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Conservation and Management Advice

LOCH SUNART MPA

APRIL 2025

This document provides advice to Public Authorities and stakeholders about the activities that may affect the protected features of Loch Sunart Marine Protected Area (MPA). It provides advice from Scottish Natural Heritage (SNH) under Section 80 of the Marine (Scotland) Act to public authorities as to matters which are capable of damaging or otherwise affecting the protected features of Nature Conservation MPAs, how the Conservation Objectives of the site may be furthered or their achievement hindered, and how the effects of activities on MPAs may be mitigated. It covers a range of different activities and developments but is not exhaustive. It focuses on where there is a risk to achieving the Conservation Objectives. The paper does not attempt to cover all possible future activities or eventualities (e.g. as a result of accidents) and does not consider cumulative effects.

Further information on marine protected areas and management is available at - www.scotland.gov.uk/Topics/marine/marine-environment/mpanetwork

For the full range of MPA site documents and more on the fascinating range of marine life to be found in Scotland's seas, please visit - www.nature.scot/mpas or www.jncc.defra.gov.uk/scottishmpas

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Contents

1 Overview of document

This document provides details of the Conservation Objectives and Advice to Support Management for Loch Sunart Marine Protected Area (MPA) and it is divided into eight main sections. The introduction in section 2 gives an overview of Loch Sunart MPA and its contribution in terms of conservation and wider benefits. Section 3 provides an overview of the roles of the various bodies involved with advising, regulating and managing the marine protected area. Section 4 describes the protected features and their condition, and section 5 introduces the Conservation Objectives for the site. Section 6 describes the threats and pressures to which the protected features are sensitive, and section 7 provides the management advice for these activities. Section 8 identifies what further research and surveys may be required to increase our understanding of how the protected features utilise the site for which they are designated.

Annex 1 sets out the Loch Sunart MPA Conservation Objectives. Annex 2 provides supporting information relating to the protected features.

2 Introduction

2.1 Purpose statement

The Loch Sunart MPA has been designated to protect flame shell beds, northern feather star aggregations (*Leptometra celtica*) on mixed substrata and serpulid aggregations. By doing so, it contributes to the Scottish, UK and OSPAR MPA networks, the conservation of the wider marine environment around Scotland, and progress towards Good Environmental Status. The main purpose of the Loch Sunart MPA is to conserve the protected features in favourable condition. This makes a contribution to the OSPAR MPA network in the North-East Atlantic.

2.2 Conservation benefits

Loch Sunart MPA provides conservation benefits by affording protection to flame shell beds, northern feather star aggregations on mixed substrata and serpulid aggregations and their associated species. In summary the conservation benefits of this designation are:

- The primary flame shell bed within the Laudale Narrows is one of the most extensive in Scotland and the loch is considered to support the second largest population of flame shells taking into consideration this and other examples of the feature distributed throughout the MPA.
- Loch Sunart also supports very high densities of northern feather stars on mixed muddy sediments across a range of depth zones.
- Serpulid aggregations are extremely rare biogenic structures only known from one other sea loch in Scotland and at four other known locations in Europe.
- Whilst not a protected feature of the MPA, it is also home to maerl beds, which are considered scarce in the UK and internationally.

2.3 Wider benefits

Loch Sunart MPA provides ecosystem services locally and to the wider marine ecosystem. We describe these ecosystem services in terms of their functions (the support or provision of something to the wider ecosystem e.g. habitat, nutrient cycling, sediment stabilisation) and natural resources (e.g. fish and shellfish, aggregates, wildlife), which in turn lead to benefits for people.

Figure 1 illustrates how the protected features of Loch Sunart MPA contribute to benefits for people. There can be many complex interactions and dependencies amongst the protected features, their functions, associated natural resources and the benefits we gain from them.

The functions associated with the protected features of Loch Sunart MPA are described in Annex 1 as part of the site's Conservation Objectives. The features together, especially when taken within the context of the whole MPA and/or local ecosystem, contribute to certain functions more than others, e.g. carbon storage and nutrient cycling. The functions of the protected features are fundamental to the continued supply of natural resources and benefits associated with this MPA, and to the long-term health of the protected features.

Loch Sunart MPA encompasses a long narrow sea loch at the northern end of the Sound of Mull. Within the loch there are numerous small islands creating narrow channels through which the incoming and outgoing tide is squeezed. These fast-flowing currents create the essential conditions for the development of extensive flame shell beds, the largest of which is found in the Laudale Narrows. The fish and shellfish (excluding native oysters), and seaweeds living within the MPA that can be harvested by humans or utilised by other marine species, are the most obvious resource. Habitats within the MPA (e.g. maerl beds, flame shell beds and burrowed mud) act as carbon stores, with carbon stored for centuries to millennia. The complexity of the MPA, which include a mosaic of sea lochs, bays, and near shore island channels, create a unique seascape and a sense of place.

The Loch Sunart MPA is a location where people can engage in outside pursuits for health and wellbeing e.g. sailing and walking and is home to wildlife and habitats that can be watched, enjoyed and studied. It is a place where communities and visitors can spend time connecting with and enjoying nature.

The benefits that arise from the functions and natural resources of Loch Creran are typically small in the context of the whole of Scotland, but some are of greater importance for this MPA and the people that use it. There is potential for benefits to be enhanced. This may be achieved by improving the quantity or quality (health) of the protected features themselves and/or through promoting, for example, more recreational enjoyment or use of natural resources that is compatible with the site's Conservation Objectives.

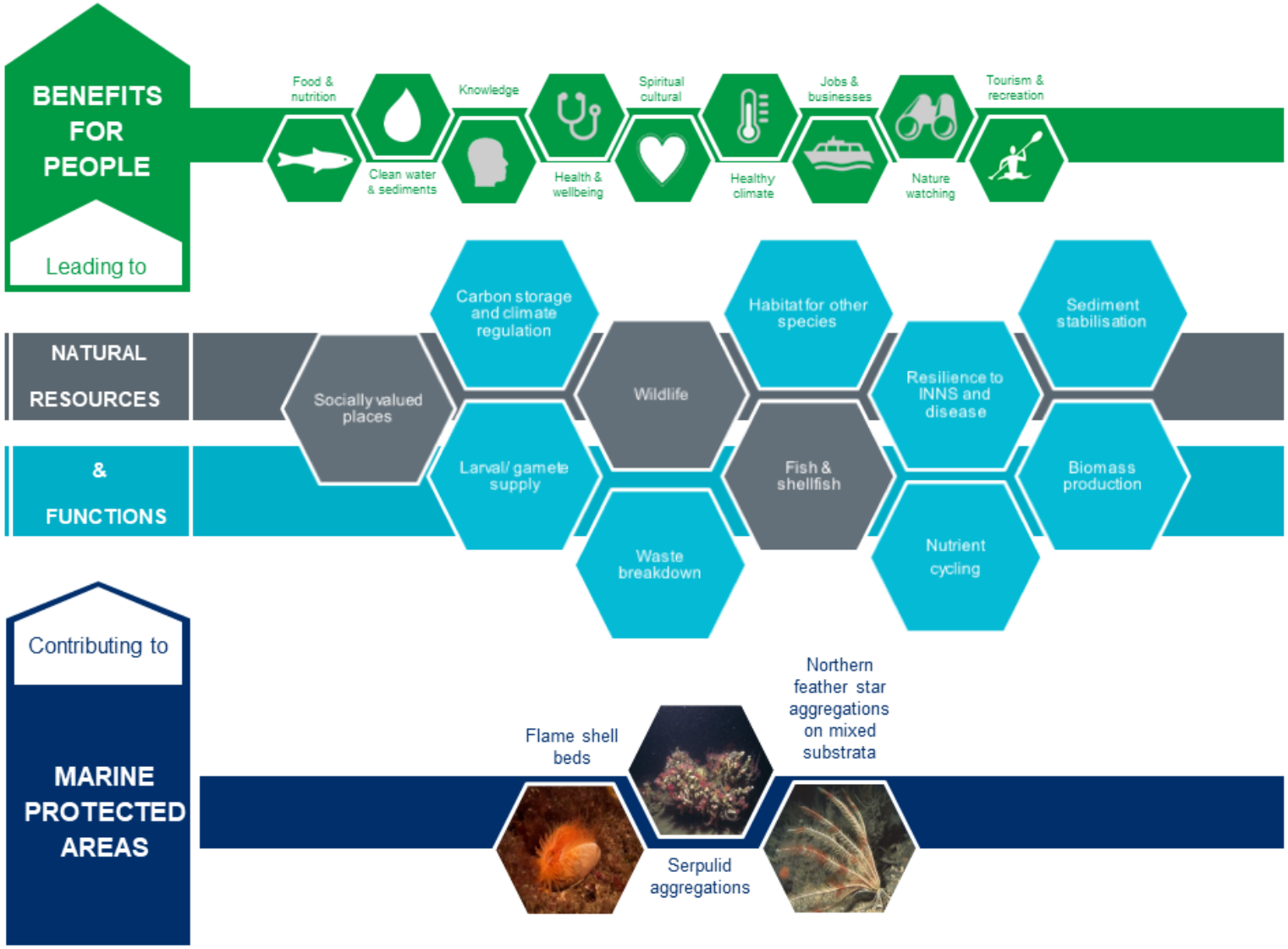

Figure 1 *Benefits to people associated with protected features of the Loch Sunart MPA.*

2.4 Contribution to policy commitments

Managing this MPA to conserve the flame shell beds, northern feather star aggregations (*Leptometra celtica*) on mixed substrata and serpulid aggregations in favourable condition, will ensure the continued provision of the benefits above as well as the site's contribution to:

- An ecologically coherent network of MPAs which are well managed under the OSPAR convention and national legislation.
- The protection of flame shell beds, northern feather star aggregations on mixed substrata and serpulid aggregations which are Priority Marine Features.
- Progress towards achieving Good Environmental Status in relation to biological diversity and seafloor integrity.
- Protection, enhancement and health of the marine area under the Marine (Scotland) Act 2010.
- Restoring marine and coastal ecosystems and increasing the environmental status of our seas under the Scottish Biodiversity Strategy.
- Helping to adapt to climate change under The Scottish Climate Change Adaptation Programme.

