integrated spatial planning and management (Long et al. 2006).

This study, although non-exhaustive, covered a considerable variety of sources in terms of different geographical areas, habitat types and features for both key marine habitats and degraded marine habitats. Key habitat records were unevenly distributed across geographic regions with most map sources originating from the Mediterranean Sea, the North-East Atlantic and the Baltic Sea. This result is consistent with general availability of knowledge and synthesis of regional marine biodiversity in the European Seas (Narayanaswamy et al. 2013 and references therein). Relatively higher proportion of habitat maps in the Mediterranean Sea can be due to very rich habitat diversity, associated with geological and geomorphological peculiarities of the region compared with the North-East Atlantic Ocean and the Baltic Sea (e.g. Danovaro et al. 2010 and references therein). Habitat mapping has been a long-term focus of many initiatives and is still high on the research agenda in these regions (e.g. through the Barcelona Convention in the Mediterranean, the OSPAR Convention in the North-East Atlantic, and HELCOM in the Baltic Sea). However, differences are also likely linked to the size of these regions, the uneven distribution of habitats across Europe (biogeographic heterogeneity) and the presence of multiple records for specific map sources (i.e. one specific source may provide maps for multiple habitats or provide maps for the distribution of a specific habitat in several sub-regions). Trends can also be seen within individual regional seas, with specific sub-regions presenting a higher number of map records than others (e.g. Western Mediterranean compared with the other Mediterranean sub-regions).

The dominance of recent key habitat map sources for sublittoral soft and deep-sea habitats can be interpreted as an indication of where research efforts and stakeholder priorities have been placed within the last few decades or where technology is still not adequately tailored towards these specific issues. Surprisingly, our study showed that sublittoral hard substrate habitats are least represented in terms of map records, even compared to deep-sea habitats that are still understudied in many respects (Danovaro et al. 2017a,b). This may reflect patchy/discontinuous distributions of sublittoral hard substrate habitats (e.g. Giakoumi et al. 2013) with more limited extent compared to soft substrates. Where sublittoral hard substrate habitats have been mapped on the local scales, they have not been scaled up to cover larger geographical areas (Zapata-Ramirez et al. 2014). Furthermore, whilst sublittoral soft and deep-sea habitats in the open sea are mapped by large oceanographic vessels, shallow hard substrate habitats are often the focus of very small-scale sampling by SCUBA diving.

Our search for maps on degraded habitats yielded a lesser number of map records compared to those for key habitats. This finding is in accordance with the recent report on the "*State of Europe's Seas*", showing that a high percentage of European seabed habitats are still not assessed in relation to their status (EEA 2015). Although there is ample literature about regime shifts and alternate states (e.g. Folke et al. 2004; Knowlton 2004; Hughes et al. 2013; Ling et al. 2015), there is currently no international consensus on habitat degradation (but see Diaz and Rosenberg 2008). This is due to both data gaps concerning the past and current status of several habitat types (e.g. deep-sea habitats), and lack of harmonised evaluation methodologies. Therefore, it is often difficult to report the extent and degree of degradation, due to differences in classification systems, monitoring methodologies and/or threshold levels adopted by different countries and/or organizations. Furthermore, several marine habitats (e.g. detritic muds, terrigenous muds, and coastal detritic bottoms) classified as “Vulnerable” or “Near Threatened” under the Red List Habitats assessments (e.g. Lindgaard and Henriksen 2011; Gubbay et al. 2016) and occurring in all sub-regions of the considered sea basins, were not present due to the lack of data available to produce distribution maps. In half of the records, the assessment of degraded marine habitats is based on observations, while degraded habitats formally assessed in an “Unfavourable/Sub-GES” status are lower in number. Whilst modelled or predicted status of degradation (e.g. Halpern et al. 2008; Korpinen et al. 2012; 2013; Micheli et al. 2013; Katsanevakis et al. 2016), gives a broad overview, and may help focus future research, they may not accurately represent the actual level of degradation on the fine scale.

Our study shows a paucity of information relating to the extent of degradation of marine habitats and their recovery/restoration potential. Furthermore, the information that is available is typically qualitative in nature and tends to be based on expert opinion relating to the spatial distribution of activities/pressures and the restorative aspects of the habitat’s key species. For example, although little information is available on the recovery potential of deep-sea features, there is a general consensus that highly impacted corals are unlikely to recover at relatively short-medium temporal scales due to their slow growth rate, high longevity, long reproductive cycles and low rates of recruitment coupled with the continuously increasing degree of human-induced impacts (OSPAR 2008; Williams et al. 2010; Carreiro-Silva et al. 2013; Montero-Serra et al. 2018).

In all major habitat types concerned, the majority of records reported multiple activities and pressures (mostly physical and chemical), suggesting that management measures are necessary. The most frequently acknowledged human activities and pressures impacting the examined types of key marine habitats are also among the most well-mapped in the European Seas (Dailianis et al. 2018). However, in the latter study the majority of catalogued maps do not contain any habitat-specific reference. These maps could provide an additional valuable resource for overlaying human activities and pressures on existing and degraded habitat maps.

