

# PRIORITY MARINE FEATURE (PMF) - FISHERIES MANAGEMENT REVIEW

## Feature

### FLAME SHELL BEDS

#### Image



#### Map



## Description

**Characteristics** - The flame shell (*Limaria hians*) creates nests by weaving together tough threads (byssus) with surrounding material such as seaweed, maerl and shells. Adjoining nests coalesce to form larger structures which, in some locations, carpet the sea bed for several hectares. Flame shell beds stabilise the sediment and provide an attachment surface for many organisms including hydroids, bryozoans, ascidians and seaweeds. These structural species increase habitat complexity, providing shelter for more mobile species such as brittle stars, crabs, queen scallops and saithe (Tyler-Walters & Perry, 2016). A rich diversity of fauna is also found within and below the flame shell bed. Deterioration of flame shell bed habitat can have a significant impact on local biodiversity.

**Definition** - A minimum cover of 10% byssal turf material over an area of at least 5 m x 5 m has been used to define a flame shell bed. At certain locations (for example the low-density bed in the Sruth Lagaidh Narrows in Loch Broom), a continuous blanket of byssal material is not present; instead, flame shells occur amongst stone and shell material which they may bind together, but do not form a layer overtopping the substrate. The concept of a byssal turf can be less clear in such circumstances and a better practical definition of a bed here would be a mixed substrate supporting a flame shell density of at least 1 per 0.1 m<sup>2</sup> (Moore *et al.*, 2013; Moore & Harries, 2017). This equates to *Common* or *Abundant* on the SACFOR species abundance scale used by scientific divers (Hiscock, 1996).

**Environmental preferences** - Flame shells occur on mixed, muddy sand and gravel bottoms at depths of 5-100 m in sheltered areas with moderately strong currents (~1 to 3 knots or 0.5 to 1.5 m/sec.). Flame shell beds are commonly associated with tide-swept narrows including the entrances or sills of sea lochs, primarily between depths of 5-25 m but occasionally >40 m (52 m within Loch Alsh - Moore, 2017) in variable to full salinity (18 to 35 ppt) (Trigg, 2009).

## Distribution

**Scottish distribution** - Flame shell beds have been recorded at 11 locations within Scottish waters, primarily on the west coast, with the most extensive beds occurring in Loch Carron, Loch Alsh and Loch Sunart. Beds have also been found in Scapa Flow, Orkney.

**Estimated known Scottish extent** - Beds vary considerably in size and in the proportion of dense nest / turf cover present. One of the smallest mapped beds, at the western entrance to the Creagan Narrows in the Loch Creran MPA covers ~0.5 ha, is fragmented (comprising three discrete patches of habitat) and dense nest cover (>50% of the seabed) is confined to an area of ~0.1 ha (Moore *et al.*, 2013). In contrast, the largest known bed in the Loch Carron MPA extends to ~194 ha with cover averaging 30 - 70% across the bed and extensive areas supporting 100% (Moore *et al.*, 2018). Known beds in Scottish waters are currently considered to cover an area of ~500 ha.

**Wider distribution** - Flame shell beds have a globally restricted distribution. Outside Scottish waters, the only records of this habitat are from the Moross Channel area in Mulroy Bay SAC on the north-west coast of Ireland. Survey work there in 2008 (MERC Consultants, 2008) recorded only small numbers of flame shells and not the extensive carpets of dense aggregations previously described in Minchin (1995). Other available records worldwide / within European waters relate to the presence of individual flame shells rather than flame shell beds. Flame shell species distribution is patchy; extending from the Mediterranean to the Canary Islands and northwards to the Lofoten Islands in Norway.

### Status

Scottish beds are of international importance. The habitat is considered to be severely declined and threatened in Scottish waters (Howson *et al.*, 2012b). Evidence of declines in the beds in the Loch Carron MPA, Wester Ross MPA and the Upper Loch Fyne and Loch Goil MPA led to a 'recover' conservation objective being set for the feature in these sites. Declines have also been observed in beds outside the Scottish MPA network e.g. at Port Appin (Moore *et al.*, 2012; Scott, 2016; Moore, 2018).

### Sensitivity (including recovery)

[Key sources: [FEAST](#); [Fisheries Management Guidance](#)]

Flame shell beds are highly sensitive to physical damage, particularly in the form of abrasion and habitat removal / change (Hall-Spencer & Moore, 2000a; Tyler-Walters & Perry, 2016) but also to changes in siltation, smothering, water flow and wave action (Mazik *et al.*, 2015). The species is highly sensitive to contamination (e.g. Minchin, 1995). Activities associated with these pressures include bottom-contacting fishing (including creels), aquaculture and anchoring / moorings (Mazik *et al.*, 2015). The predicted impacts of climate change also threaten flame shell beds (Hiscock *et al.*, 2001).