3 Roles

This document provides advice for Loch Sunart MPA in relation to activities that may affect the protected features. More detailed advice can be provided to public authorities to inform their decision making as required. In doing this, our aim is to ensure the Conservation Objectives for the protected features are met.

Section 80 of the Marine Scotland Act gives Scottish Natural Heritage (SNH)(now referred to as NatureScot) the remit to provide advice and guidance to public authorities as to the matters which are capable of damaging or otherwise affecting the protected features of Nature Conservation MPAs, how the Conservation Objectives of the site maybe furthered or their achievement hindered, and how the effects of activities on MPAs may be mitigated.

It is the role of relevant and competent authorities[1] to ensure that the activities they regulate, permit or licence do not hinder the achievement of the Conservation Objectives of Loch Sunart MPA. The management advice in this document is provided to assist public authorities in managing the activities outlined in Annex 2 and carrying out their duties under Section 82 and 83 of the Marine (Scotland) Act 2010.

Stakeholders can provide additional evidence to support the development of management including local knowledge of the environment and of activities. This will contribute to the development of well-designed and effective management measures.

[1] Relevant authorities are defined in Regulation 5 of the Habitats Regulations and encompass those authorities that have functions in relation to land/water within or adjacent to a European Marine Site (includes marine SACs). They are nature conservation bodies, local authorities, water undertakers, navigation authorities, harbour authorities, lighthouse authorities, SEPA, district salmon fishery board and, National Park Authorities and local fisheries committees. Competent authorities include any Minister, government department, public body, or person holding public office.

4 Protected features and status

The Loch Sunart MPA has been selected to become part of Scotland's MPA network which in turn has been established to help conserve and recover a range of Scotland's important marine habitats, wildlife, geology and landforms.

Table 1 provides a summary of the protected features within the MPA, their condition within the site, and the broader conservation status of the protected features.

The locations and extent of the protected features within the Loch Sunart MPA are shown on Figure 2a and Figure 2b. This may not be the most up-to-date information on extent/distribution of features. The most up-to-date distribution of the features described is available to view at National Marine Plan Interactive[2].

Table 1. Protected features and condition for the Loch Sunart MPA. Feature condition refers to the condition of the protected feature assessed at a site level. Broader conservation status is the overall condition of the feature throughout its range as outlined by the *.

Protected Features	Feature condition	Assessment date	Broader conservation status
Flame shell beds	Favourable	2014	Good Environmental Status has not yet been achieved*
Northern feather star aggregations on mixed substrata	Favourable	2014	Good Environmental Status has not yet been achieved*
Serpulid aggregations	Unfavourable	2024	Good Environmental Status has not yet been achieved*

* This is the broad UK Marine Strategy status of sublittoral rock and biogenic habitats and soft sediments.

[2] https://marinescotland.atkinsgeospatial.com/nmpi/

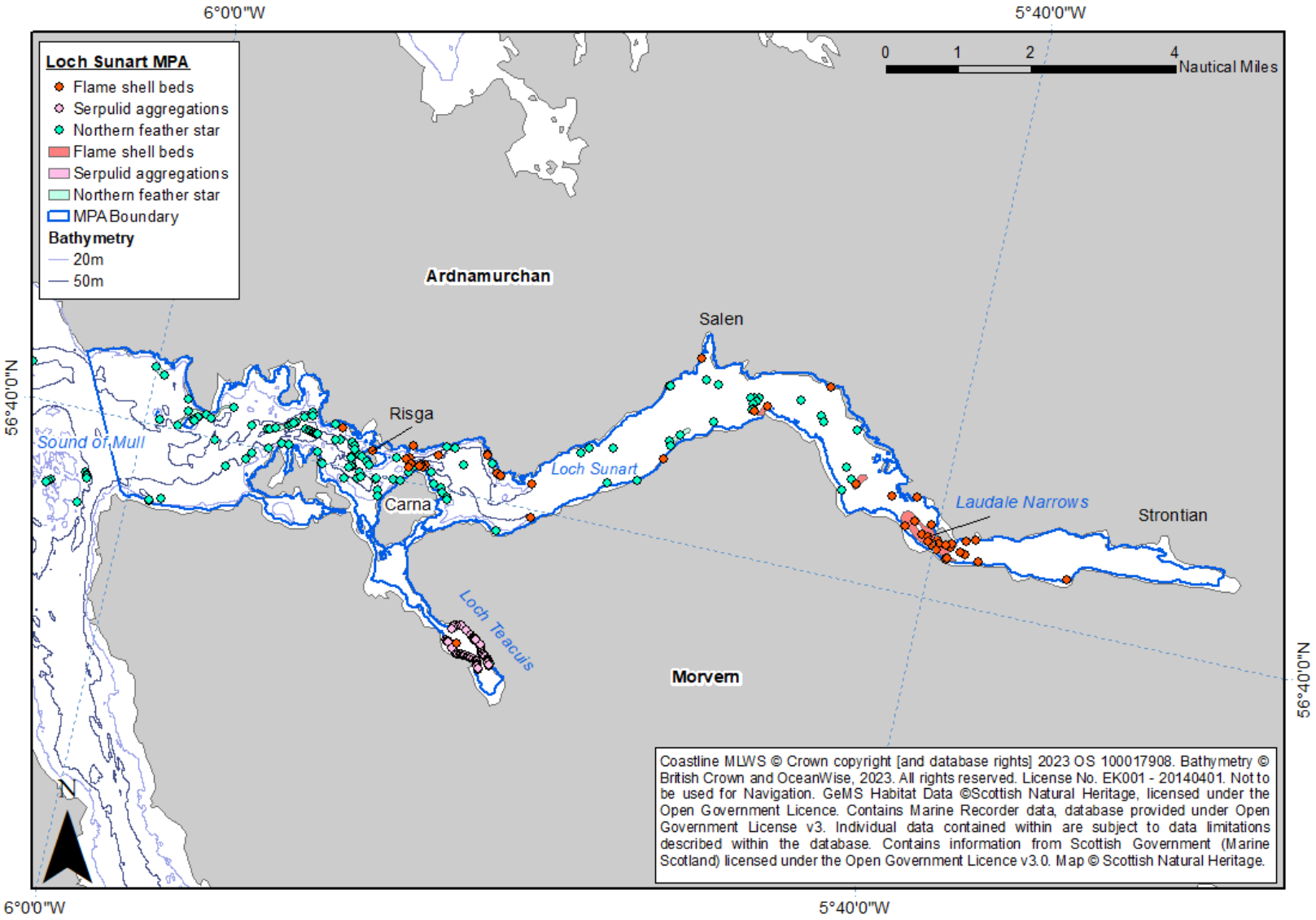

Figure 2a *Location of the Loch Sunart MPA and distribution of the protected features.*

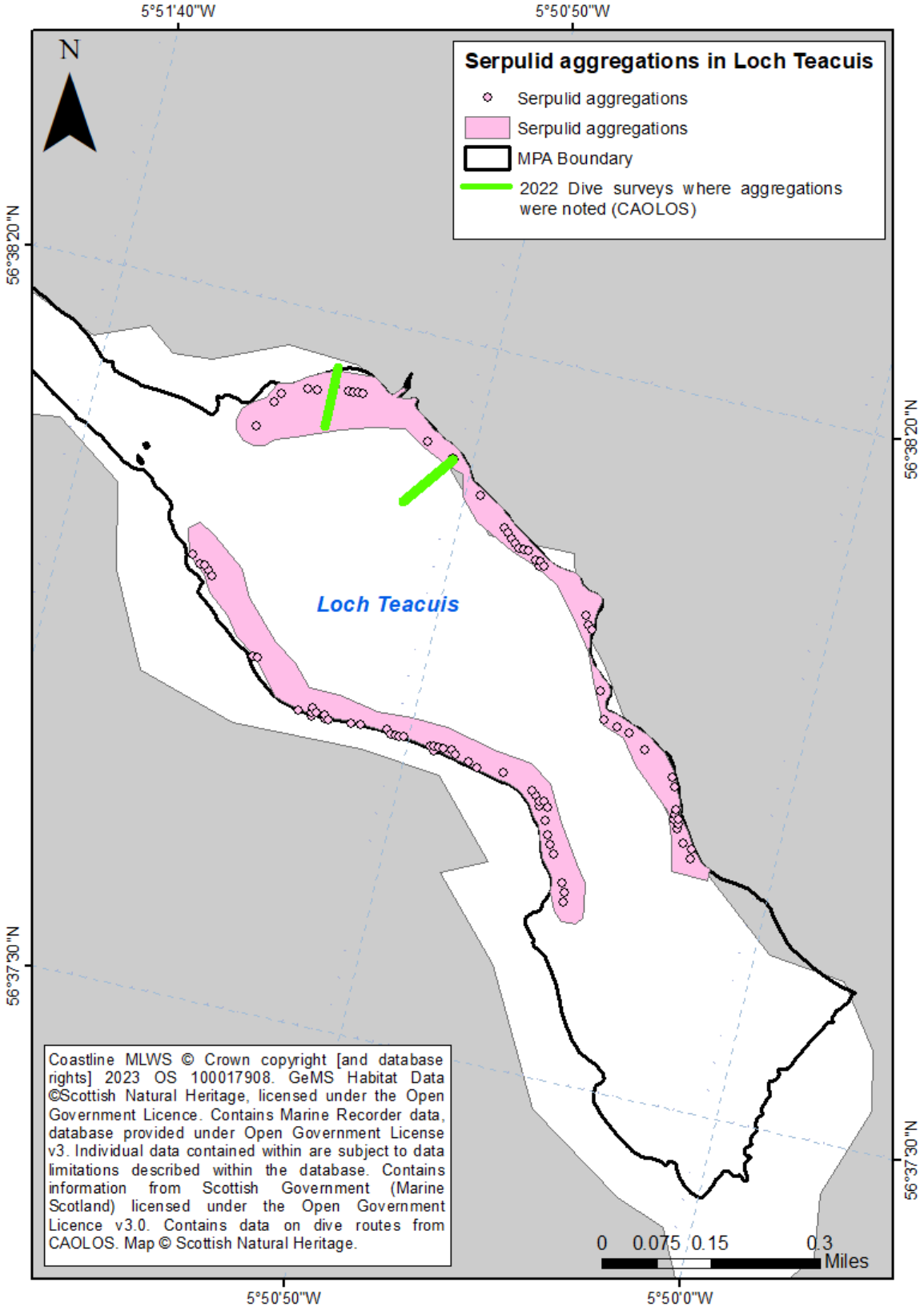

Figure 2b *Location of the serpulid aggregations in within Loch Teacuis. Point data is from 2006. Polygons are extrapolated from 2006 point data. More recently, serpulid aggregations have only been found on the northern and eastern shores in 2022, as denoted by the green lines (Sim, 2024).*