Active restoration as a sole activity was suggested in very few cases and, as expected, tended to be in combination with removal/reduction of activities and threats that prevents further deterioration (Possingham et al. 2015; McDonald et al. 2016), but may also be under-represented due to the logistical constraints and cost of applying active restoration measures at large scales (van Dover et al. 2014; Bayraktarov et al. 2016; Jones et al. 2018). The assignment of the reported activities and pressures to the degraded marine habitats attempted in this study could form a first step towards identifying and linking specific drivers with degradation. Such an attempt would be useful for managing and eliminating specific activities and pressures for the protection – and restoration – of different marine habitats.

Identified data gaps and suggestions for future habitat mapping initiatives

Our study revealed several limitations and gaps in knowledge relating to the thematic and geographic coverage of information, as well as its immediate availability and data format. Similar limitations were recently identified for available map sources on human activities and pressures mapping initiatives across the European Seas (Dailianis et al. 2018). A high number of habitat map records was located in project reports, which may be provided in languages other than English. They often contained maps at relatively large scales, highlighting the importance of grey literature, as a valuable source of information. This unfolds the need for a greater effort to effectively disseminate this information to a wider audience. Furthermore, a relatively low percentage of maps contained geo-referenced information (e.g. raster and vector files, and collections of points, lines and polygons) limiting the ability to extract the data and use it in additional analyses (e.g. for conservation and marine spatial planning initiatives). This is particularly true for historical habitat maps produced prior to 1990's, which could be useful for assessing decline in extent, but have not been digitised and are not publicly available through online data search tools. A number of more recent maps could be made potentially available through formal requests to the authors, but the response rate is unknown, and the lack of immediate access and/or conditional release of data creates barriers. Nevertheless, in the near future, it is expected that many more resources will be available through coordinated implementation of current EU environmental Directives while EMODnet will increase in resolution and feature content (Boyes et al. 2016; Calewaert et al. 2016). Furthermore, it is also expected that there will be a general trend towards more open access geo-referenced data (e.g. through Horizon 2020 projects).

Consequently, it is recommended that future key marine and degraded habitat mapping initiatives focus on the following:

- Making geo-referenced spatial data freely available (inclusion in supplementary files in peer-reviewed papers or in online repositories);
- Enabling free and open access to grey literature (e.g. through online repositories);
- Production of high resolution and fine-scale habitat maps based on comparable or harmonized methodologies;

- Ground-truthing of habitat maps and reporting model uncertainties, especially in cases of habitat modelling;
- Filling thematic gaps concerning specific habitats (e.g. hard substrate and deep-sea habitats);
- Filling geographical gaps regarding specific (sub-)regions;
- Filling temporal gaps through the digitization of old/historical maps.

Conclusions

Comprehensive mapping of habitats using ground-truthed high-resolution techniques and covering all European Seas should be the ultimate target in marine habitat mapping in Europe. This will serve as baseline to monitor changes, and as a tool to ensure spatial planning initiatives and conservation actions to be undertaken using the best available knowledge to act beyond the 2020 headline target and enables meeting the 2050 vision of the EU Biodiversity Strategy "*European Union biodiversity and the ecosystem services it provides — its natural capital — are protected, valued and appropriately restored for biodiversity's intrinsic value and for their essential contribution to human wellbeing and economic prosperity*" (EU 2011). Thus, one of the ultimate priorities in this context is to understand the extent of degradation of habitats within European Seas, to evaluate it through time and to relate it to a complex suite of multiple human activities and associated, often co-occurring, interacting pressures (Bevilacqua et al. 2018). This will, amongst other, also allow frameworks to be put in place to mitigate human impacts through an ecosystem-based management and guide the marine spatial planning process (Ansong et al. 2017). Such information is required to enable marine restoration to be properly addressed, thus achieving the aims and ambitions of many policies and legislative acts in Europe and beyond. The current study provides the basic information required to design further actions along this path.

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Supplementary online material

The complete dataset, a total of 580 map records, supporting these analyses, is provided as supplemental material in the form of an excel spreadsheet. Each record contains information on habitat type, habitat features, species, depth, site location, region, regional sea, degradation, info on recovery/restoration potential, management/restoration suggestions, main activities and pressures, map source, source link, references, and comments.

