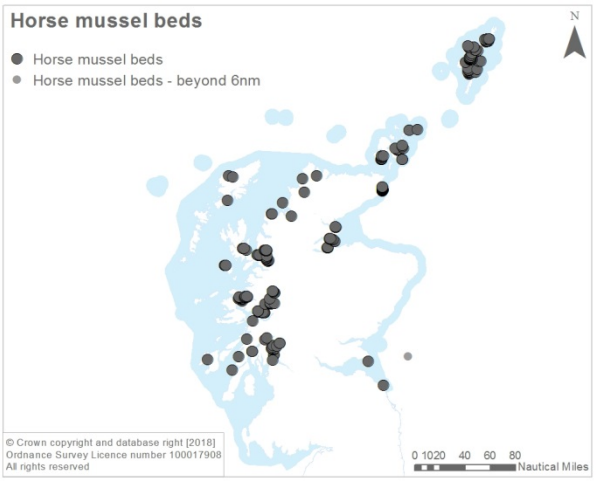
PRIORITY MARINE FEATURE (PMF) - FISHERIES MANAGEMENT REVIEW

Feature

HORSE MUSSEL BEDS

Image	Map
 Image: Rob Cook	

Description

Characteristics - Horse mussels (*Modiolus modiolus*) may occur as isolated individuals or aggregated into beds in the form of scattered clumps, thin layers or dense raised hummocks or mounds, with densities reaching up to 400 individuals per m^2 (Lindenbaum *et al*., 2008). Individuals can grow to lengths >150 mm and live for >45 years (Anwar *et al*., 1990). The mussels attach to the substratum and to each other using tough threads (known as byssus) to create a distinctive biogenic habitat (or reef) that stabilises seabed sediments and can extend over several hectares. Silt, organic waste and shell material accumulate within the structure and further increase the bed height. In this way, horse mussel beds significantly modify sedimentary habitats and provide substrate, refuge and ecological niches for a wide variety of organisms. The beds increase local biodiversity and may provide settling grounds for commercially important bivalves, such as queen scallops. Fish make use of both the higher production of benthic prey and the added structural complexity (OSPAR, 2009).

Definition - Beds are formed from clumps of horse mussels and shells covering more than 30% of the seabed over an area of at least 5 m x 5 m. Live adult horse mussels must be present. The horse mussels may be semi-infaunal (partially embedded within the seabed sediments - with densities of greater than 5 live individuals per m^2) or form epifaunal mounds (standing clear of the substrate with more than 10 live individuals per clump) (Morris, 2015). Horse mussel beds support distinct communities with high species richness (or diversity) compared to surrounding sediments (Holt *et al*., 1998; Fariñas-Franco *et al*., 2014).

OSPAR (2009) note that beds may also be recognised at lower levels of coverage where frequent smaller clumps of mussels influence ecosystem functioning. Horse mussel beds vary considerably in their appearance and structure depending on environmental conditions, particularly exposure and tidal flow (Fariñas-Franco *et al*., 2014). Beds occurring in sheltered sea lochs are very different to those found on exposed coasts (Morris, 2015).

Environmental preferences - Horse mussel beds develop in areas of weak to strong water movement (<1 to >3 knots or <0.5 to >1.5 m/sec.), in depths of 5-220 m (although most known beds are 20-50 m) on a variety of mixed substrates from cobbles through to muddy gravels (Gormley *et al*., 2013). Predominantly found in fully saline conditions, horse mussel beds have also been recorded in the outer reaches of estuaries (e.g. Firth of Forth and Solway Firth - Mair *et al*., 2000).

Distribution

Scottish distribution - Recorded from sea lochs, embayments, tidal channels and at the open coast; in Shetland, Orkney, off Caithness and down the west coast, with scattered records from the Outer Hebrides and Moray Firth. The most northerly record is in Bluemull Sound (Shetland) and the most southerly record is off the Berwickshire coast to the east, with historic records of beds in the Solway Firth to the west (Cutts & Hemmingway, 1996; Allen *et al*., 1999).