5 Conservation Objectives

5.1 Background

Conservation Objectives set out the desired quality of the protected features within the Loch Sunart MPA. They form part of the designation order for the MPA and are in place at the time the site is formally designated. They provide the framework for the setting of site conservation measures (management) and for public authorities in managing the activities outlined in Annex 2 and carrying out their duties under Section 82 and 83 of the Marine (Scotland) Act 2010.

5.2 Relationship between feature condition and Conservation Objectives

The Conservation Objectives seek to *conserve* protected feature(s) of a MPA where evidence exists that it is in favourable condition in the site, or where there is uncertainty concerning the assessed condition of a feature (see section 4) but no reason to suspect deterioration in condition since designation. Where evidence exists that a feature is declining and/or damaged and therefore is in unfavourable condition in the site, the Conservation Objectives will seek to *recover* the protected feature.

Flame shell beds and northern feather star aggregations on mixed substrata are in favourable condition at Loch Sunart MPA and therefore the Conservation Objectives seek to *conserve* this condition. Serpulid aggregations are in unfavourable condition at Loch Sunart MPA and therefore the Conservation Objectives seek to *recover* this condition.

The recover Conservation Objective for serpulid aggregations reflects their condition which has significantly declined between 2006 and 2022 within Loch Teacuis. Serpulid aggregations are now locally extinct in many areas of the loch, with some small aggregations only present in a small number of areas (Sim, 2022; NatureScot, *unpublished*). The reason for this decline is not yet clear, although declines in serpulid reefs have been noted at another site, Loch Creran. A recent desk study has investigated declines in serpulid reefs in Loch Creran (Hughes et al., 2024). Several factors were investigated including available evidence on changes in plankton community, land use in the catchment and local weather but they could not attribute the decline to a single cause or a combination of causes. It is possible that the decline is part of a natural cycle of growth and collapse in the habitat (Hughes et al., 2024), although it is not known why aggregations within Loch Teacuis have collapsed and not developed into reefs.

5.3 Overlapping Protected Areas

The following protected areas overlap with, or are immediately adjacent to, the Loch Sunart MPA:

- Loch Sunart and the Sound of Jura NCMPA
- Sunart SAC
- Sunart SSSI
- Inner Hebrides and the Minches SAC

There are no apparent management conflicts between the protected features of the Loch Sunart MPA and the protected features of the other overlapping areas.

Site information including the Conservation Objectives for the protected areas overlapping Loch Sunart MPA are available on SiteLink.

6 Feature sensitivity

The following sections provide an overview of the pressures most relevant to the protected features. Further information on feature sensitivity, can be found at Marine Scotland's

Feature Activity Sensitivity Tool (FeAST)[3] and also for the features not covered by FeAST, Marine Evidence based Sensitivity Assessment (MarESA)[4]. The information in FeAST reflects our current understanding of the interactions between activities, pressures and features. It highlights that activities can give rise to a range of pressures, which the protected features may be sensitive to. Our assessment of sensitivity is based on a feature's tolerance (response to change) and its ability to recover.

6.1 Flame shell beds

Flame shell beds are highly sensitive to physical disturbance including surface abrasion. Activities that cause physical disturbance can break up the nest structure that the flame shells create, remove and kill individuals and damage the delicate shells, subsequently leaving them vulnerable to predation. In addition to direct impacts, flame shell beds are sensitive to increased levels of sedimentation. This causes smothering of the bed, blocking the water flow and exchange of oxygen, a reduction in light and a reduction in the ability to feed, affecting the flame shells and other plants and animals associated with the beds. Flame shell beds do have the capacity to recover from impacts (albeit this may be slowly) provided that pressures that they are sensitive to are removed/avoided, suitable environmental conditions are maintained, and there are existing flame shell beds in the locality of the area that has been damaged to provide a source of larvae and suitable substrate for larvae to settle on.

6.2 Northern feather star aggregations on mixed substrata

Northern feather star (*Leptometra celtica*) aggregations are most sensitive to high changes in siltation rate which can cause deoxygenation and can result in a reduction in species numbers, abundance and biomass. The species is also sensitive to low changes in siltation rates, smothering, deoxygenation, organic enrichment, the physical removal of substratum and abrasion. Smothering can result in the death of feather stars, with feeding and respiratory structures becoming clogged. The physical removal of substratum and abrasion could result in the loss of Northern feather star as the species have delicate structures, although some individuals may be able to avoid removal by swimming or crawling short distances. The species requires sufficient water flow of passive suspension feeding so a decrease in water flow may reduce food supplies.

Following disturbance recolonization and recovery of northern feather stars could take place and may be possible within five years. However, if populations are completed removed, recovery may take longer than five years due to the relatively short pelagic phase of larvae and reliance on relatively local populations. The species can regenerate body parts even when most arms and part of the disc have been lost so most damaged individuals are likely to recover.

6.3 Serpulid aggregations

Serpulid aggregations are sensitive to physical disturbance, which damages the physical structure of the aggregations which are slow to recover. They are also sensitive to deoxygenation and heavy siltation, which may block the water flow and exchange of oxygen, nutrients and also food for the serpulid worms which are filter feeders. Serpulid aggregations are also thought to be sensitive to changes in salinity. Serpulid aggregations are slow to grow and develop into reefs. Aggregations do not always develop into reefs (the definition of a biogenic reef is live material growing on dead material) and have been observed to disappear before reaching the reef stage. It is possible that serpulid reefs undergo a natural process of development from large numbers of individual *Serpula vermicularis* to

[3] https://feature-activity-sensitivity-tool.scot/

[4] https://www.marlin.ac.uk/sensitivity/sensitivity_rationale

aggregations to reefs if the correct conditions (retention of larvae in the system and sufficient food) persist. It could also be possible that a natural cycle of reef collapse (when they are too large to support their own weight) and regeneration exists. The recovery of this feature is dependent on the reason for the decline in reef condition. If the decline is due to human pressures, the reef may recover if the pressures they are sensitive to are removed/avoided. If the decline in reef condition is part of the natural cycle, recovery will be dependent on suitable environmental conditions being maintained including availability of suitable substrate (rocks, shells, live reef material and dead reef material that is free of bio fouling) and larval and food supply. There is the potential for serpulid reefs not to recover following collapse.

7 Management advice

7.1 Advice to support management

Table 2 provides NatureScot's advice on management for activities where we consider this may be necessary to achieve the Conservation Objectives for the protected features. The advice is focused on the activities that cause an effect (a pressure) that a feature is sensitive to. Pressures can be physical (e.g. abrasion of the seabed), chemical or biological. Different activities may cause the same pressure, e.g. fishing using bottom gears and aggregate dredging both cause abrasion which can damage the surface of the seabed.

Our advice takes a risk-based approach, i.e. we are focusing on providing advice where we believe there is a risk to achieving the Conservation Objectives. We have identified risks to achieving the Conservation Objectives where there is an overlap between protected features and activities associated with pressures that the features are sensitive to. We have provided management advice to support public authorities and others in managing these risks. Our advice is based on existing data and information on protected features and relevant activities, and our understanding of the relationships between the features and activities. We have identified a range of management advice:

- management to remove or avoid pressures;
- management to reduce or limit pressures; or
- no additional management required.

For our advice on fisheries management we have also stated where we think this should be 'considered' or 'recommended'. The term 'considered' is included to highlight that a fishery-feature interaction exists, but circumstances mean that a specific recommendation for action cannot / or need not be made at this point. However, there is sufficient cause to make fishery managers aware and for them to consider if a fishery management measure may be helpful in achieving Conservation Objectives – particularly where there may be a synergy between the benefits of management actions for the fishery and the Conservation Objectives for the feature. The term 'recommended' highlights than an issue of fishery-feature interaction exists, there is a reasonable evidence base and a specific recommendation can be made/ justified.

New or other activities would need to be considered on a case-by-case basis.
We recognise that stakeholders can provide local environmental knowledge and more detailed information on activities, including in relation to intensity, frequency and methods. This additional information will help public authorities and others develop more specific management, focussed on the interaction between features and activities. If new information becomes available our management advice may be revised.

Activities that are considered not likely to affect the protected features (other than insignificantly) are listed in Table 3. Spatial data relating to the location and extent of the

activities listed can be accessed on Marine Scotland's National Marine Plan Interactive[5] (where available).