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FIGURES

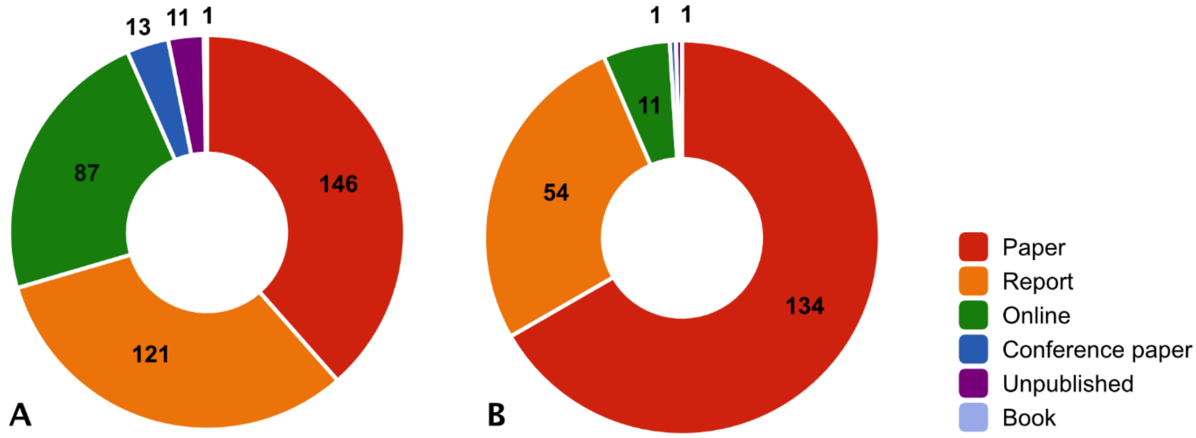

Fig. 1. Number of existing habitat map (A) and degraded habitat map resource records (B) by source type.

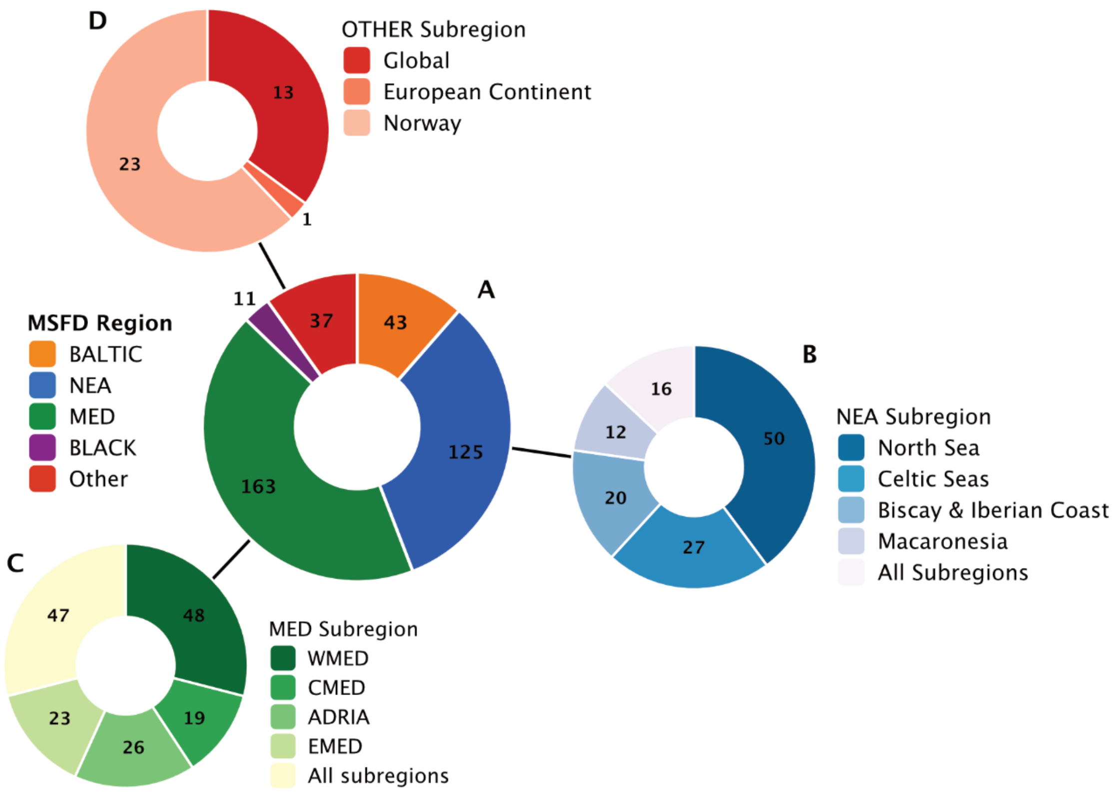

Fig. 2. Habitat map records by regions (A) and sub-regions (B-D). BALTIC, Baltic Sea;

NEA, North-East Atlantic Ocean (B); MED, Mediterranean Sea (C); BLACK, Black Sea; Other, non-EU regional seas or global maps (D); WMED, Western Mediterranean; CMED, Central Mediterranean; ADRIA, Adriatic Sea; EMED, Eastern Mediterranean.

