NatureScot
Scotland's Nature Agency

**NatureScot**

**SCIENTIFIC ADVISORY COMMITTEE**

**DISCUSSION PAPER**

# HORIZON SCANNING, SEPTEMBER 2023

## Purpose

1. This is the routine Horizon Scanning paper, with a focus on marine and coastal issues. A separate paper explores climate tipping points and associated impacts in marine systems including sea surface temperatures and ocean circulation, as flagged in the March horizon scanning paper.

## Action

1. The SAC is invited to:
   * Discuss the paper, including any additional items to note, and to identify whether a deeper dive into specific issues is required (none identified / recommended based on this paper).
   * Comment on style and content, to refine future versions accordingly.

## Preparation

1. The paper was written by Clive Mitchell and Ben James with contributions from Chris Leakey, David Donnan, Cass Bromley, Liam Wright, Rona Sinclair, Eunice Pinn, Cathy Tilbrook, Corallie Hunt, Sarah Cunningham, Tracey Begg, Brodie Thomas, Erica Knott, Kelly James, Ruth Patterson, Karen Hall & Beth Scott. It is sponsored by Eileen Stuart.

## Background

1. As before, the paper groups issues based on the STEEPLE (social, technology, environment, economy, political, legal and ethics) framework, focussing on the nearer-term (1-5 years) and then longer term (5-10 years).

## Near-term - 1-5 years

1. We explore a varied subset of near-term topics in a little more detail later in this section including NatureScot’s role in the different work areas. Other potential near-term threats, risks and opportunities that were identified in the production of the paper but that are not expanded upon here include -
   * **Wider adoption of eDNA techniques**. Building on recommendations from the recent SEPA-led NatureMetrics study[[1]](#footnote-1), eDNA sampling in the marine environment has potential to facilitate a phased transition from more labour intensive, destructive and increasingly cost-prohibitive infaunal sampling. This is already starting to happen in respect of baseline and post-consent monitoring for offshore wind developments.
   * **Dynamic management**. Automated monitoring technologies may offer multiple benefits around activities such as fishing, aquaculture and shipping, allowing real time (or near real time) management responses to the presence (and absence) of marine life[[2]](#footnote-2),[[3]](#footnote-3) (see also para. 14), including in response to abrupt events such as marine heatwaves and unusual stratification events.
   * **Invasive Non-Native Species**. INNS are likely to be increasingly problematic as sea conditions change and as a result of new shipping patterns and coastal development (e.g. associated with freeports, restoration projects etc.).
   * **Pathogens & disease outbreaks**. In light of the ongoing HPAI outbreak and incidences of transmission to other mammals stimulating discussions around risks to human health[[4]](#footnote-4), this is a relevant and high profile topic but one that is hard to predict and prepare for. Arguably, we are overdue an outbreak of seal distemper (phocine morbillivirus - formerly phocine distemper virus - PDV[[5]](#footnote-5)) and ‘mouth rot’ in harbour seals off the English coast is the subject of ongoing studies[[6]](#footnote-6).
   * **Climate change**. Key issues are dealt with in a separate paper. Rapid changes in marine conditions may also affect the composition and toxicity of chemicals and associated assessment requirements.

### *Social*

1. **Supporting transformational change**. As highlighted in the March paper, a Just Transition to a nature-positive net zero world will require significant behavioural change. Recent experiences around proposals for enhanced protections in the seas around Scotland have highlighted the need for more careful approaches to co-design and co-production, closer working with communities and a better articulation of drivers for action[[7]](#footnote-7). As on land, sea use decisions will balance the need to maintain jobs and address perceived threats to food security[[8]](#footnote-8),[[9]](#footnote-9) in the face of increasing ‘spatial squeeze’[[10]](#footnote-10). Effective communication of state of the environment and climate change and adaptation messaging combined with greater use of social science insights and methods may help ensure a wider range of views is heard and acted on.