Estimated known Scottish extent - Horse mussel beds vary in terms of the extent, density, elevation above the seabed and mussel size distribution. The largest known bed in Scotland, estimated at over 410 ha in size, is off Noss Head near Wick (Moore & Roberts, 2011; Hirst *et al*., 2012). This very tidally-swept, open coast bed supports a high abundance of live bound, low-lying mussels providing almost 100% cover in places with cryptic/encrusting associated epifauna (Morris, 2015). Other dense, continuous large beds occur off Copinsay in Orkney (~40 ha) and in the Dornoch Firth (at least 25 ha). Smaller beds occur in the Annat Narrows in Loch Linnhe (4 ha and 6 ha), Loch Leven (<1 ha), Oban Bay (<1 ha) and off Port Appin (~2 ha) (Moore *et al*., 2012).

Wider distribution - Horse mussel beds have been recorded from the Ards Peninsula and Strangford Lough in Northern Ireland, off both ends of the Isle of Man and off north-west Anglesey. The most southerly known bed is located off the Llŷn Peninsula in Wales, although scattered horse mussels have been recorded as far south as the Bay of Biscay. Beds also occur in Norway, Iceland and Newfoundland (east coast of Canada).

Status

Horse mussel beds are an OSPAR threatened and / or declining habitat (OSPAR, 2009) and are recognised as biogenic reefs under the EU Habitats Directive (European Commission, 2013).

The extent and quality of horse mussel bed habitat has declined since the 1950s. The loss of formerly extensive beds in Strangford Lough (N. Ireland) is attributed to scallop dredging and trawling activity (Strain *et al*., 2012). Recovery has been minimal with continued declines in the diversity of associated species and density of horse mussels reported seven years after the exclusion of towed bottom-contacting fishing gear (Fariñas-Franco *et al*., 2018). The reduction in horse mussel abundance and habitat extent in Strangford Lough has been associated with a loss of ecosystem function (Strong *et al*., 2016).

In Scottish waters, declines in horse mussel bed cover have been recorded in Loch Alsh and Loch Fyne (Moore *et al*., 2013).

Horse mussels were reported as common in the Firth of Forth in the 1800s with subsequent documented declines linked to the exploitation of the former oyster fishery. Dredge survey work undertaken in 1895 (Fulton, 1896) to assess the state of the then dwindling native oyster population recorded just 317 living oysters in the 233 dredges (~550 m long tows). In contrast, nearly 35,000 live queen scallops and 8,113 horse mussels were taken during the survey (Thurstan *et al*., 2013).

Sensitivity (including recovery)

[Key sources: FEAST; Fisheries Management Guidance]

Horse mussel beds are sensitive to physical disturbance, surface and sub-surface abrasion, siltation changes and removal of non-target and target species. Aquarium experiments found that while blue mussels are able to migrate vertically when smothered, horse mussels were not and after 16 days burial, over 50% mortality occurred (Hutchison *et al*., 2016). Horse mussels are also vulnerable to climate change with the area of suitable habitat predicted to decrease over the next century (Gormley *et al*., 2013).

Towed bottom-contacting fishing gears have the potential to cause damage to individual mussels, to the structural integrity of mussel clumps and to epifauna, as documented in Strangford Lough (Magorrian & Service, 1998; Roberts *et al*., 2004), North Wales (Cook *et al*., 2013) and the Isle of Man (Jones, 1951; Cook *et al*., 2013).

Habitat recovery following impact is dependent on removal of the pressure, the continued presence of suitable substrates and a source of adult mussels to act as colonists or larval recruits. Horse mussels are slow growing, have variable dispersal success, low fertilisation and settlement success rates as well as high juvenile mortality. No studies have observed recovery of horse mussel beds, following either passive recolonisation after disturbance or active restoration. Overall, several elements of the biology and ecology of horse mussels significantly reduce the recovery potential of this species (Mazik *et al*., 2015).

Flame shells may out-compete horse mussels. Flame shell bed development in Loch Alsh between 1999 (Mair *et al*., 2000) and 2012 coincided with a marked decline in horse mussel density (Moore *et al*., 2013). A similar natural succession between the two habitat-forming species may have occurred in the Strome Narrows in Loch Carron since 1985 (Moore *et al*., 2018).