7.2 Best Practice

In our management advice for activities in Table 2 we refer to the development, adoption or use of 'best practice' as a way of managing interactions between activities and the features. Best practice is taken to mean approaches or procedures that are developed and accepted by regulators and relevant stakeholders as being an effective way of dealing with an interaction between a habitat or species and the pressures created by an activity. Much of this best practice is already being implemented by sectors and regulators, e.g. pre-application discussions between developers and regulators, the Scottish Marine Wildlife Watching Code, Scottish Outdoor Access Code, and Technical Standards for Scottish Finfish Aquaculture.

7.3 Conservation measures

The following conservation measures are currently in place for the Loch Sunart MPA:

- Activities and developments subject to licensing that could affect the protected features of the MPA also need to be assessed. Authorities need to determine whether if by carrying out their duties e.g. permitting an activity to take place, it would hinder the achievement of the Conservation Objectives of the MPA. This is referred to as an assessment under Section 82 or Section 83 of the Marine (Scotland) Act 2010.
- *Fishing - demersal mobile/active gear* **–** fishing for sea fish with a dredge, set net, long line, line, beam trawl, demersal trawl, or demersal seine net is prohibited in the Loch Sunart Marine Protected Area The Inshore Fishing (Prohibition of Fishing and Fishing Methods) (Scotland) Order 2015 (No. 435). A further prohibition of fishing with creel or parlour creel applies in Loch Teacuis.

[5] https://marinescotland.atkinsgeospatial.com/nmpi/

Table 2. NatureScot's advice to support management for Loch Sunart MPA for activities which are considered capable of affecting the protected features.

The text under the 'Advice to support management' columns provides NatureScot's management advice for the features in relation to the activities (further details about the terminology used are provided in section 7.2). Where a cell is coloured grey this indicates that management is already in place, this includes where there are existing regulatory requirements for new proposals. Cells are also coloured grey where it is considered there is no additional management required to achieve the Conservation Objectives. For some activities, the pressures associated with new proposals are considered unlikely to affect some the features either because these activities do not occur in the same locations as the features or the pressure is unlikely to be at levels that can affect the features (see also Table 3).

Activities considered capable of affecting the protected features	Advice to support management		
	Flame shell beds	**Northern feather star aggregations on mixed substrata**	**Serpulid aggregations**
Anchorage areas	**No additional management** required for current anchorage areas. **Remove or avoid pressures** associated with new anchorage areas		**Remove or avoid pressures** associated with the anchorage in Loch Teacuis. **No additional management** required for other current anchorage areas. **Remove or avoid pressures** associated with new anchorage areas
Aquaculture	**Remove or avoid pressures** associated with new farms and undeveloped consents as well as the expansion or relocation of existing farms.	**Reduce or limit pressures** associated with new farms and undeveloped consents as well as the expansion or relocation of existing farms.	**Remove or avoid pressures** associated with new farms and undeveloped consents as well as the expansion or relocation of existing farms.

Activities considered capable of affecting the protected features	Advice to support management		
	Flame shell beds	**Northern feather star aggregations on mixed substrata**	**Serpulid aggregations**
Cables and pipelines	**Remove or avoid pressures** associated with new cables and pipelines. Early discussion of siting, design and construction is recommended to reduce the risks of disturbance to the feature caused by the development and installation of new cable and pipeline infrastructure.	**Reduce or limit pressures** associated with new cables and pipelines. Early discussion of siting, design and construction is recommended to reduce the risks of disturbance to the feature caused by the development and installation of new cable and pipeline infrastructure.	**Remove or avoid pressures** associated with new cables and pipelines. Early discussion of siting, design and construction is recommended to reduce the risks of disturbance to the feature caused by the development and installation of new cable and pipeline infrastructure.
Coastal development - other	**Remove or avoid pressures** associated with new coastal development.	**Reduce or limit pressures** associated with new coastal development.	**Remove or avoid pressures** associated with new coastal development.
Fishing - demersal mobile/active gear	**Remove or avoid pressures *is recommended*** *–existing management measures in place (see section 7.3)*	**Reduce or limit pressures *should be considered*** *– existing management measures in place (see section 7.3)*	**Remove or avoid pressures *is recommended*** *–existing management measures in place (see section 7.3)*
Fishing – static gear	**Reduce or limit pressures** associated with static fishing on flame shells **should be considered**	**No additional management required**	**Remove or avoid pressures *is recommended* -** *existing management measures in place in Loch Teacuis (see section 7.3)*
Fishing – diver collection of bivalves (not including hydraulic dredging)	**Remove or avoid pressures** associated with the collection of horse mussel associated with this habitat **is recommended.**	*Pressure unlikely to affect feature*	
Fishing – hydraulic (diver or vessel)	**Remove or avoid pressures *is recommended*** *– existing*	**Reduce or limit pressures *should be considered*** *– existing management*	**Remove or avoid pressures *is recommended*** *– existing*

Activities considered capable of affecting the protected features	Advice to support management		
	Flame shell beds	**Northern feather star aggregations on mixed substrata**	**Serpulid aggregations**
	management measures in place (see section 7.3)	*measures in place (see section 7.3)*	*management measures in place (see section 7.3)*
Moorings	**No additional management required** for current mooring areas. **Remove or avoid pressures** associated with new mooring areas.	**No additional management required** for current mooring areas. **Reduce or limit pressures** associated with new mooring areas.	**No additional management required** for current mooring areas. **Remove or avoid pressures** associated with new mooring areas.
Scientific survey/ research	**Reduce or limit pressures.** Pressures associated with survey work in areas where there would be likely to be an impact upon flame shell beds should be minimised. Early discussion of the survey/research proposals is recommended to reduce potential impacts.	**Reduce or limit pressures.** Pressures associated with survey work in areas where there would be likely to be an impact upon northern feather star aggregations on mixed substrata should be minimised. Early discussion of the survey/research proposals is recommended to reduce potential impacts.	**Reduce or limit pressures.** Pressures associated with survey work in areas where there would be likely to be an impact upon kelp and serpulid aggregations should be minimised. Early discussion of the survey/research proposals is recommended to reduce potential impacts.

Table 3. Activities that are considered not likely to affect the protected features (other than insignificantly)[6]

Activity	Comments
Discharges – industrial and agricultural	Discharges are considered unlikely to reach a level where they will affect the protected features of this site.
Discharges - sewage	Discharges are considered unlikely to reach a level where they will affect the protected features of this site.
Tourism and recreation	Charter and recreational vessels as well as activities such as scuba diving take place but not at levels that is likely to affect the features.
Fishing – recreational fishing	Existing but due to the low level of recreational fishing (both angling from shore and off private and chartered boats) it is not considered to be at a level where it affects the protected features.

8 Research and survey requirements

We recognise that there are still important gaps in our understanding and knowledge of the features of this site. We will identify research and survey projects to inform our understanding of these aspects. The requirements identified below are not a commitment to undertake this work. However, by highlighting these gaps we hope to inform future discussions with parties interested in undertaking research in this site and/or on these features, to help direct research and aid monitoring priorities.

1. Monitoring any changes in extent, structure, function and biological communities of all features since management measures have been put in place.
2. Improved understanding of serpulid aggregation and reef development, collapse and potential recovery cycles.

[6] Only the specific examples of activities listed in the table have been excluded, rather than the broad activity types. New plans or projects will still need to be considered by the relevant competent authority (see Annex 1 for further details).

Annex 1. Loch Sunart MPA Conservation Objectives

The box below provides the high-level Conservation Objective statements. The full Conservation Objectives, which includes site-specific advice and information on the features that form part of this MPA, are provided in the tables that follow.

The site specific advice and information provides more detail in relation to each of the high level Conservation Objective statements for each feature type, e.g. detail on the extent of a habitat within a site and what the supporting features are for a species.

Information is also provided below on how minor changes to features should be considered and the influence of environmental change on features, particularly in relation to climate change for context.

A definition of the terms used is in the Glossary.

A map of the MPA, the location of the features and the place names mentioned in the site-specific information is provided in Figure 2a, Figure 2b and Figure 3.

Loch Sunart MPA

Protected features:
Habitats - Flame shell beds, Serpulid aggregations
Low/limited mobility species - Northern feather star aggregations on mixed substrata

The Conservation Objectives of the Loch Sunart MPA, are that the protected features

- so far as already in favourable condition, remain in such condition; and
- so far as not already in favourable condition, be brought into such condition, and remain in such condition.

"Favourable condition", with respect to a marine habitat, means that

a) its extent is stable or increasing; and
b) its structures and functions, its quality, and the composition of its characteristic biological communities are such as to ensure that it is in a condition which is healthy and not deteriorating.

In paragraph (b) the reference to the composition of the characteristic biological communities of a marine habitat includes a reference to the diversity and abundance of species of marine flora and fauna forming part of, or inhabiting, that habitat.

Any temporary deterioration in condition is to be disregarded if the habitat is sufficiently healthy and resilient to enable its recovery from such deterioration.

"Favourable condition", with respect to a low or limited mobility species of marine fauna, means that the quality and quantity of its habitat and the composition of its population are such that they ensure that the population is maintained in numbers which enable it to thrive.

Any temporary reduction in numbers of a low or limited mobility species of marine fauna is to be disregarded if the population of that species is thriving and sufficiently resilient to enable its recovery from such reduction.

For the purpose of determining whether a protected feature is in favourable condition any alteration to that feature brought about entirely by natural processes is to be disregarded.

Interpretation of temporary deterioration in condition (for marine habitats) and consideration of minor changes
For marine habitats any temporary deterioration in condition is to be disregarded if the marine habitat is sufficiently healthy and resilient to enable its recovery from such deterioration. In order to determine what “temporary deterioration” is we must know the longevity of the habitat and timescales involved to enable a habitat (protected feature) to fully recover. Resilience can vary widely between ecosystems and ecological resilience has been defined as "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks". It is generally recognised that high biodiversity in a system makes it more resilient to some forms of disturbance. For other features (low or limited mobility species), temporary short-term and/or minor changes in the numbers of the feature due to human activity may be considered not to compromise the Conservation Objectives and will be considered on a case-by-case basis. The recovery of the habitat in which northern feather star are found depends on environmental factors such as type of sediment as well as the type and duration of impact. Assessments should consider the timing, duration and scale of the impact on the features and their ability to recover. Factors determining the potential for features to recover following temporary deterioration vary between features. These are described in more detail in Annex 2 ‘‘*Factors determining the potential for features to recover’*.