* **We support some social research projects exploring better inclusion of diverse values in stakeholder engagement processes and governance outcomes. These include (a) a PhD on incorporating cultural and heritage values of nature in marine management, including a placement with us to develop ideas specific to the MPA process, and (b) the steering group of a UK-wide project under the SMMR programme (‘**[**Integrating Diverse Values**](https://www.smmr.org.uk/funded-projects/integrating-diverse-values-into-marine-management/)**’) that includes marine governance in Shetland as a case study. We are also engaged in the Scottish Marine Energy Research (ScotMER) socio-economic receptor group which is about to publish new socio-economic impact assessment tool kits.**
* **We support local authorities in planning for our future climate at the coast, promoting long-term adaptation and resilience of our coastal communities. We are part of a steering group with Dynamic Coast and partners that has developed and published Coastal Change Adaptation Plan Guidance. This encourages collaborative working to help ensure communities, businesses and infrastructure become more resilient and can adapt to future climate change.**

1. **Youth Voice**. Youth voice for marine nature is becoming more organised, most recently with the formation of Young Sea Changers Scotland. YSCS (website under development) seeks to empower and legitimise 16-25 year-olds as influential stakeholders in marine policy. This has arisen independently but should also serve to support government ambition for more inclusive governance and stakeholder engagement processes, as identified in the Blue Economy Vision. Indeed, YSCS has been actively involved in the delivery of the first national stakeholder forum for the current National Marine Plan revision.

* **NatureScot are represented on the YSCS advisory panel. We are also supporting a linked social research PhD on ‘Including a youth voice for nature in marine planning’. This student will have a 3 month placement with us (probably during 2025-26).**

### *Technology*

1. **Automation, AI & 3D-visualisation**. Advances in technologies such as robotics, autonomous underwater vehicles (AUVs), drones, tracking devices, earth observation systems, machine learning and photogrammetry will all play an increasingly important role in servicing our survey and subsequent analysis requirements, engaging new audiences and raising awareness and understanding of marine nature and its management. In the near-term, we foresee a shift from a few, high-cost, low availability AUVs to having access to ‘fleets’ of low cost devices in Scotland, able to collect higher resolution datasets amenable to semi-automated Artificial Intelligence (AI) analyses. Project Puffin[[11]](#footnote-11), a proof of concept project that explored AI for undertaking counts of puffins at their burrows has now moved to real time analysis as part of post-consent monitoring for Beatrice wind farm. Increasingly high resolution sensors and derived datasets present challenges in but these may be offset by potential savings in field sampling and processing costs and the benefits of improved engagement.

Upward facing survey platforms with multiple sensors are improving our understanding of predator-prey interactions across whole ecosystems - providing insights into fine temporal scale bio-physical changes in the water column, associated changes in fish distribution and behaviour, as well as consequent interactions with marine bird and mammal predators[[12]](#footnote-12). Submersible gliders[[13]](#footnote-13) (e.g. Boaty McBoatface) can be used to collect data across broad sea areas between monitoring platforms[[14]](#footnote-14).

* **NatureScot is a partner in the SAMS-led SEA-AI project**[[15]](#footnote-15) **and has previously worked with Masters students looking into automated identification and quantification of maerl habitats on survey imagery. We are currently supporting a PhD exploring the development of geovisualisation technology for stakeholder engagement around different marine policy visions. We are also engaged in proof-of-concept projects with the Marine Directorate of Scottish Government delivered through CivTech (e.g. Challenge 8.4[[16]](#footnote-16)).**

1. **Semi-closed containment production - Reducing the impacts of aquaculture**. We are seeing a growing interest in novel, semi-closed containment systems in Scotland. The systems use non-permeable membranes to separate farmed fish from the wider marine environment, while also introducing waste systems, which capture a large proportion of the solids waste that would usually be deposited on the seabed. Semi-closed containment systems may offer potential solutions to a number of the key environmental impacts often associated with traditional marine open-pen systems. These include: significantly reduced sea lice levels; reduced use of chemical treatments; significantly reduced solids deposition and associated nutrient inputs; reduced predator interactions and associated need for prevention measures.

* **NatureScot will continue to input through the relevant regulatory processes to help ensure that remaining environmental impacts are appropriately assessed.**

### *Environment*

1. **Natural Capital**. We anticipate an acceleration in the uptake of marine natural capital approaches that will better represent the many benefits of nature and the state of the underlying assets in marine governance decisions[[17]](#footnote-17). These approaches can also stimulate investment in nature (see para. 16), or incentivise avoidance of impacts. Advances are being driven through the predominantly England-focussed[[18]](#footnote-18) Natural Capital and Ecosystem Assessment (NCEA) programme, but in the near-term we will be able to adapt and use the tools and techniques developed.