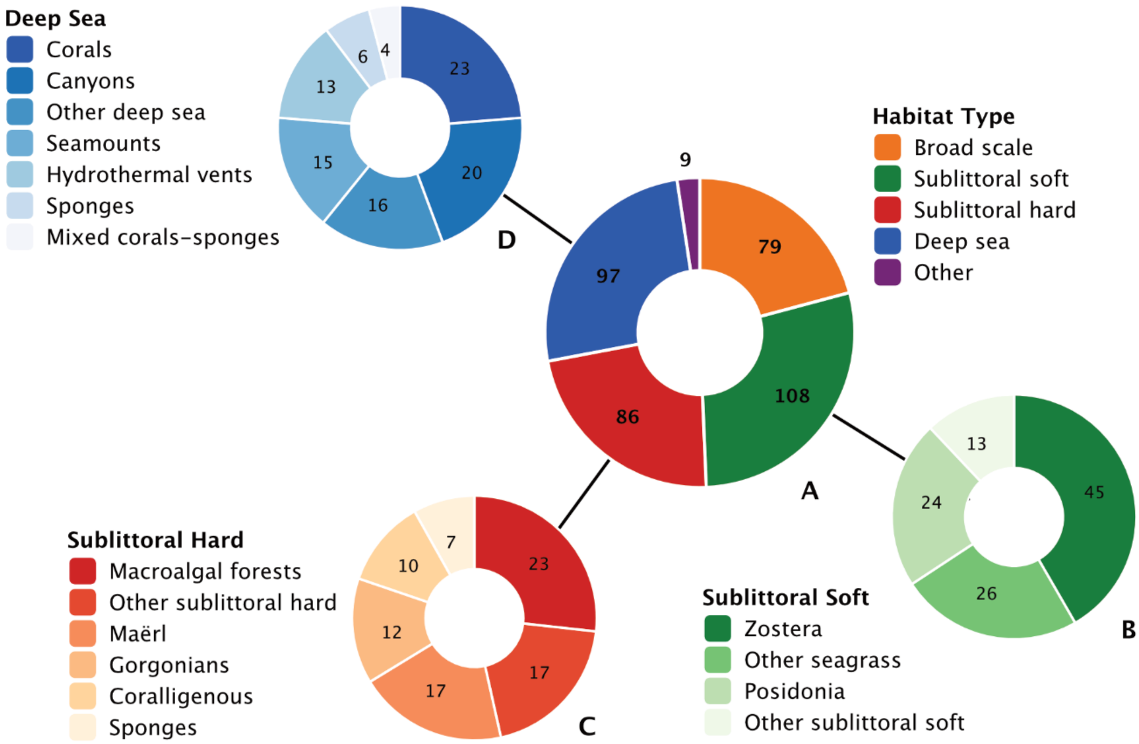

Fig. 3. Map records by major habitat type (A) and focal habitats/features: sublittoral soft substrate (B), sublittoral hard substrate (C) and deep-sea habitats (D). Broad scale, synthetic maps and multi-layered viewers including maps on various habitat types and seabed features; Other, habitats not classified into the listed categories.