Environmental Change	
The Conservation Objectives recognise and acknowledge that the protected features of the MPA are part of a complex, dynamic and multi-dimensional marine environment. Habitats are exposed to a wide range of drivers of change. This may include changes to their population and habitats that reflect their natural cycles, and also broader environmental changes, i.e. those related to climate change and environmental variability that are beyond the scope of the MPA. Any alterations to the protected features that are brought about by entirely by natural processes is to be disregarded when assessing against the Conservation Objectives. In relation to the Loch Sunart MPA and its protected features, the following effects of climate change are relevant as outlined below. These effects should be taken into account when considering plans and projects within Loch Sunart MPA as additional pressures may reduce the habitat’s resilience to climate change, and additionally climate change impacts may start to hinder the habitat’s ability to recover from human activities.	
Flame shell beds	These have been assessed to have high sensitivity to the physical disturbance and damage as a result of increased storm and wave impact from climate change. Flame shell beds are also likely to have high sensitivity to predicted increases ocean acidification, which could affect reproduction, larval settlement, reproduction and growth (Strong *et al.* unpublished). Several of the typical species associated with flame shell beds e.g. crabs, echinoderms have bodies as larvae and adults that are subject to reduced growth and lower survival rates from increased ocean acidification (Strong *et al.*, Unpublished). The development of flame shell beds and the dispersal of larvae between beds (connectivity) are also reliant on adequate water flow and patterns of water movement, and flame shell beds are moderately sensitive to changes in these, which might occur under climate change. These climate change pressures could result in a

	change in the extent, distribution, structure (bed thickness and density of individuals) of flame shell beds, and changes in their characteristic communities in the MPA, and throughout the habitat's range in the future.
Northern feather star aggregations on mixed substrata	As northern feather star aggregations are found in relativity deep water, they are not considered sensitive to changes in salinity, sea level rise and increased wave action. As they have limited mobility, they may be able to move away from adverse conditions such as hypoxic zones. In general echinoderms are considered sensitive to reductions in pH, although there is limited species-specific evidence on this. Juveniles may be more vulnerable to ocean acidification than adults which could impact recruitment (Leung *et al.,* 2022). They have a large thermal range, from the Faroes to Spain and Morocco, thus in Scotland, northern feather stars are not considered sensitive to temperature rises. Genetic connectivity may be affected by changes in circulation, with genetic information shared between the Small Isles MPA and other sites via the movement of pelagic larvae (Gallego *et al.*, 2017).
Serpulid aggregations	Like serpulid reefs, aggregations may be sensitive to storm damage, with the potential for greater water to damage aggregations. However, evidence on this is not clear, with attempts to relate storm events to reef damage in Loch Creran have so far been unsuccessful (Moore et al., 2020). Aggregations may be less sensitive to storm damage than reefs, as aggregations are smaller in height. Serpulid aggregations may be vulnerable to future climate impacts associated with ocean acidification (see Chan, 2013) and de-oxygenation. The worm tubes of Serpula vermicularis, the building blocks of serpulid aggregations, along with several of the typical species associated, e.g. crabs, squat lobsters, whelks could be subject to reduced growth and lower survival rates as larvae and juveniles/adults under increased ocean acidification (Strong et al., unpublished), making their recovery from other impacts more difficult, and resulting in changes in the typical species abundance, diversity and distribution in the MPA.

HABITATS

(a) Extent		
Feature	**Site specific advice**	**Site specific information**
Flame shell beds	Conserve the current extent and distribution of the flame shell beds within the site so that they are stable or increasing.	The extent and distribution of flame shell beds are limited by depth and suitable habitat. The flame shell bed at Laudale Narrows covers an estimated 51 ha (Moore et al 2013, Envision Mapping Ltd 2014) mostly as a dense spongy bed of *Limaria* nests on sediments from coarse sand to muddy sand at depths of 2-47 m, although dense flame shells (>50% nest cover) was restricted to coarse sediments in the strongest tidal currents at 3-20 m (covering ca, 20 ha). Existing data are too sparse to gauge the extent of the other known Sunart beds with any degree of accuracy, but they are likely to be considerably smaller in size (estimates of 5-10 ha are given for four other mapped beds in Envision Mapping Ltd 2014). Flame shell beds are likely to have a slow rate of recovery (Trigg and Moore, 2009), and the key factors influencing the recovery of their extent and distribution include, water flow, the availability of a sufficient larval supply and suitable substrate for larval settlement. All disturbance to flame shell beds by human activities is likely to be judged detrimental. This is because it has the potential to cause a long-term or permanent reduction in the extent of the habitats and/or change the local distribution on a continuing basis. Therefore, any damage or disturbance that would lead to a reduction in extent and/or a restricted/modified distribution of the flame shell beds should be avoided. Assessments should focus on activities involving significant abrasion or disruption of seabed sediments. Such pressures may significantly physically damage flame shell beds and break up nest structure. Pressures may also alter local water hydrographic and sedimentary processes leading to an increase in sedimentation rates and organic particulate matter in the immediate area. This could result in smothering and block the exchange of water and oxygen.
Serpulid aggregations	Recover the current extent and distribution of the serpulid aggregations within the site so that they are stable or increasing.	During the 2006 survey the area supporting serpulid aggregations in Loch Teacuis was approximately 20 ha (Dodd *et al.,* 2009). The aggregations were scattered around the periphery of the loch attached to hard substrates on a seabed of mixed muddy sands with cobbles, pebbles and shells. The aggregations were recorded from 0 to 13.4 m below chart datum. The availability of hard substrates in slightly deeper water appeared to increase the depth range of the aggregations, allowing them to colonise areas otherwise surrounded by soft

		sediment. It is thought that the density of individual *S. vermicularis* in a loch system needs to be at a certain level before the necessary number of larvae (specific to the size and flushing rate of the loch) can be produced and retained triggering aggregation development (Dodd *et al.,* 2009). Declines in the extent of serpulid aggregations have been noted in Loch Teacuis. Surveys of Loch Teacuis in 2013 (Last, 2014; SNH, 2014a) and 2014 (Kamphausen, 2015) showed a decline in the serpulid aggregations compared to 2006 surveys. A NatureScot survey in 2022 recorded no serpulid reefs (NatureScot, *unpublished*) with a very small number of serpulid aggregations present around mooring anchors (NatureScot, *unpublished*). Several small aggregations have been noted by CAOLAS in 2022 on the northern shore (below 3m; colonies with a height of >=10cm noted; Sim, 2024). Whilst serpulid worms were also present in other parts of the loch, the height of these was either too small to be characterised as an aggregation, or did not have associated height data, meaning that it is unclear if serpulid aggregations are present in the rest of the loch (Sim, 2024). The 2022 surveys by NatureScot and CAOLAS suggest that the extent of serpulid aggregations have significantly declined since 2006 and could be locally extent in some parts of the loch (Sim, 2024; NatureScot, *unpublished*). Changes in the extent in serpulid aggregations in Loch Teacuis is linked to changes in structure (as discussed in the next section). Natural recovery of serpulid aggregation extent should be supported by maintaining the environmental conditions required for aggregation establishment. The key factors influencing the recovery include the availability of a sufficient larval and food supply and suitable substrate for larval settlement. Human intervention to recover the loss of extent of serpulid aggregations is currently being trialled in Loch Creran (Herriot-Watt, *unpublished*), although it is unclear whether his is a viable option. The recovery of serpulid aggregations is likely to be slow. Any loss in extent or distribution of serpulid aggregations within the site therefore has the potential to cause a long-term or permanent reduction of the habitat and/or change the local distribution on a continuing basis. Therefore, any damage that would lead to a reduction in extent or a restricted/modified distribution, or prevent recovery, should be avoided. Assessments should focus on activities involving significant abrasion or disruption of seabed sediments. Such pressures may physically damage serpulid aggregations and alter local water hydrographic processes changing food and larvae supply.

(b) Structures		
Feature	**Site specific advice**	**Site specific information**
Flame shell beds	Conserve the current bed thickness, density of individuals, and associated sediments so that they are stable or increasing.	The structure of a flame shell bed relates primarily to the thickness of the nest material of the bed, the density of individuals and associated sediment composition. The beds in Loch Sunart are considered to be typical of the habitat with dense flame shells (ca 230-400 per m^2) and a rich associated infaunal community (Bates et al, 2004, Mercer et al 2007). Dense flame shells (>50% nest cover) are restricted to an area of coarse sediments in the strongest tidal currents at 3-20 m in Laudale Narrows, extending over an area of around 20 ha. The thickness of this bed has not been investigated and the extent and thickness of other smaller beds in the loch notably north of Carna and at various headlands along the loch have not been investigated. Assessments should focus on activities which may significantly alter water flow and sedimentation characteristics, involve significant abrasion or disruption of the seabed and increase in organic particulate matter in the immediate area.
Serpulid aggregations	Recover the three-dimensional structure of serpulid aggregations.	Serpulid aggregations are clumps of individual tubes of *Serpula vermicularis* growing vertically from the seabed twisting together to form chimney like structures. Serpulid aggregations are not defined by a minimum number of tubes but rather their clumping together, growing vertically up from the seabed (generally greater than 10 cm in height) and forming a discrete community different from the surrounding seabed. More substantial aggregations (approx. >1 m diameter) are recognised as biogenic reefs (see also Holt et al., 1998; European Commission, 2013). The calcareous remains of old serpulid tubes may serve as substrate for new aggregations to grow on. Serpulid reef development is thought to go through a cyclical nature of growth and collapse. Serpulid reefs are thought to naturally develop from aggregations. When reefs get too big to support their own weight, they are thought to collapse. Some of the worms in the broken pieces continue to grow while others act as substrate for more worms to grow on, eventually forming new reefs. In 2006 the serpulid aggregations were described as having a mean height of 26cm (SD 9 cm, n=59) and mean diameter of 19 cm (SD 10 cm, N=59) in Loch Sunart (Dodd *et al.,* 2009) growing on rocks, and amongst kelp holdfasts around the margin of the loch in depths of 1-5 m. It was assumed that the serpulid aggregations in Loch Teacuis would develop into larger reefs. However, subsequent surveys of Loch Teacuis in 2013 (Last, 2014; SNH, 2014) and 2014 (Kamphausen, 2015) showed a decline in the serpulid aggregations. Several small