* **We are watching, learning and actively contributing to the marine-NCEA programme. In Scotland we are developing ideas and nascent collaborations to take forward a limited range of pilot and proof-of-concept projects, principally with Marine Directorate of Scottish Government, and Crown Estate Scotland.**

1. **Source-to-Sea (S2S)**. Source-to-sea management principles are taking hold, providing more coherent approaches that reflect the biophysical connectivity of ecosystems with siloed governance systems, and to the heart of broken earth-system processes that underpin the climate and nature crises. NatureScot has joined the global S2S platform[[19]](#footnote-19) to stimulate our ambition. In England, progress on supporting science and indicator development is being made via the ‘land-sea interface projects’ within the Defra-funded NCEA programme. Model and indicator development has also been ongoing though the Agri and Food Biosciences Institute (AFBI) in Ireland, in collaboration with Seafish and others.

* **We recently hosted an internship project, stimulating dialogue on source-to-sea approaches internally and externally. A full report is coming soon, but the topic was engaged with enthusiastically across public, academic and third sectors, including several government departments and CSA Mat Williams. Following this we joined the steering group of a 2023-24 follow-on SEFARI funded project by JHI & SRUC.**

1. **Scaling-up coastal and marine restoration projects**. There is huge interest and enthusiasm for marine restoration, although active work is still in its infancy. Scotland is unusual in that much of the active restoration is community-led and relies heavily on volunteers. This leads to strong buy-in for projects but also presents challenges for scaling-up in terms of capacity and funding.

Larger scale projects require a long-term commitment - necessitating a strategic approach and appropriate, flexible funding mechanisms. The current licensing and planning landscape will need to adapt. Site selection will also be key. There are finite suitable spaces and still gaps in the science evidence-base. Improvements are needed in key underpinning datasets (e.g. the resolution of nearshore hydrodynamic models etc.) to inform robust climate change risk assessments that should be a pre-requisite of restoration project proposals.

Scaling-up will require the adoption of new techniques. Mechanised planters, etc. are being developed and we will need to consider how the impacts of such machinery should be assessed. Sourcing sufficient plants or animals for large-scale restoration work is a significant challenge and there are already supply chain issues.

**NatureScot staff play a key role in providing advice to Scottish Government colleagues, other UK administrations and agencies, OSPAR, and active and potential restoration projects[[20]](#footnote-20) throughout Scottish inshore waters.**

1. **Improved Sea lice Regulatory Framework**. SEPA is introducing a new regulatory framework to manage sea lice interactions between farmed and wild salmonids. The proposed adaptive regime will differ substantially from the existing approach under the land use planning system. Currently out for consultation[[21]](#footnote-21), the intention is to introduce this enhanced protection in time for the 2024 wild salmon smolt run.

* **NatureScot are working closely with SEPA and other key regulators to ensure the framework addresses the issues that are core to our remit. We will respond to the public consultation and continue to work closely with SEPA as the framework is rolled out over the coming years.**

1. **Sustainable Marine Fisheries**. Marine fisheries policy in Scotland is evolving rapidly. The period up to 2030 presents an opportunity for NatureScot to contribute to significant improvements across the marine fisheries and marine protection interface. The emerging programme of work (e.g. the development of new fishery management plans - FMPs - for target stocks by the end of 2024) and delivery structures[[22]](#footnote-22) have the potential to improve the sustainability, accountability and resilience of Scottish fisheries - while also delivering against climate and ecosystem objectives. For example, the imminent introduction of remote electronic monitoring and activity tracking[[23]](#footnote-23) should provide better fishing activity information in inshore waters. This will allow better assessments of fishery / biodiversity interactions, and so better decision making on fisheries management, the management of protected areas and wider marine planning.

The challenges of sustainable marine fisheries require innovation and innovative thinking. Examples include work to reduce carbon emissions in the fleet[[24]](#footnote-24) and to reuse and recycle materials from fishing gear[[25]](#footnote-25) as part of a moves to a circular economy. Some of the best examples of innovation are conceived by industry, e.g. real time closures agreed to support recovery of the North Sea cod stock[[26]](#footnote-26). Adaptive management often involves testing or trialling approaches. These require resources to monitor and assess the associated outcomes to inform adjustments, which, in turn, will rely on strong Government, industry and academic partnerships.

1. **Marine Energy**. The continuing licensing of oil and gas resources is an ongoing environmental issue, given it has been established that existing reserves exceed global carbon budgets to limit warming to 1.5-2°C[[27]](#footnote-27).