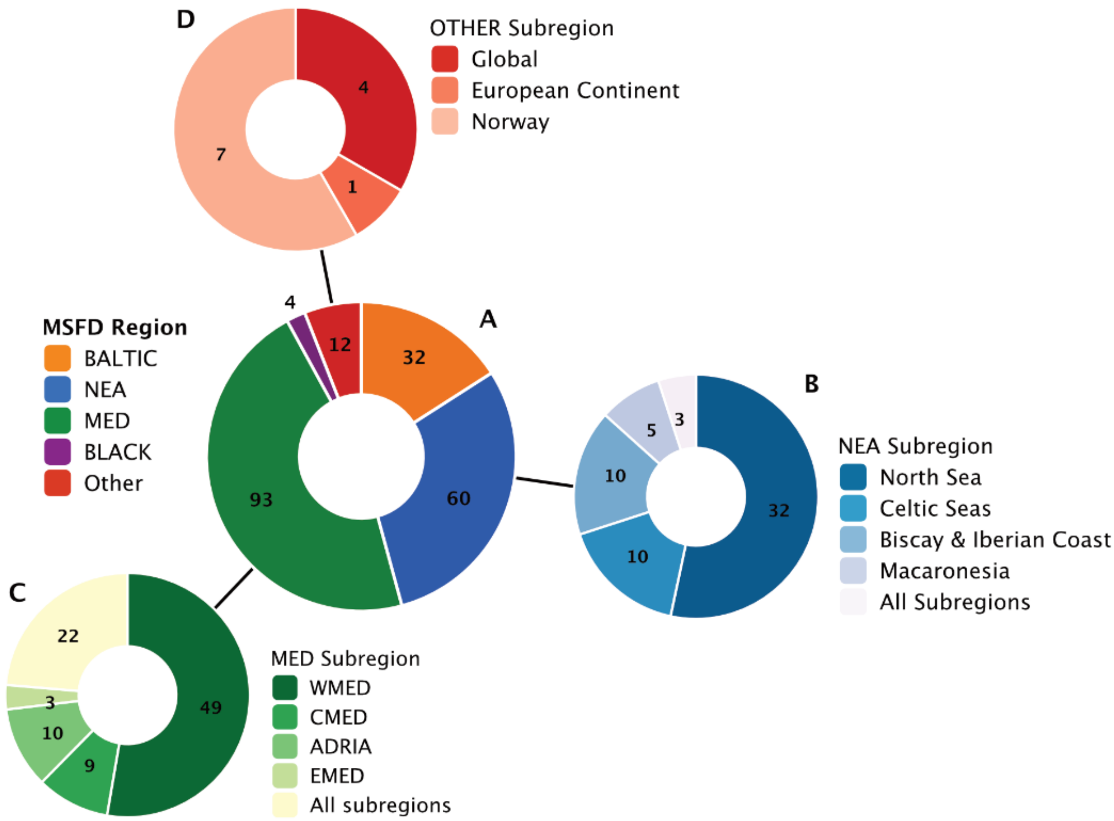

Fig. 4. Degraded habitat map records by regions (A) and sub-regions (B-D). BALTIC, Baltic Sea; NEA, North-East Atlantic Ocean (B); MED, Mediterranean Sea (C); BLACK, Black Sea; Other, non-EU regional seas or global maps (D); WMED, Western Mediterranean; CMED, Central Mediterranean; ADRIA, Adriatic Sea; EMED, Eastern Mediterranean.

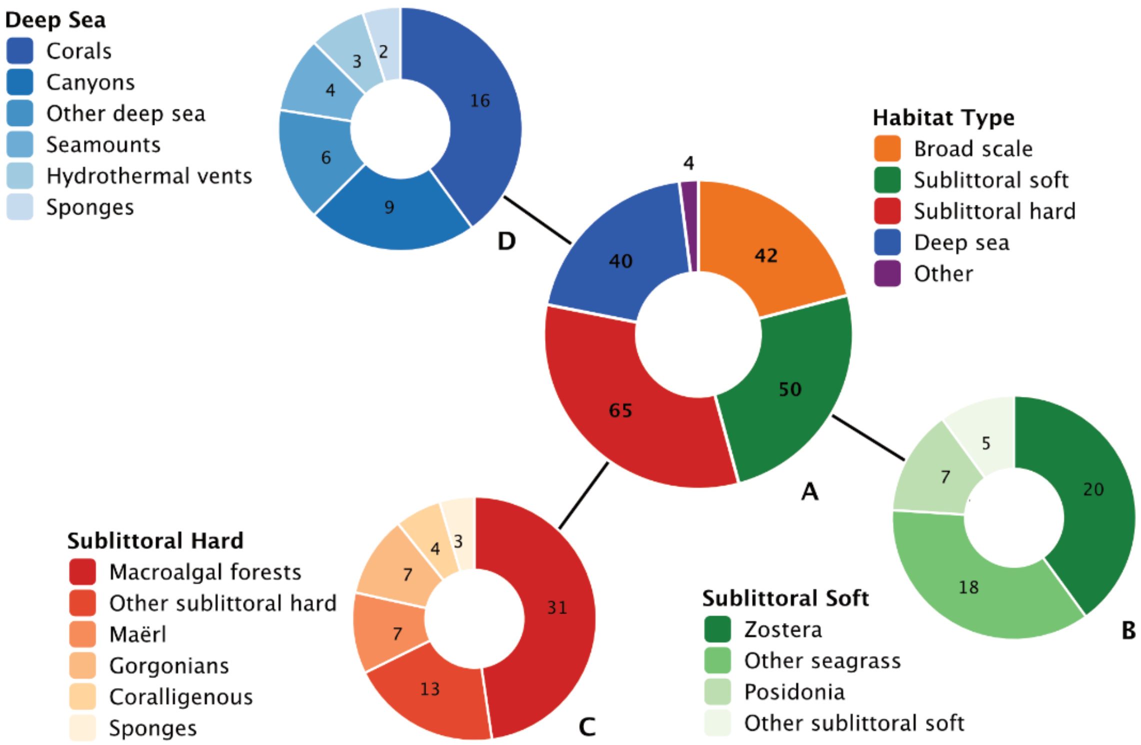

Fig. 5. Degraded habitat map records by major habitat type (A) and focal habitats/features: sublittoral soft substrate (B), sublittoral hard substrate (C) and deep-sea habitats (D). Broad scale, synthetic maps and multi-layered viewers including maps on various habitat types and seabed features; Other, habitats not classified into the listed categories.