Towed bottom-contacting fishing gear can affect flame shell beds in two main ways. Firstly, direct mortality from damage to the shells and secondly, through disruption or removal of the structure of flame shell nests, resulting in the loss of associated species (Hall-Spencer & Moore, 2000a&b; Hall-Spencer *et al.*, 2003; Trigg & Moore, 2009). Towed bottom-contacting fishing (predominantly dredging) is considered to be the likely cause of the decline in extent of former beds in the Clyde (Hall-Spencer, 1998; Hall-Spencer & Moore, 2000a&b). This is corroborated from observations of the impact of scallop dredging in Loch Carron (Moore *et al.*, 2018). There are no studies directly addressing the effects of other towed bottom-contacting gears on this habitat, however it is assessed as highly sensitive to pressures associated with trawling (e.g. surface abrasion) (Tillin *et al.*, 2010).

Habitat recovery following impact is dependent on removal of the pressure, the continued presence of suitable substrates and a source of adult colonists or larval recruits. Trigg & Moore (2009) is the only known study to investigate recovery in flame shell beds following simulated scallop dredge damage. For a dredged area 7.5 m wide, that study estimated a recovery time of 117 years, assuming linear growth of 3.2 cm per annum. Where complete defaunation does not occur, sensitivity to changes in current speed and sediment mobility are likely to increase following disturbance due to reduced nest integrity and fragmentation.

Recovery may be quicker where a dense, actively recruiting flame shell population remains post-impact. Rapid bed development observed in Loch Alsh between 1999 (Mair *et al.*, 2000) and 2012 may be linked a decline in horse mussel density (Moore *et al.*, 2013). This is considered to be natural ecological succession.

### Connectivity

**Between flame shell beds** - Flame shells have the ability to swim (see - <https://www.youtube.com/watch?v=wolmbCqMKIc>). However, the mechanism by which a flame shell propels itself through the water is likely to be energetically expensive and dispersal over large distances through swimming activity is not expected. Therefore, establishment and maintenance of flame shell populations is likely to be limited to areas of suitable habitat within proximity to a source of colonists (through expansion of existing beds and / or larval settlement to form new beds). On the basis of laboratory experiments (Lebour, 1937) flame shell larvae are believed to spend at least a few weeks in the plankton (Tyler-Walters & Perry, 2016). Preliminary hydrodynamic modelling outputs concluded some connectivity across the known beds in Scottish waters up the west coast to Orkney (e.g. Gallego *et al.*, 2013). However, the nearshore and semi-enclosed sea loch environments that support most of the extant beds are less dispersive than open water models predict and larval supply is likely to be restricted. Due to a lack of self-recruitment, small beds may have a greater reliance on adjacent larger beds as a source of larval recruits (see Moore *et al.*, 2012 regarding the loss of a bed at Shuna Island) and some beds may be isolated and incapable of recovery if damaged. There are large spatial gaps between the Clyde and Argyll beds and along the north-west and north coasts. SNH, Marine Scotland and Heriot-Watt University are currently exploring flame shell bed connectivity in more detail (Millar *et al.*, *in prep.*). Additional management could help provide connectivity between beds, including those within the MPA network.

**With other PMFs** - Nests of the flame shell are often found in conjunction with the *maerl beds* PMF (Hall-Spencer *et al.*, 2003; Moore *et al.*, 2018). Flame shells bind maerl together with their byssal threads, helping to stabilise the maerl bed (Birkett *et al.*, 1998). In Loch Linnhe, Loch Alsh and Loch Carron there are records of flame shell beds adjacent to or intermixed with the *horse mussel beds* PMF (Moore *et al.*, 2012; 2013; 2018).

Flame shell beds are also often found in combination with *tide-swept algal communities*; the nests providing a stable substratum for the attachment of seaweeds in an otherwise unsuitable location (Lancaster *et al.*, 2014).

### Ecosystem services

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|--|---|
| <ul style="list-style-type: none"> <li>• Biomass production</li> <li>• Larval/gamete supply (supporting connectivity)</li> <li>• Nutrient cycling</li> <li>• Formation of habitat for other species (supporting biodiversity)</li> <li>• Resilience to INNS &amp; disease</li> <li>• Coastal protection</li> </ul> | <ul style="list-style-type: none"> <li>• Waste breakdown &amp; detoxification of water and sediments</li> <li>• Carbon storage &amp; climate regulation</li> <li>• Fish and shellfish stocks</li> <li>• Sediment stabilisation</li> <li>• Socially valued places/seascapes</li> <li>• Watching/studying nature</li> </ul> |
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### Existing Marine Protected Areas

Flame shell beds are a protected feature of 6 MPAs: Upper Loch Fyne & Loch Goil; Loch Creran; Loch Sunart; Lochs Duich, Long and Alsh; Wester Ross; and, Loch Carron.