Offshore wind is expected to play a key role in decarbonising energy production and energy security, with considerable upscaling signalled through [ScotWind](https://eur03.safelinks.protection.outlook.com/?url=https%3A%2F%2Fwww.crownestatescotland.com%2Fscotlands-property%2Foffshore-wind%2Fscotwind-leasing-round&data=05%7C01%7CBen.James%40nature.scot%7Cd151823d33274847e0c308dba4b25ef9%7C074028c0e165499999ad31603ad73bac%7C0%7C0%7C638284858220947976%7CUnknown%7CTWFpbGZsb3d8eyJWIjoiMC4wLjAwMDAiLCJQIjoiV2luMzIiLCJBTiI6Ik1haWwiLCJXVCI6Mn0%3D%7C3000%7C%7C%7C&sdata=PA7dCjvMDV4Bxeo0qxJsxximYTWsDdEt8Jc2zp2iUHg%3D&reserved=0) and [INTOG](https://eur03.safelinks.protection.outlook.com/?url=https%3A%2F%2Fwww.crownestatescotland.com%2Fscotlands-property%2Foffshore-wind%2Fintog-leasing-round&data=05%7C01%7CBen.James%40nature.scot%7Cd151823d33274847e0c308dba4b25ef9%7C074028c0e165499999ad31603ad73bac%7C0%7C0%7C638284858220947976%7CUnknown%7CTWFpbGZsb3d8eyJWIjoiMC4wLjAwMDAiLCJQIjoiV2luMzIiLCJBTiI6Ik1haWwiLCJXVCI6Mn0%3D%7C3000%7C%7C%7C&sdata=NcpIe1bXwSkTNBrh1vt2FrRSueK%2BdDE8SUW56gPwQ5g%3D&reserved=0) leasing, in addition to commercialising novel technologies such as floating wind. Scotland also has significant wave and tidal energy resources[[28]](#footnote-28). There will be a corresponding upsurge in data collection (baseline, pre- construction, construction and post construction) to evaluate impacts.

Impacts on biodiversity interests to date have largely focused on marine birds (collision, displacement and disturbance) and marine mammals and fish (underwater noise). The planned upscaling of development will mean more predicted impacts to these receptors. In addition, new impacts may emerge as evidence is collected around floating wind technology and developments move into new locations (e.g. marine mammal migratory route displacement, impacts to oceanographic fronts).

Data quality, database management/availability and long-term data collection for more ecosystem level work will become increasingly important, supported by the energy companies and coordinated across Governments, the Crown Estate (Scotland and UK) and the Offshore Wind Evidence and Change programme (OWEC) working with Marine Environmental Data and Information Network (MEDIN).

Adaptive approaches will be needed to manage uncertainties. Reviews of post-consent monitoring will need to inform adjustments, potentially including different approaches to data collection as well as assessment tools and techniques. Other events that may change predicted impacts, e.g. HPAI implications for seabird species and colonies, will need to be factored into assessments.

Offshore infrastructure will be complemented by coastal and onshore works - both for specific projects and to meet collective needs, including grid reinforcements, redesign and upgrades. These works are likely to be technically, environmentally, politically and potentially legally challenging.

* **NatureScot continue to input through the relevant regulatory processes to help ensure that environmental impacts are appropriately recognised and assessed. We produce guidance, support externally funded research and provide advice on spatial planning for energy infrastructure as well as emerging Government policies on energy targets and biodiversity loss.**

### *Economy*

1. **Investment in the marine environment - NRF, SMEEF, financing & credits**. Interest in new mechanisms for investing in the marine environment is growing rapidly. Work to develop carbon codes (initially for saltmarsh) and biodiversity credits for marine and coastal habitats is underway. There has been significant recent investment in coastal and marine enhancement and restoration work funded by Scottish Government through the Nature Restoration Fund[[29]](#footnote-29) and increasingly from private finance contributions to the Scottish Marine Environmental Enhancement Fund (SMEEF - see recent Impact Report[[30]](#footnote-30)). SMEEF is rapidly maturing as a funding mechanism and a FIRNS[[31]](#footnote-31) (Facility for Investment Ready Nature in Scotland) application aims to explore options for engagement in the new market approaches as well as potential for wider Source-to-Sea projects (see para. 11). A number of greater value and longer-term contributions are now being discussed and there is growing interest in how the fund can support research collaboration and build capacity for enhancement work within coastal communities.