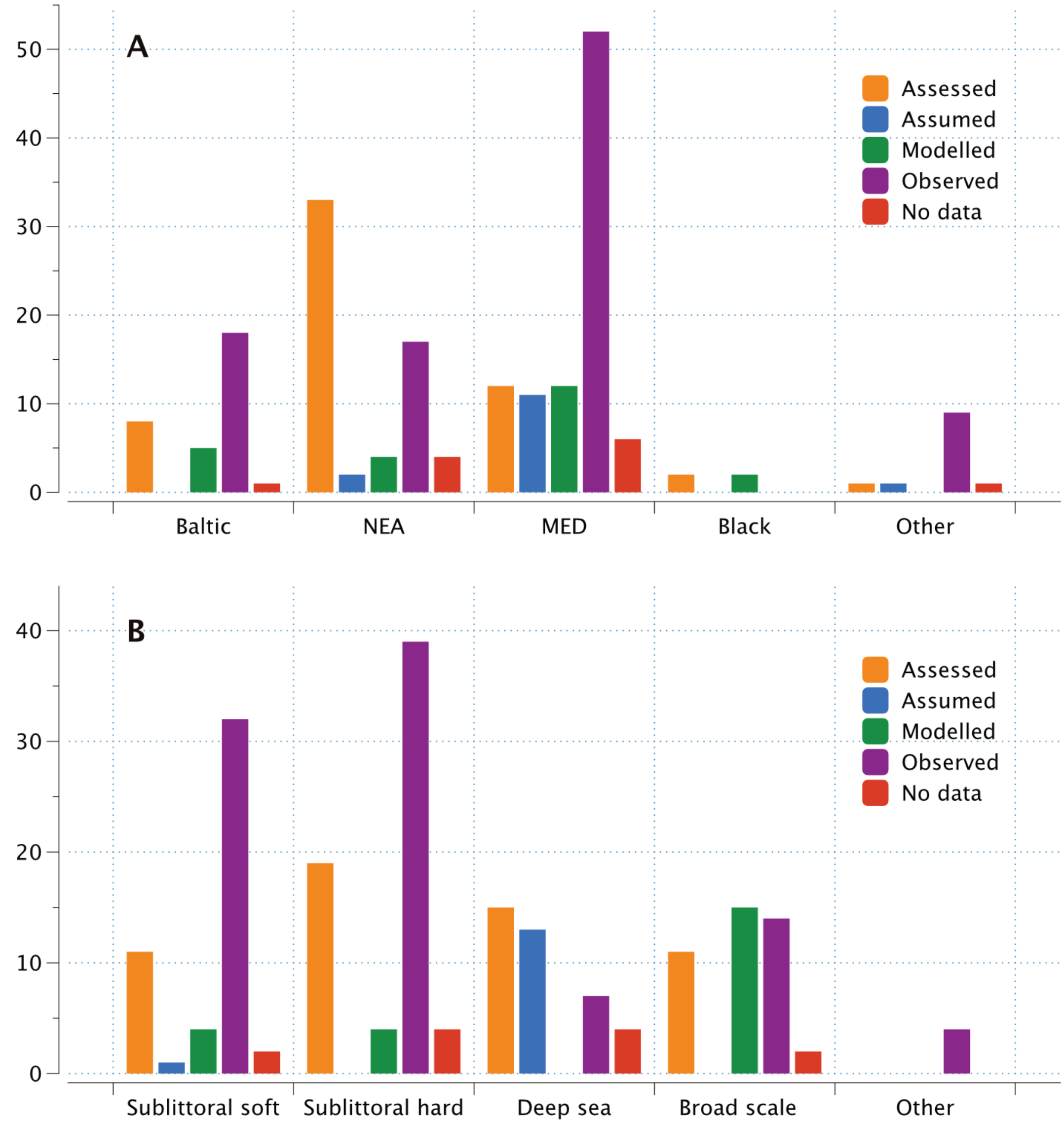

Fig. 6. Number of degraded habitat map records by region (A) and habitat (B) with respect to their assessment status. Baltic, Baltic Sea; NEA, North-East Atlantic Ocean; MED, Mediterranean Sea; Black, Black Sea; Other (A), non-EU regional seas or global maps; Other (B), habitats not classified into the listed categories.