### Existing and proposed fisheries measures providing PMF protection

Details of existing fisheries measures associated with the first 5 of the MPAs listed above are provided on Marine Scotland's web pages (<http://www.gov.scot/Topics/marine/marine-environment/mpanetwork/MPAMGT/protectedareasmgt>).

Loch Carron was designated as an MPA on urgent basis in May 2017. An urgent Marine Conservation Order (MCO) came into force at the same time to manage fishing activity within the loch. This prohibits the deployment and use of any towed, bottom-contacting gear. A public consultation on the case for making the MPA and associated MCO permanent closed on 13 June 2018. Further details are available online (<http://www.gov.scot/Topics/marine/marine-environment/mpanetwork/developing/2017MPA>).

A single 1989 record of the habitat in the Lynn of Morven is afforded protection by fisheries measures associated with the common skate feature of the Loch Sunart to the Sound of Jura MPA (see web link at the top of this section for details of the measures). However, following survey work in 2011 there is some uncertainty regarding the continued presence of flame shell habitat in this location (Moore *et al.*, 2012).

Fisheries management measures also provide protection to a potentially significant bed in the Inner Sound [within the BUTEC range - CA138] (Moore *et al.*, 2018).

#### Examples of PMFs that have no or partial coverage by fisheries measures

- Scapa Flow - multiple recent records from Seasearch dives and follow-up academic research by Heriot-Watt University near Lyness, Fara and south of Cava (Hood, 2016; Jo Porter *pers comm.*).
- Port Appin, Loch Linnhe - there is good evidence for a marked temporal decline in the extent of the Port Appin flame shell bed over the last thirty years with creel fishing a possible contributory factor. Although even early records indicate some patchiness in coverage, it now appears to be absent from most of its previous range (Moore *et al.*, 2012; Scott, 2016; Moore, 2018). Previously considered one of the larger Scottish beds (~40ha - Moore *et al.*, 2011); current evidence suggests that it is now one of the smallest.
- Shearwater Rock, south-east of Inchmarnock, Clyde - a single flame shell bed record from 2010 (Allen *et al.*, 2013).

#### Assessment against National Marine Plan General Policy 9:

Development and use of the marine environment must not result in significant impact on the national status of Priority Marine Features.

**Flame shell beds are functionally important, biodiverse, sensitive, slow to recover and if lost completely may not recover. They have a globally restricted distribution and are scarce in Scotland where there is evidence of recent declines. Therefore any activities that lead to the loss of entire beds or damage beds to the extent that function or provision of ecosystem services cannot be maintained should be considered a significant impact on national status.**

**Existing licensing and consenting processes will continue to consider the potential for significant impacts on the national status of development proposals on flame shell beds. The following assessment relates to fishing using towed bottom-contacting gear only but is consistent with the approach taken for assessing proposed developments. Please refer to the *consultation overview* for further details.**

Flame shell beds are concentrated on the west coast and in Orkney and are afforded protection by fisheries measures in 8 locations. Only a small number of known beds are situated outside the Scottish MPA network.

In a fisheries context, additional measures to protect flame shell beds from pressures associated with towed bottom-contacting gears are recommended in the following areas: **Scapa Flow** and **Port Appin**. The recommendations for flame shell beds need to be considered alongside the recommendations for the other 10 PMFs considered as part of this review. The areas identified provide a starting point for discussions regarding future fisheries management. These discussions will be led by Marine Scotland.

The beds in **Scapa Flow** in Orkney are the most northerly examples of the habitat in Scottish waters. The Scapa beds are adjacent to a number of horse mussel and maerl bed records around Fara and Cava. Measures to support recovery of the declining beds at **Port Appin** in lower Loch Linnhe should include static gear. Due to the proximity of adjacent extant habitat, the proposed area includes Shuna Island, where former flame shell bed records were not validated in 2011 (Moore *et al.*, 2012).

### Knowledge gaps and other records

**Knowledge gaps** - A 2010 flame shell bed record from **Inchmarnock** in the Firth of Clyde (Allen *et al.*, 2013) supplements a species-only Seasearch observation from this area in 2007. The 2010 survey recorded five discrete flame shell nests in a 5 m radius search area and concluded that further survey work was required to determine if the nests actually represent a bed of the species (Allen *et al.*, 2013). Any new survey work could also ascertain the full extent and current status of maerl habitats in this location.