Overall, we anticipate that these future funding streams will provide transformative opportunities for scaling-up enhancement and tackling biodiversity loss in our coasts and seas. However, there are significant challenges to be addressed. The rush to invest in marine carbon in particular is driving some ill-informed initiatives (such as misleading offers of carbon offsets from native oyster restoration projects) that could risk credibility of green finance more widely. The evidence base on which to develop codes, credits and metrics is less advanced than those for terrestrial equivalents and gathering data in the marine environment remains costly and difficult despite technological advances.

* **NatureScot are leading NRF and hosting the small SMEEF staff team, whilst exploring options to develop the fund and scale-up its work. We are also involved in UK and Scottish Blue Carbon Forums, contributing to work on developing a saltmarsh code (potentially widened to include other ecosystem services) and supporting related research. Working closely with the new Marine Directorate Nature Enhancement Team, we will continue to develop our capacity and skills in this growing work areas so we can strategically steer investment in coastal and marine recovery and enhancement to provide maximum benefits for nature and climate.**

### *Politics*

1. **Scottish & UK Govt. priorities**. Changes in future commitments following elections (UK by 24 January 2025; Scotland May 2026) may take work in different directions.

### *Legal*

1. **2023 Judicial Review - fisheries, PMFs and NMP**. We are currently liaising with officials who are working through the implications of a recent legal challenge raised around fisheries, Priority Marine Features and the National Marine Plan[[32]](#footnote-32).

## Longer term (5-10 years)

1. The following items were identified by a recent EU report[[33]](#footnote-33) for the next 5-10 years -

### *Ecosystem impacts:*

* **Wildfire impacts** on coastal and marine ecosystems from released aerosols, particles and materials containing nutrients - such as nitrogen and phosphorus - transported to oceans via wind and rain (more of a regional/global risk than for Scotland).
* **Coastal darkening of marine waters** due to browning from organic carbon/iron/particles entering the ocean, re-suspended sediments due to dredging and other fishing activities, and algal blooms from eutrophication.

### *Resource exploitation:*

* **The untapped potential of marine collagens** and their impacts on marine ecosystems. Collagens, increasingly used in cosmetics and pharmaceuticals, were originally taken from bovine and porcine sources. New sources of collagens could be taken from farmed sponges and jellyfish, while offcuts from the fishing industry could offer a sustainable approach to collagen production. The researchers highlight the overfishing of sponges, as well as the use of sharks and other cartilaginous fish - as these species are already under pressure.
* **Impacts of deep-water fishing on the biological ocean carbon pump** (the process through which the ocean takes up excess carbon). Approximately 10 billion tons of fish, such as lantern fishes (Myctophidae), currently sequester carbon to the ocean floor, and these fish may soon be exploited by the fishing industry for aquaculture feed.
* **Extraction of lithium from deep-sea brine pools in response to the demand for batteries**. If this occurs on a large scale, it could harm deep-sea brine ecosystems which may have high levels of endemism (when a species is found in a single geographic location) and/or genetically distinct diversity (potentially offering new genetic resources to medicine).

### *New technologies:*

* **Co-location of marine activities or multipurpose projects** - for example, siting offshore windfarms in conjunction with aquaculture developments optimising spatial planning. Such activities and projects can create technical, economic and environmental challenges that could be mitigated by siting them in the same location.
* **Trace-element contamination in coastal sediments** resulting from the global transition to green technologies - for example increased use of electric-vehicle battery elements (e.g. nickel and cobalt).
* **New underwater-tracking systems to study non-surfacing marine animals** (such as ‘underwater backscatter localisation’ - a battery-free technology based on acoustic recordings). These systems could offer improved information about the movements and distribution of marine animals, but their potential impacts on species behaviour are as yet unknown.
* **Soft robotics for marine research** - this technology could be used to collect data from deeper waters, currently not easily accessible, and facilitate the safe collection of species. However, the devices used may add pollutants to deep sea regions, or be inadvertently swallowed by predatory species.
* **Long-term effects of new biodegradable materials** (e.g. biodegradable polymers) in the marine environment. The impacts of these materials remain largely unknown.