		aggregations have been noted by CAOLAS in 2022 on the northern shore (below 3m; colonies with a height of >=10cm noted; Sim, 2024). Serpulid worms were also present on the eastern shore (between 0-3m depth), however the height of these were <10 cm (Sim, 2024), meaning that they are not recognised as serpulid aggregations (aggregations are >=10cm in height). Serpulid worms were recorded on the southern shore of the Loch (Sim, 2024), however no height data are available meaning that it is unclear if serpulid aggregations are present. The decline in serpulid aggregations in the loch has resulted in a loss in the structure provided by the aggregations. Reasons for the decline in serpulid aggregations at Loch Teacuis are unknown. One hypothesis is that the decline is part of a natural cycle of growth and collaspe (a hypothesis in which the Hughes *et al* (2024) report was unable to confirm or deny in Loch Creran where declines have also been observed; Hughes *et al.*, 2024). Other factors (including changes in the planktonic community structure, changes in land use in the loch catchment area, and alterations in the localised weather; Tulbure, 2015) have been hypothesised as reasons for the decline in serpulid reefs in Loch Creran (Hughes *et al.*, 2024) and may also be relevant for the declines in aggregations in Loch Teacuis. Other hypotheses, include that an increase in biofouling of reef rubble and decrease in larval recruitment (Heriot-Watt unpublished) is preventing the regeneration of reefs (Heriot-Watt, unpublished). Regardless for the reasons for decline, it is still important that any areas previously colonised by serpulid aggregations are considered as potential areas for recovery when consents/licenses for human activities are being considered. Natural recovery of serpulid aggregation structure should be supported by maintaining the environmental conditions required for aggregation establishment. The key factors influencing the recovery include the availability of a sufficient larval and food supply and suitable hard substrate for larval settlement. Human intervention to recover the loss of extent of serpulid aggregations is currently being trialled in Loch Creran (Heriot-Watt, unpublished), although it is unclear whether his is a viable option. Serpulid aggregations are likely to have a slow rate of recovery. Further details are provided in the section on *'Factors limiting recovery'* at the end of this document. Whilst recovery may be possible, all disturbance to serpulid aggregations by human activities is likely to be judged detrimental because it has the potential to cause a long-term or permanent reduction in the

		extent of aggregations. Therefore, any damage that would lead to a reduction in extent or a restricted/modified distribution, or prevent recovery, should be avoided.

(b) Function and quality

The boxes below provide the site-specific advice on the '**function of the habitat and its quality'** element of this conservation objective.

'Quality' in this context is taken to mean the processes relevant to the features e.g. water movement, chemical water quality parameters etc and are referred to as environmental conditions in the table below. Consideration of the functioning of the habitat and supporting environment on which it relies needs to take into account the wider functioning and environmental conditions within this water body.
Loch Sunart is a complex fjordic sea loch, situated between the Ardnamurchan and Morvern Peninsulas on the west coast of Scotland (see Figure 1). Six shallow sills divide the loch into a series of steeply shelving basins with a maximum depth of 125 m. The mouth of Loch Sunart opens into the northern end of the Sound of Mull. Loch Teacuis, a small and extremely sheltered sea loch (max. depth ~30 m), enters the south side of Loch Sunart.

There is inter-dependence between the functions of the habitats in Loch Sunart and the supporting environment. Together, the habitats and supporting environment lead to direct and indirect benefits for people. The sections below identify key functions associated with each habitat; different habitats contribute to different functions to different degrees. It is also useful to consider some functions at the scale of the whole site / local ecosystem, such as resilience to invasive non-native species (INNS) and disease, and carbon storage and climate regulation. For resilience to INNS and disease, the combined function of healthy and biodiverse habitats in Loch Sunart is likely to contribute to the ability of the local ecosystem to resist, recover from or adapt to the introduction of a non-native or disease/pathogen. For carbon storage and climate regulation, the site as a whole ranked 29th (per unit area) in the total carbon stocks of Scotland's Inshore MPAs (Burrows et al, 2017). Substantial contributions from individual habitats are noted below with kelp and macroalgae within the MPA providing a particularly large store of organic carbon. The presence and maintenance of this stock is linked to other habitat functions and external factors.

Feature	Site specific advice		Site specific information
All qualifying habitats	Maintain the overall water body condition status of Loch Sunart		Loch Sunart was assessed as having a 'good' overall water body status in 2022 (SEPA, 2022). This assessment includes consideration of water chemistry, pollutants, the physical condition of the water body, plant and animal communities, including plankton, and the risk from invasive non-native species.
Flame shell beds	Conserve the functions provided by flame shell beds and the environmental	**Key functions** • Formation of habitat • Sediment stabilisation	The key functions provided by flame shell beds are habitat provision, elevated biodiversity and associated productivity. Flame shell beds stabilise a seabed that would otherwise consist of mobile sand or gravel, increasing biodiversity by creating habitat for organisms such as kelps, peacock worms and brittle stars. Examples of the characteristic biological communities

	conditions that support them.	• Waste breakdown & detoxification of water/sediment Environmental conditions • Water movement • Water quality	supported by the beds are described in the next section. Flame shell beds in Loch Sunart are mainly self-recruiting although beds will provide larvae to other beds within the loch (Millar *et al.,* 2019). As bivalves flame shells contribute to waste breakdown and detoxification. Alongside these functions, the flame shell beds of Loch Sunart contribute to a number of wider benefits for people (see section 1.3). Although their lower abundance compared to horse mussels limits the volume of water they filter, as bivalves they do contribute to waste breakdown and detoxification as well as nutrient cycling. Flame shells contribute to carbon storage, with their shells made of both organic and inorganic carbon (Porter *et al.*, 2020; Cunningham *et al.*, 2023). Flame shells nests are made up of byssus thread and trapped shell, algae, and sediment and can contain a significant amount of carbon (Porter *et al.*, 2020). Maintaining the flame shell beds relies on adequate supply of larval recruits and food (plankton) and suitable environmental conditions for growth. Environmental conditions, including water movement patterns and water quality are important in the provision of these requirements. Flame shell beds are strongly associated with areas of high current flow. The tide entering and leaving Loch Sunart is squeezed through the narrow, shallow Laudale Narrows creating the tidal currents necessary for the development of a flame shell bed here. The current water body status provides suitable conditions for sustaining flame shell beds. If any of the environmental conditions were to be significantly altered, it could detrimentally affect the function of the flame shell beds.
Serpulid aggregations	Recover the functions provided by serpulid aggregations and maintain the environmental	**<u>Key functions</u>** • Formation of habitat Environmental conditions • Water movement • Water quality	The key function relevant to serpulid aggregations is the formation of habitat. Serpulid aggregations provide habitat for other animals, lifting them up off the seabed to facilitate filter feeding, and providing shelter from predators. Compared to reefs, serpulid aggregations provide limited contribution to habitat complexity, but they do provide some on a seabed that would otherwise be gravelly with boulders and cobbles. This habitat provision results in elevated biodiversity and associated productivity on a seabed that

	conditions that support them.		would otherwise consist of boulders and cobbles. Examples of the typical species supported by the aggregations are described in 2c. However, as serpulid aggregations have declined throughout the loch, they no not contribute significantly to habitat provision. Key factors limiting the recovery of their functions include, the availability of a sufficient larval supply and food, the presence of existing live reefs or reef rubble or hard substarte clear of biofouling upon which larvae can settle (Lancaster et al., 2014). Individual *Serpula vermicularis* are common around the coast of the UK but the combination of the water movement and ecology of Loch Teacuis allows the growth of rare Serpulid aggregations. The conditions of faster water movement created when the incoming and outgoing tides pass into and out of Loch Sunart prevents the growth of serpulid aggregations here, rather, serpulid aggregations prefer the slower moving waters of Loch Teacuis created by the narrow, shallow entrance to the loch at Caolas Rahuaidh. Current thinking suggests that before serpulid aggregations are able to develop, individual *S. vermicularis* have to be present in sufficient numbers in a restricted sea loch for larvae to settle on existing worm tubes first forming serpulid aggregations. The narrow entrance of Loch Teacuis encourages aggregation growth by retaining the serpulid larvae within the loch so they are more likely to settle on established worm tubes. Additionally, the entrance helps retain plankton within the loch system, and the continually moving currents created by the tide, keep this food supply passing by the filter feeding reefs. Serpulid aggregations also require good water quality for their survival and growth, including an adequate larvae and food supply. Declines in serpulid aggregations have been observed in Loch Teacuis. As discussed in the previous section, the reasons for this decline are unknown. There have been no significant changes in water quality in Loch Sunart since 2007 (SEPA, 2022), with the overall status assessed as ‘Good’. This suggests that the current water body status provides suitable conditions for supporting the recovery of serpulid aggregations. If any of the environmental conditions were to be significantly altered, it could detrimentally affect the function of the serpulid aggregations. It is important to maintain the

			conditions within the loch to observe whether the aggregations will regenerate and help us understand more about the cyclical nature of serpulid reef development.