The Inchmarnock knowledge gap area (illustrated on the map provided) extends northwards to encompass waters off Ardlamont Point where survey work in 2011 recorded maerl beds with ~5% live maerl cover (a comparatively high proportion of live material in the context of many other maerl beds in the Clyde - Allen *et al.*, 2013).

Discussions with scallop divers in 2017 suggest that the flame shell bed in the **Inner Sound** was formerly significantly larger, potentially extending beyond the limits of the measures associated with the BUTEC range to Red Point on the outer, northern coast of Loch Torridon. New survey work to establish the current extent of the bed is proposed in 2018. Scallop dredging is currently exempted from the prohibitions imposed under the *Loch Torridon and the Northern Inner Sound* (CA56) measures. Maerl beds are known to be present along this stretch of coastline and the area identified as a knowledge gap for flame shell beds is encompassed by an area recommended for management consideration to protect maerl beds (please refer to the maerl beds PMF paper for further details). Any measures implemented here for maerl beds would cover the potential flame shell interest.

Flame shell bed habitat exists in **Loch Leven**. Occasional nests were recorded in fissures on a rocky slope off Burial Island by Seasearch divers in 2016. Flame shells were also recorded within horse mussel clump samples collected here in 2011 (Moore *et al.*, 2012). However, the nest material was highly cryptic and unobserved by divers *in situ*. and the species was not considered to be a significant habitat former at that time. There are a number of additional flame shell species records here on the NBN Atlas. The Loch Leven knowledge gap area falls within the **Lochs Linnhe, Leven and Eil** area for management consideration identified for the horse mussel beds PMF (please see associated paper for details). Measures implemented to protect the horse mussel beds would confer protection to any flame shell bed habitat present. It is unlikely that Loch Leven is accessible to towed bottom-contacting fisheries but due to the presence of horse mussel beds, the area would be considered during licensed activity processes.

**Other records** - There are historic records of flame shells around the South of Bute and the Cumbrae Islands in the Clyde, with abundant dead shells recorded on shallow maerl grounds in Stravanan Bay, SW of Isle of Bute and SW of Great Cumbrae Island during research conducted in the late 1990s. Historic maerl samples collected from the Tan Buoy site off SW Cumbrae in 1885 included flame shell byssus nest material (Hall-Spencer & Moore, 2000a). Nearshore habitats here including flame shell and maerl beds have been heavily fished over the last 60 years so recovery potential is likely to be low. However, the NBN Atlas holds a more recent 2014 record of flame shells (as a species not habitat) from the NW coast of Little Cumbrae so there is some potential and the bed in the Otter Narrows (Moore *et al.*, 2013) to the north, a feature of the Upper Loch Fyne and Loch Goil MPA, represents a potential source of larvae.

In terms of species-only records, fisheries measures proposed for the Clyde Sea Sill would afford protection to 2 of 4 historic records from waters around Sanda Island. Similarly, new measures in the Sound of Mull afford protection to 2 of 6 older species records (see inset on map provided). More recent survey work has not confirmed the continued presence of flame shells here but ongoing MPA-related benthic monitoring would identify habitat recovery and inform any future case for extending existing measures further up the sound if appropriate.

Future survey work may yet confirm the presence of flame shell beds in the Sound of Canna (part of the Small Isles MPA). The location of a grab sample collected here in 2011 that contained six flame shells (Howson *et al.*, 2012a), is expected to be afforded protection by new MPA-related fisheries management measures. Flame shell beds may also be present at the southern end of the Inner Sound to the east of Skye. A number of flame shell records (as a species only) exist around Guillamon Island to the SE of Scalpay. Survey work is proposed here in 2018 as part of a Marine Scotland-led EMFF project<sup>1</sup>.

### Data confidence

Available records span 1987-2017. Surveys vary in their original aims from Seasearch (carried out by volunteer divers) to MPA-related nature conservation assessments (e.g. Ullapool approaches survey in 2010 or SNH/MSS Loch Carron surveys in 2017). Records primarily come from diving but also infaunal grab samples and remote video surveys. New records of this feature were made in Loch Carron and the Inner Sound in 2017 (Moore *et al.*, 2018). Given the cryptic nature of this habitat (i.e. the beds can be difficult to distinguish from the surrounding seabed) it is possible that this feature is under-recorded.

There are additional flame shell species records in NBN Atlas. These records have been considered and presented in this paper.

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<sup>1</sup> <http://www.gov.scot/Topics/marine/marine-environment/mpanetwork/MPAmonitoring/EMFFproject>

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**Areas where fisheries management should be considered to avoid a significant impact on the national status of the PMF**