1. In addition to the extraction of lithium, there is a wider issue of deep sea mining activities for polymetallic nodules on the abyssal plains, especially in the west Pacific (but the nodules are present in all oceans). The elements they contain are used for renewable energy sources in the transition to net zero, but raise environmental concerns for ocean ecology, disturbance of carbon-rich sediments on the ocean floor and the operation of the biological pump. The International Seabed Authority, a UN affiliated regulator, has until 2025 to establish a regulatory regime for strip-mining the deep ocean. Scotland’s transition to net zero could moderate or intensify the pressure to exploit this resource, depending on the emphasis placed on demand management and circular economy principles.
2. The SAC is invited to:
   * discuss the paper, including any additional items to note, and any topics that warrant closer monitoring due to their potential to significantly impact on the marine environment or our work;
   * comment on style and content, to refine future versions accordingly.

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1. [Developing habitat scale DNA monitoring in support of post 2020 biodiversity reporting requirements](https://www.sepa.org.uk/about-us/how-we-work/our-research/tools-techniques-and-technologies/) [↑](#footnote-ref-1)
2. [Dynamic spatial zoning to manage southern bluefin tuna capture in a multi‐species longline fishery](https://www.researchgate.net/publication/229868117_Dynamic_spatial_zoning_to_manage_southern_bluefin_tuna_Thunnus_maccoyii_capture_in_a_multi-species_longline_fishery) [↑](#footnote-ref-2)
3. [FishFarmer - Automated identification of harmful algae blooms](https://www.fishfarmermagazine.com/news/automated-identification-of-harmful-algae-blooms-2/) [↑](#footnote-ref-3)
4. [Bird flu could become the next human pandemic - and politicians aren’t paying attention](https://www.theguardian.com/commentisfree/2023/may/16/research-bird-flu-humans-prepare-now) [↑](#footnote-ref-4)
5. [Longitudinal analysis of pinnipeds in the northwest Atlantic provides insights on endemic circulation of phocine distemper virus](https://royalsocietypublishing.org/doi/10.1098/rspb.2021.1841) [↑](#footnote-ref-5)
6. [Detailed exploration of 'mouth rot' in UK seal populations](https://research.tees.ac.uk/en/projects/detailed-exploration-of-mouth-rot-in-uk-seal-populations) [↑](#footnote-ref-6)
7. [Fishing News - McAllan hears HPMA concerns in Eyemouth](https://fishingnews.co.uk/news/mcallan-hears-hpma-concerns-in-eyemouth/) [↑](#footnote-ref-7)
8. [Scientists support the EU’s Green Deal and reject the unjustified argumentation against the Sustainable Use Regulation and the Nature Restoration Law](https://www.idiv.de/fileadmin/content/Files_CAP_Fitness_Check/ENGLISH_Scientists_support_Green_Deal_and_reject_attack_on_SUR_and_NRL_13.6.23.pdf) [↑](#footnote-ref-8)
9. [Row erupts between conservationists and fishing group over Lamlash Bay](https://theferret.scot/lamlash-bay-row-conservationists-fishing-group/) [↑](#footnote-ref-9)
10. [The Frightening Outlook of Fisheries Displacement - Spatial Squeeze Report Published](https://www.nffo.org.uk/the-frightening-outlook-of-fisheries-displacement-spatial-squeeze-report-published/) [↑](#footnote-ref-10)
11. [Bird’s Eye View: Cutting Edge Puffin Monitoring Pilot](https://www.sse.com/news-and-views/2021/09/bird-s-eye-view-sse-partners-with-microsoft-avanade-and-naturescot-for-cutting-edge-puffin-monitoring-pilot/) [↑](#footnote-ref-11)
12. Embling, CB *et al*. (2013). [Fish behaviour in response to tidal variability and internal waves over a shelf sea bank](https://doi.org/10.1016/j.pocean.2013.06.013), *Progress in Oceanography*, **117**: 106-117; Williamson, BJ. (2017). [Multisensor Acoustic Tracking of Fish and Seabird Behavior Around Tidal Turbine Structures in Scotland](https://ieeexplore.ieee.org/document/7820138)" in *IEEE Journal of Oceanic Engineering*, **42** (4): 948-965. [↑](#footnote-ref-12)
13. A type of AUV that uses an internal pump to change buoyancy and move up and down in the water column instead of a propeller. While not as fast as conventional AUVs, gliders offer significantly greater range and endurance, extending sampling missions from hours to weeks or months over thousands of kilometres. [↑](#footnote-ref-13)