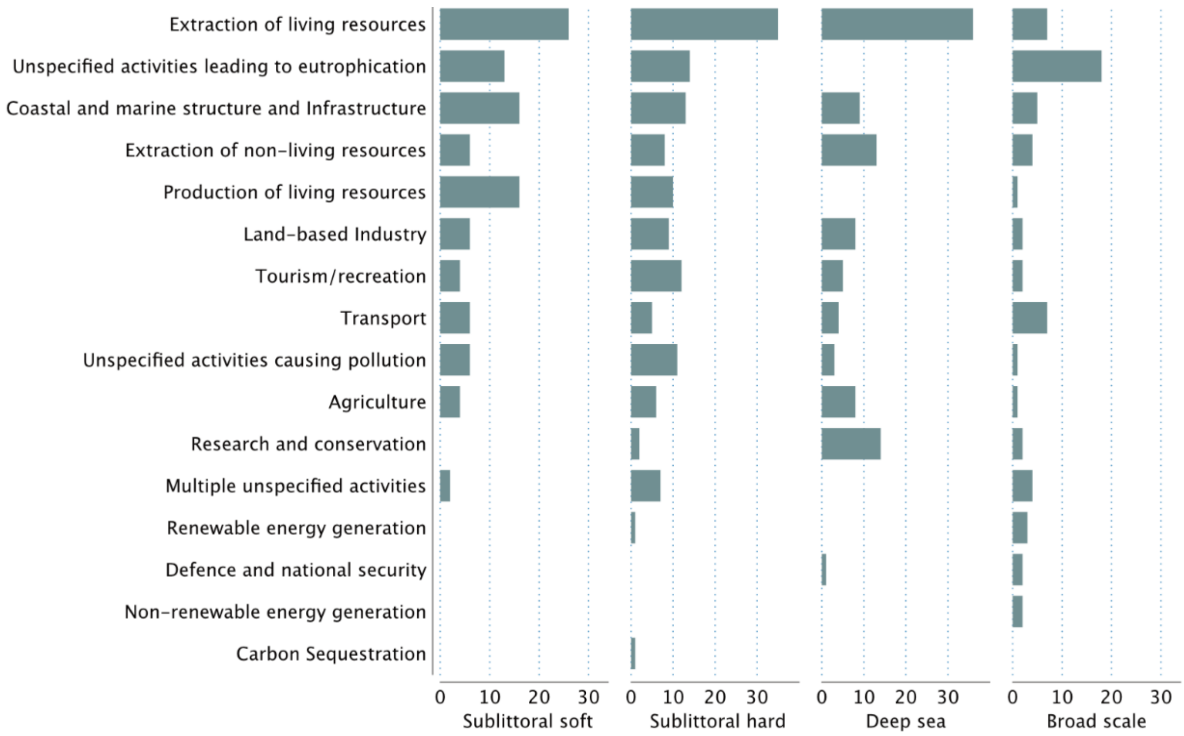

Fig. 7. Degraded habitat map records by major habitat type reporting human activities (presented in decreasing order of frequency). The list of activities was derived from Smith et al. (2016).