(b) Composition of its characteristic biological communities		
Consideration of characteristic biological communities should not be limited to the list provided below, however it does give an indication of the main species we would expect to be present.		
Feature	**Site specific advice**	**Site specific information**
Flame shell beds	Conserve the diversity, abundance and distribution of characteristic species associated with the habitat.	The flame shell bed in the Laudale Narrows supports a diverse infaunal community (seven 0.01 m^2 core samples collected during survey work in 2006 contained 114 taxa with a mean of 47 taxa per core). This is comparable with other flame shell beds in Scotland (Hall-Spencer and Moore, 2000; Trigg *et al*., 2011; Moore *et al*., 2013). Diver surveys of the associated epibiota carried out as part of the survey work in 2006 recorded rather modest levels of species diversity (a total of 83 taxa with a mean of 25 taxa per sampling station and 43 taxa at the most diverse station) across the bed (Mercer *et al*., 2007). Brittlestars were Superabundant at two stations which may have contributed to the low diversity measures (Moore *et al*., 2013). Within the infralittoral zone (<10 m depth), the flame shell bed supports *Laminaria hyperborea* and *Saccharina latissima* kelps with foliose red algae below. Below the kelp and down to ca. 20 m, a steep slope of muddy sand and shell gravel has terraces of cobbles, pebbles and shells consolidated by flame shell nests. In 2006 the common brittlestar *Ophiothrix fragilis*, black brittlestar *Ophiocomina nigra* and the crevice brittlestar *Ophiopholis aculeata* were all present in high numbers. Green sea urchins *Psammechinus miliaris* and rugose squat lobsters *Munida rugosa* were common. Coralline encrusting algae, particularly *Lithothamnion glaciale*, was prevalent on the cobbles and the parchment tube worm *Chaetopterus variopedatus* was scattered amongst the flame shell nests. At depths of ca.27 m almost 100% coverage of nest material was present. Also present were colonies of dead man's fingers *Alcyonium digitatum* and large *Urticina eques* anemones. Assessments should focus on activities which involve physical change to and/ or the removal of substratum, those which may significantly alter local hydrographic and sedimentary

		processes and those which may lead to an increase in organic particulate matter in the immediate area.
Serpulid aggregations	Recover the diversity, abundance and distribution of characteristic species associated with the habitat.	Small aggregations of Serpulid worms were found around the periphery of Loch Teacuis, a small and extremely sheltered sea loch (max. depth ~30 m) which enters the south side of Loch Sunart, in 2006 (Mercer *et al*., 2007). Thirty-six conspicuous species were recorded in association with the serpulid aggregations which also undoubtedly support more taxa living within the worm colony structure. The aggregations were recorded on a shallow slope of muddy sand with cobbles, pebbles and shell debris lying just below the sediment surface. Sugar kelp *Saccharina latissima* was scattered amongst the serpulid aggregations with slender seapens *Virgularia mirabilis* and burrowing anemones *Cerianthus lloydii* present in the surrounding sediments. The aggregations themselves supported hermit (*Pagurus bernhardus* and *Pagurus prideaux*) and swimming crabs, squat lobsters, terebellid worms, small queen scallops *A. opercularis*, shrimps *Palaemon serratus*, common starfish *Asterias rubens*, sea squirts *Ascidia mentula* and common whelks *Buccinum undatum*. Subsequent surveys by CAOLAS in 2022 also found a rich associated community, including the polychaetes *Spirobranchus triqueter* and *terebellids*, the sponges *Esperiopsis fucorum* and *Suberites* sp., the ascidians *Ascidiella aspersa*, *Dendrodoa grossularia* and *Diplosoma listeri anum*. Sea urchins (*Psammechinus miliaris*), feather stars (*Antedon bifida*), the queen scallop and variegated scallop (*Chlamys varia*), the chiton (*Tonicella marmorea*) and the crustaceans (*Galathea squamifera* and *P. bernhardus*) were also present. This suggests that even when aggregations are small in height, they may still support a rich associated community.

LOW OR LIMITED MOBILITY SPECIES

Quality and quantity of habitat		
Feature	**Site specific advice**	**Site specific information**
Northern feather star aggregations on mixed substrata	Conserve the quality and quantity of the habitat in which northern feather star aggregations are found in this site (mud and muddy sand substrates with scattered cobbles)	Very high densities of *Leptometra* have been recorded at a number of locations within Loch Sunart present on a variety of substrates in various water depths. In deeper water (>110 m) and in more sheltered shallower areas (ca. 40 m), attached to cobbles, pebbles and shell gravel and in areas with species typical of burrowed mud (Bates *et al.,* 2004; Mercer *et al.,* 2007). The six discrete polygons of this feature were mapped within the MPA (outputs of a predictive mapping study resulting in polygons of moderate to low confidence - Envision Mapping Ltd., 2014) ranging in size from 2 to 17 ha. Loch Sunart also contains several records of *L. celtica* aggregations on bedrock and stony reefs. These aggregations are not part of the protected feature, as they do not meet the definition of Northern feather star aggregations on mixed substrata. However, they do increase the viability and coherence of the population in the loch overall. Maintaining the quality and quantity of the habitat in which northern feather star are found relies on the continued presence of the substrates on which they depend (mud and muddy sand substrates with scattered cobbles), an adequate supply of larval recruits and suitable environmental conditions for growth. Environmental conditions, including water movement patterns and water quality are important for the continued presence of this species. Loch Sunart MPA was assessed as having a 'good' overall water body status in 2022 (SEPA). The current status of these parameters provides suitable conditions for sustaining the northern feather stars. The recovery of the quality and quantity of the habitat in which northern feather stars are found depends on environmental factors as well as the type and duration of impact. Further details are provided in the section on 'Factors limiting recovery'. Northern feather stars occur at various locations throughout this MPA, therefore, any change in the quality and quantity of the habitat they inhabit due to human activity may be considered to compromise the Conservation Objectives within the site.

Composition of its population		
Feature	**Site specific advice**	**Site specific information**
Northern feather star aggregations on mixed substrata	Conserve the density of the the northern feather star aggregations in this site so that it is stable or increasing.	Aggregations of northern feather stars in Loch Sunart occur in dense fields at the mouth of Loch Sunart, and throughout the loch and are considered typical. These aggregations serve as increase habitat complexity of the surrounding seabed and providing settlement surfaces and shelter to a range of associated species (Holt, 1991). The longevity of *Leptometra celtica*, is unknown, with suggestions that adult crinoids live at least several years (Last *et al.,* 2019).

Annex 2. Supporting information

Factors limiting the recovery of features

Flame shell beds
Whilst studies on the recovery of flame shells (*Limaria hians*) are limited, there is some evidence that indicate that this species can recover following the removal of pressures, assuming suitable environmental conditions are present. Following contamination by TBT, Minchin (1995) indicated that recovery may take less than 10 years for recovery of the species and bed, although no information was available for the recovery of the associated bed communities. In contrast, Trigg and Moore (2009) indicated that following physical disturbance associated with scallop dredging, recovery may take over 100 years to achieve spatial coverage but the time for recovery of nest thickness is not known. Early evidence from Loch Carron suggests that beds can recovery within a couple of years if flame shells are not completely removed. The ability of flame shell beds to recover depends on the level and type of disturbance (with more extensive areas of damage taking longer to recover) and the density of remaining individuals and the fragmentation of the bed (higher remaining densities, lower levels of fragmentation are likely to recover more quickly). Within Loch Creran, flame shells are considered generally self-recruiting (Millar *et al*., 2019) meaning that the ability for beds to recover depends on local spawning and recruitment.

Serpulid aggregations
If lost serpulid aggregations may take considerable time to recover and possibly never return (Lancaster et al. 2014). The combination of the hydrology and ecology of Loch Teacuis allows the growth of serpulid aggregations. The maintenance and recovery of serpulid aggregations relies on the hydrography of the loch system being maintained, an adequate source of food (plankton), an abundant supply of larval recruits, from either individuals or aggregations within the loch, and the presence of suitable habitat for settlement (existing worm tubes, other hard substrate and particularly bivalve shells (Moore et al.,1998) (Lancaster et al., 2014). There is also temporal variability in larval settlement, with this occurring predominantly from mid-June to mid-October, peaking in mid-August to mid-September (Chapman et al. 2007). Therefore, activities that could affect the viability of larvae and their ability to settle would have the greatest effect during this period. The importance of this is highlighted by the die out of Serpulid reefs in other localities i.e., Loch Sween, where the reasons for the loss are still not understood. At Loch Sween, it is unlikely that the reefs will regenerate naturally because of a lack of a viable population in the loch to provide a dense enough supply of larvae, although aggregations have been recently reported in Linne Mhuirich, Loch Sween, which may supply larvae to other localities within the loch. Efforts to recolonise Loch Sween using transplanted reef were not successful (Hughes et al., 2008), and whilst this may remain technically feasible (Herriot-Watt *unpublished*) the scale of the task is currently likely to be impractical (Lancaster et al., 2014).

Tubes of *Serpula vermicularis* (which form the serpulid aggregations) have been observed to have a growth rate of 33mm yr^{-1} and are estimated at this rate to take 6 years to fully develop (Hughes et al. 2008), although it can take much longer for a

reef to develop. The larger aggregations can therefore take many periods of recruitment to form and recover from any impact. Recovery of serpulid reefs has been documented in Loch Creran, following organic pollution from an alginate factory destroying reef on the south side of the loch (Holt et al., 1998). Around 10 years after the discharge ceased, serpulids began to re-colonise the margins of the affected area (Moore et al. 2006). However, this is not full recovery and the times scales for this or recovery from other types of damage/disturbance are unknown. Further details are available in Mazik et al. (2015).