14. National Oceanography Centre - [*Marine Autonomous and Robotic Systems* (MARS) portal](https://mars.noc.ac.uk/?times=active,2023) [↑](#footnote-ref-14)
15. [Steamlined and efficient AI assisted video analysis](https://www.sams.ac.uk/science/projects/sea-ai/) [↑](#footnote-ref-15)
16. [How can technology help us better assess and identify opportunities that will improve and increase investment in Scotland’s marine natural capital?](https://www.civtechdemoday.com/challenge-8-4-tritonia) [↑](#footnote-ref-16)
17. E.g. NERC, Defra and the Crown Estate’s [ECOWind](https://ecowind.uk/) £7M research programme - comprising 4 projects that will provide new evidence in support of marine policy and sustainable offshore wind development. [↑](#footnote-ref-17)
18. This Defra-funded programme ([NCEA](https://www.gov.uk/government/publications/natural-capital-and-ecosystem-assessment-programme/natural-capital-and-ecosystem-assessment-programme)) has explicitly switched from being exclusively-English to ‘English-focussed’ with renewed attempts to strength links and collaborations with the rest of the UK. NatureScot’s input to various projects last year is credited with inspiring this change. [↑](#footnote-ref-18)
19. [Action Platform for Source-to-Sea Management (S2S Platform)](https://siwi.org/source-to-sea-platform/) [↑](#footnote-ref-19)
20. Part of our key messaging around marine restoration is that action needs to be appropriate and necessary. Species / habitats must be suited to the proposed location and claims around the possible benefits e.g. for carbon sequestration need to have a scientifically proven basis. There is considerable value and ongoing policy action to remove pressures and allow recovery of existing habitats (passive restoration). Newly created habitats may take many years to deliver comparable benefits e.g. for carbon sequestration. [↑](#footnote-ref-20)
21. [Managing interactions between sea lice from finfish farms and wild salmonids](https://consultation.sepa.org.uk/regulatory-services/detailed-proposals-for-protecting-wild-salmon/) [↑](#footnote-ref-21)
22. Fisheries Management and Conservation (FMAC) group. Regional Inshore Fisheries Groups (RIFG) [↑](#footnote-ref-22)
23. [Improving inshore fisheries data](https://consult.gov.scot/marine-scotland/improving-inshore-fisheries-data/) [↑](#footnote-ref-23)
24. [UK Seafood Fund: Fleet Modernisation (Round 3)- Engine replacements in the Small-Scale Coastal Fleet](https://www.find-government-grants.service.gov.uk/grants/uk-seafood-fund-fleet-modernisation-round-3) [↑](#footnote-ref-24)
25. [Managing end of life fishing gear and aquaculture equipment](https://www.seafish.org/responsible-sourcing/managing-end-of-life-fishing-gear-and-aquaculture-equipment/) [↑](#footnote-ref-25)
26. [UK National North Sea Cod Avoidance Plan](https://www.gov.scot/publications/north-sea-cod-plan/) [↑](#footnote-ref-26)
27. E.g. Jakob, M., Hilaire, J. (2015). [Unburnable fossil-fuel reserves](https://doi.org/10.1038/517150a). *Nature* **517**, 150-151. [↑](#footnote-ref-27)
28. <https://www.crownestatescotland.com/scotlands-property/marine/wave-and-tidal> [↑](#footnote-ref-28)
29. [Nature Restoration F](https://www.nature.scot/funding-and-projects/scottish-government-nature-restoration-fund-nrf)und (NRF) [↑](#footnote-ref-29)
30. [SMEEF Impact Report 2021-2023](https://smeef.scot/wp-content/uploads/2023/06/SMEEF-Impact-Report-Final-08-June-2023_w.pdf) [↑](#footnote-ref-30)
31. [Facility for Investment Ready Nature in Scotland (FIRNS](https://www.nature.scot/funding-and-projects/firns-facility-investment-ready-nature-scotland)) [↑](#footnote-ref-31)
32. [Court of Session - Opinion of Lord Braid in petition of The Open Seas Trust](https://www.scotcourts.gov.uk/docs/default-source/cos-general-docs/pdf-docs-for-opinions/2023csoh39.pdf?sfvrsn=16b4dade_1) [↑](#footnote-ref-32)
33. [Global horizon scan reveals the 15 issues that are expected to impact marine and coastal biodiversity conservation in the near future](https://environment.ec.europa.eu/news/global-horizon-scan-reveals-15-issues-are-expected-impact-marine-and-coastal-biodiversity-2023-01-11_en) [↑](#footnote-ref-33)