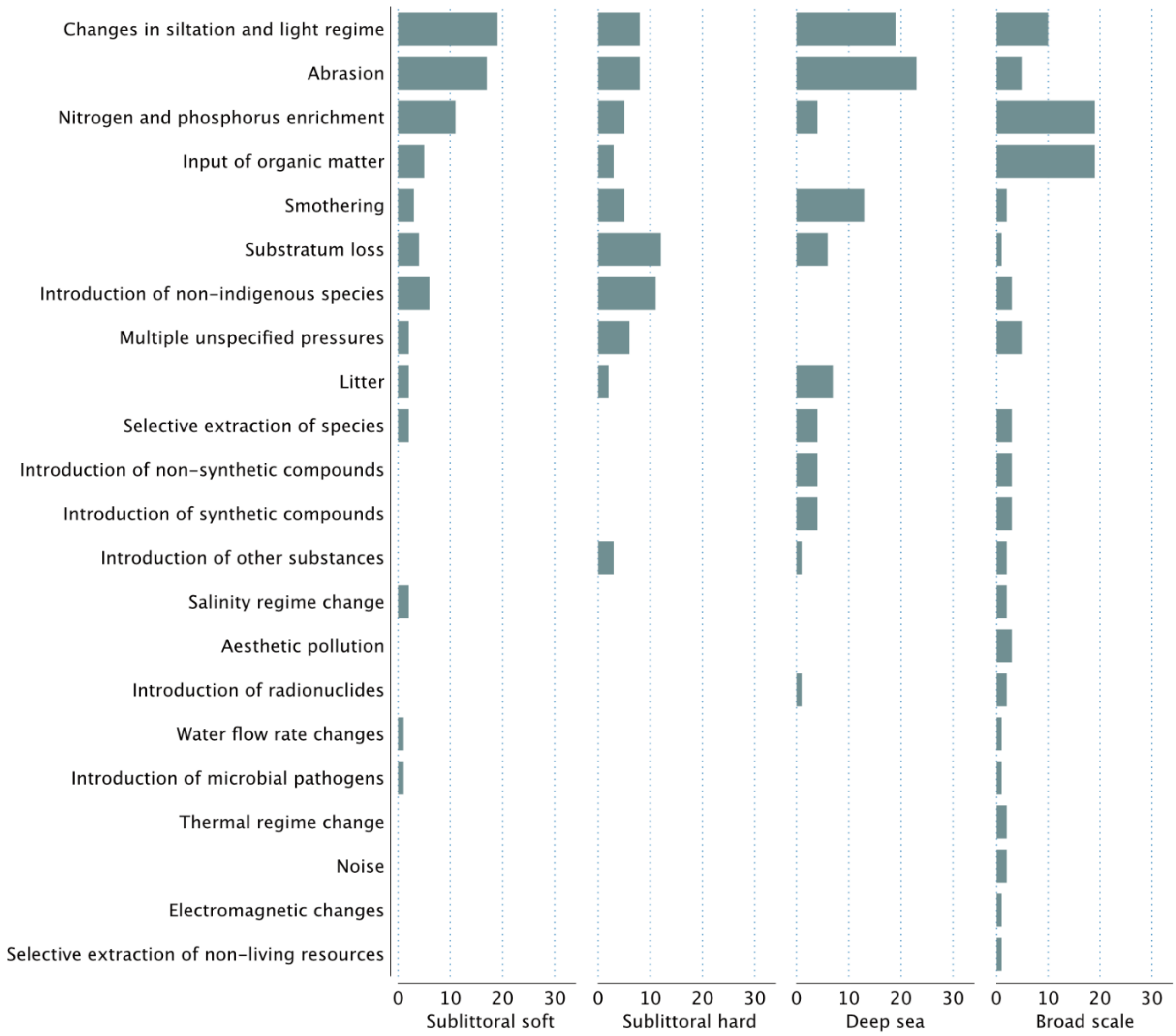

Fig. 8. Degraded habitat map records by major habitat type reporting endogenous pressures (i.e. those emanating from within the system and are directly manageable) (presented in decreasing order of frequency). The list of endogenous pressures was derived from Smith et al. (2016).

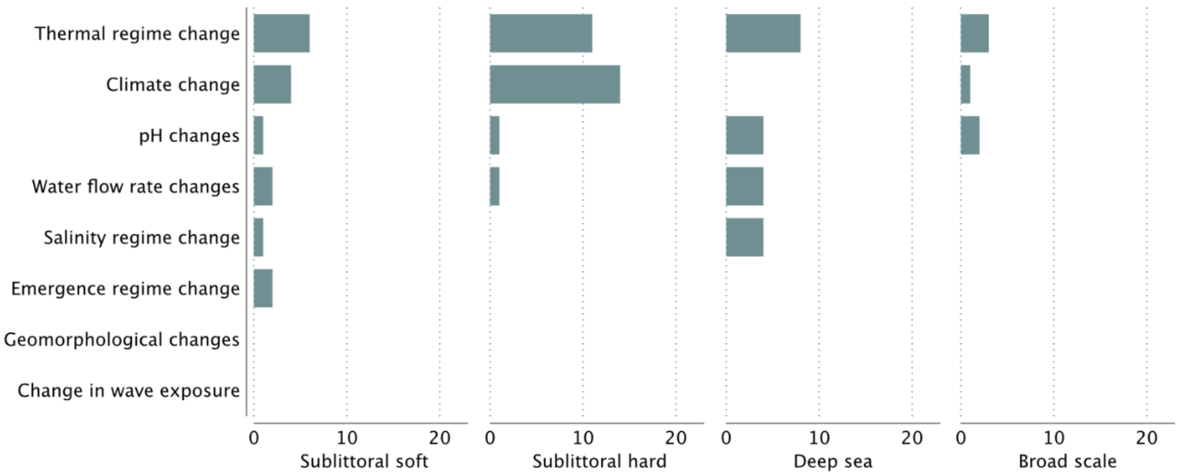

Fig. 9. Degraded habitat map records by major habitat type reporting exogenous pressures (i.e. those emanating from outside the system and cannot be directly managed) (presented in decreasing order of frequency). The list of exogenous pressures was derived from Smith et al. (2016).

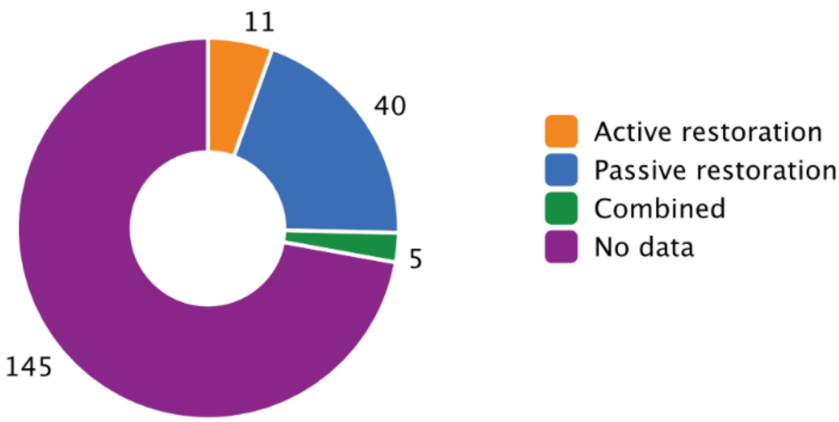

Fig. 10. Number of map records with respect to the suggested restoration action for degraded marine habitats. Combined means a combination of active and passive restoration measures.