Northern feather star aggregations on mixed substratum

The recovery of northern feather stars is dependent on the presence of viable adults, recruitment and larval supply. As northern feather stars have short pelagic larvae durations resulting in short dispersal distances (Gallego et al., 2017), recovery is expected to take longer if the population is completely removed. Feather stars are able to regenerate almost everything except the central organ, so the species may be able to recover from damage. They have limited mobility so may be able to move to some extent from adverse conditions. Recovery may also be dependent on sediment type with fauna in stable gravel, mud and biogenic habitats more vulnerable to disturbance than those in less consolidated coarse sediments (Collie et al., 2000).

Glossary for Conservation Objectives

Conservation Objective term	Definition
Composition of characteristic biological communities	This should include a reference to the diversity and abundance of species forming part of, or inhabiting, that habitat. In particular this includes those species that are especially relevant to the habitat's definition, e.g. species that form the structure of a bivalve bed, or sea pens on burrowed mud. In ecological terms, "community composition" means the number and abundance of flora and fauna included in the habitat. This is also referred to as biodiversity - the variety of life in a particular habitat.
Extent (and distribution)	The "extent" of a feature is the total area that it covers. This should also include consideration of the "distribution" i.e. how it is spread out within the MPA. A feature could be continuous and contained within one area, dispersed in smaller patches over a wider area, or as a mosaic with other habitats/features. Indeed, it could also be a combination of these.
Favourable condition	Favourable condition for each protected feature type for NC MPAs is defined in the box at the start of Annex I which summarises the conservation objectives for the site.
Function	The habitat must be able to be maintained in terms of the growth and reproduction of the habitat-forming species (e.g. through self-recruitment of larvae) and also help to maintain the provision of essential ecosystem services that the habitat provides. The text within the supplementary advice explains function in relation to both of these factors for the feature concerned where information is available.
Integrity (geodiversity)	For geodiversity features, integrity is the way the component elements make up the full extent of the feature. Integrity relates to the relationship between the component elements, where the whole is greater than the sum of the parts. In other words integrity refers to the full assemblage of component elements.
Quality / Processes	Quality outlines the processes relevant to the habitat/feature and include but are not limited to hydrography and supporting water currents, chemical water quality parameters, suspended sediment levels, radionuclide levels.
Supporting environment	This includes the following environmental conditions (but is not limited to) which are important for maintaining/restoring the protected features, e.g.hydrography and supporting water currents, chemical water quality parameters, suspended sediment levels, radionuclide levels.
Structure	The structure of a habitat/feature includes what it is created from and what it requires to exist, e.g. habitat forming species, geological features or sediment; the depth of the substrate or thickness or height of the biogenic structures from the seabed; biogenic material forming the structure should still retain a live component where this exists at baseline.

References

Bates, C.R., Moore, C.G., Harries, D.B., Austin, W. and Lyndon, A.R. 2004. Broad scale, mapping of sublittoral habitats in Loch Sunart, Scotland. *Scottish Natural Heritage Commissioned Report No. 006.*

Chan, B.S. 2013. Climate change impacts on the serpulid tubeworm *Hydroides elegans* - a biomineralization perspective. A thesis submitted for the degree of Doctor of Philosophy, University of Hong Kong. Pokfulam, Hong Kong.

Chapman, N.D., Moore, C.G., Harries, D.B. and Lyndon, A.R. 2007. Recruitment patterns of *Serpula vermicularis* L. (Polychaeta, Serpulidae) in Loch Creran, Scotland. *Estuarine, Coastal and Shelf Science*, 73: 598-606.

Collie, J.S., Hall, S.J., Kaiser, M.J., and Poiner, I. R. 2000. A quantitative analysis of fishing impacts on shelf-sea benthos. *Journal of Animal Ecology*, 69: 785-798.

Cunningham, C. and Hunt, C. 2023. Scottish Blue Carbon - a literature review of the current evidence for Scotland's blue carbon habitats. *NatureScot Research Report 1326.*

Dodd, J., Baxter, L. and Hughes, D.J. 2009. Mapping *Serpula vermicularis* (Polychaeta: Serpulidae) aggregations in Loch Teacuis, western Scotland, a new record. *Marine Biology Research,* 5: 200-205.

Envision Mapping Ltd. 2014. Predictive Mapping of MPA protected features within selected possible Nature Conservation MPAs in Scottish territorial waters using available datasets. *Scottish Natural Heritage Commissioned Report No. 600.*

European Commission. 2013. Interpretation manual of European Union habitats. EUR 28, 144 pages.

FeAST. 2013. FeAST - Feature Activity Sensitivity Tool. Online at https://feature-activity-sensitivity-tool.scot/ [accessed 14th Apr 2025].

Gallego, A., Gibb, F.M., Tullet, D., and Wright, P.J. 2017. Bio-physical connectivity patterns of benthic marine species used in the designation of Scottish nature conservation marine protected areas*. ICES Journal of Marine Science*, 74: 1797–1811.

Hall-Spencer, J.M. and Moore, P.G. 2000. *Limaria hians* (Mollusca: Limacea): A neglected reef-forming keystone species. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 10: 267-278.

Holt, T.J., Rees, E.I., Hawkins, S.J. and Seed, R. 1998. Biogenic Reefs (volume IX). An overview of dynamic and sensitivity characteristics for conservation management of marine SACs. *Scottish Association for Marine Science (UK Marine SACs Project).*

Holt, R.H.F. 1991. Surveys of Scottish sea lochs. Lochs Laxford, Inchard, Broom and Little Loch Broom. *Joint Nature Conservation Committee Report, No. 16.*

Hughes, D.J., Ross, O., Carey, R., McNeill, C., and O'Dell, A. 2024. Loch Creran Special Area of Conservation (SAC) review of activities and pressures. *NatureScot Research Report 1346.*

Hughes, D.J., Poloczanska, E.S. and Dodd, J. 2008. Survivorship and tube growth of reef-building *Serpula vermicularis* (Polychaeta: Serpulidae) in two Scottish sea lochs *Aquatic Conservation: Marine and Freshwater Ecosystems,* 18**:** 117-729.

Kamphausen, L., 2015. Loch Teacuis serpulid survey March 2015 – Post survey summary. NatureScot.

Lancaster, J. (Ed.), McCallum, S., Lowe A.C., Taylor, E., Chapman A. and Pomfret, J. 2014. Development of detailed ecological guidance to support the application of the Scottish MPA selection guidelines in Scotland's seas. Scottish Natural Heritage Commissioned Report No. 491.

Last, E.K., Robson, L.M. and Garrard, S.L. 2019. *Leptometra celtica* assemblage on Atlantic upper bathyal sand. In Tyler-Walters H. Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 14-04-2025]. Available from: https://www.marlin.ac.uk/habitat/detail/1187

Last, E. 2014. An investigation into factors affecting *Serpula vermicularis* (L.) reefs in three Scottish sea lochs. *BSc (Hons) thesis, Geography, Newcastle University.*

Mazik, K., Strong, J., Little, S., Bhatia, N., Mander, L., Barnard, S. and Elliott, M. 2015. A review of the recovery potential and influencing factors of relevance to the management of habitats and species within Marine Protected Areas around Scotland. *Scottish Natural Heritage Commissioned Report No. 771.*

Mercer, T., Howson, C.M. and Moore, J.J. 2007. Site Condition Monitoring: Loch Sunart marine SAC and SSSI. *Scottish Natural Heritage Commissioned Report No. 286.*

Millar, H., O'Hara Murray, R., Gallego, A., Gormley, K. & Kent, F. 2019. Connectivity of selected Priority Marine Features within and outwith the Scottish MPA network. *Scottish Natural Heritage Research Report No. 1048.*

Minchin, D. 1995. Recovery of a population of the flame shell, Lima hians, in an Irish bay previously contaminated with TBT*. Environmental Pollution*, 90(2): 259-262.

Moore, C.G., Harries, D.B., Tulbure, K.W., Cook, R.L., Saunders, G.R., Lyndon, A.R., Kamphausen, L., and James, B. 2020. The current status of serpulid reefs, horse mussel beds and flame shell beds in Loch Creran SAC and MPA. *Scottish Natural Heritage Research Report No. 1156.*

Moore, C.G., Harries, D.B., Atkinson, R.J.A., Clark, L., Cook, R.L., Hirst, N.E., Saunders, G.R., Lyndon, A.R., Sanderson, W.G., and Porter, J.S. 2013. The distribution and condition of proposed protected features within the Loch Sunart possible Nature Conservation MPA. *Scottish Natural Heritage Commissioned Report No. 621.*

Moore, C. G., Saunders, G. R. and Harries, D.B. 1998. The status and ecology of reefs of *Serpula vermicularis* L. (Polychaeta: Serpulidae) in Scotland. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 8: 645-656.

Porter, J.S., Austin, W.E.N., Burrows, M.T., Clarke, D., Davies, G., Kamenos, N., Riegel, S., Smeaton, C., Page, C. and Want, A., 2020. Blue carbon audit of Orkney waters. *Scottish Marine and Freshwater Science*, 11(3).

Trigg, C., Harries, D., Lyndon, A. and Moore C.G. (2011). Community composition and diversity of two *Limaria hians* (Mollusca: Limacea) beds on the west coast of Scotland. *Journal of the Marine Biological Association of the United Kingdom,* 91: 1403-1412.

Trigg, C., and Moore, C.G. 2009. Recovery of the biogenic nest habitat of *Limaria hians* (Mollusca: Limacea) following anthropogenic disturbance. *Estuarine, Coastal & Shelf Science,* 82: 351-356.

Sim, T. 2024. Monitoring *Serpula vermicularis* colony presence in Loch Teacuis, western Scotland. CAOLAS, 17pp.

SNH. (2014). SNH diver survey of the serpulid aggregations in Loch Teacuis, 16 - 18 June 2014. Unpublished field data.

Strong, J.A., Mazik, K., Franco, A., Roberts, L, Bhatia, N. and Smyth, K. Unpublished. Implications of climate change for the Scottish Marine Protected Area Network *Scottish Natural Heritage Commissioned Report.*