Connectivity

Between horse mussel beds - Horse mussel larvae are thought to have a pelagic larval duration of over 50 days resulting in a high dispersal potential. Genetic connectivity is thought to be relatively high with populations in Oban Bay (west coast of Scotland) being similar to those in the north of Shetland (Mackenzie *et al*., 2018). Larval migration is thought to follow the general south to north tidal flow direction on the west coast of Scotland (Turrell, 1992; Gallego *et al*., 2013). SNH, Marine Scotland and Heriot-Watt University are exploring horse mussel 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 - Horse mussel beds can be found interspersed with the *flame shell beds* PMF, for example in Loch Alsh, Loch Creran and Loch Carron (Moore *et al*., 2018). In Loch Alsh, Moore *et al.* (2013) suggest that an observed decline in horse mussels may be related to flame shell population growth. Horse mussel beds are also found in the same location as *maerl beds* in Hascosay Sound (Hirst *et al.,* 2012), *fan mussel aggregations* in the Sound of Canna (see Moore & Roberts, 2011) and subtidal *blue mussel beds* in the Dornoch Firth (The Highland Council, 2017).

Ecosystem services

- Biomass production
- Larval/gamete supply (supporting connectivity)
- Nutrient cycling
- Formation of habitat for other species (supporting biodiversity)
- Resilience to INNS & disease
- Coastal protection
- Waste breakdown & detoxification of water and sediments
- Carbon storage & climate regulation
- Fish and shellfish stocks
- Sediment stabilisation
- Socially valued places/seascapes
- Watching/studying nature

Existing Marine Protected Areas

Horse mussel beds are a protected feature of 12 MPAs: Loch Creran; Sullom Voe; Dornoch Firth and Morrich More; Lochs Duich, Long and Alsh; Sunart; Berwickshire and North Northumberland Coast; Sanday; Loch Laxford; Fetlar to Haroldswick; Noss Head; Upper Loch Fyne and Loch Goil; and, Small Isles.

Existing and proposed fisheries measures providing PMF protection

Details of existing fisheries measures associated with 7 MPAs: Loch Creran; Lochs Duich, Long and Alsh; Sunart; Sanday; Loch Laxford; Noss Head; Upper Loch Fyne and Loch Goil, are provided on Marine Scotland's web pages (http://www.gov.scot/Topics/marine/marine-environment/mpanetwork/MPAMGT/protectedareasmgt).

New fisheries management measures that will provide PMF protection in 4 other MPAs: Sullom Voe; Dornoch Firth and Morrich More; Fetlar to Haroldswick; and, Small Isles will be consulted upon later in 2018 (see - http://www.gov.scot/Topics/marine/marine-environment/mpanetwork/inshorempas/Management).

Berwickshire and North Northumberland Coast SAC is already considered well managed from a fisheries perspective (Marine Scotland, 2014).

The Shetland Shellfish Management Organisation (SSMO - https://www.ssmo.co.uk) is the regulator for shellfish fisheries within Shetland's six mile limit. There is an expectation that measures to manage scallop dredging activity within relevant MPAs will be introduced by the SSMO to complement measures proposed by Marine Scotland and provide the necessary protection for designated habitats and species (including the sensitive PMFs covered by this review). The mapping presented in this paper assumes that measures will be implemented accordingly to afford protection to horse mussel beds in the Sullom Voe MPA. Existing SSMO measures encompass the known distribution of horse mussel beds in the Fetlar to Haroldswick MPA.

Horse mussel bed records are afforded protection by virtue of fisheries measures associated with other designated features in the Wester Ross and Loch Carron MPAs.

Horse mussel beds are also afforded protection through the Loch Roag (CA67) and Gare Loch (CA53) / Rhu Narrows (CA122) fisheries areas.

Proposed measures in the Dornoch Firth are expected to derogate the Tain blue mussel fishery from wider mechanical dredge prohibitions and enable future fishing subject to satisfying a Habitats Regulation Appraisal for the Special Area of Conservation. Recent surveys (2015 and 2016 - Cook *et al*., 2016) recorded an area of horse mussel beds (and fragile sponge communities) in the Dornoch Firth, adjacent to subtidal blue mussel beds (The Highland Council, 2017).

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

- Orkney - a relatively large, dense bed has been recorded off Copinsay. Beds are also present off the SMS *Karlsruhe* wreck and within Gutter Sound in Scapa Flow (Sanderson *et al*., 2014).
- Shetland - there are numerous records of horse mussel beds around Shetland, although some of these are scattered clumps of live mussels at relatively low density. Outside MPAs, some of the records are afforded partial protection (with prohibitions in place for scallop dredging only) within SSMO (https://www.ssmo.co.uk/maps) statutory closed areas (e.g. Whiteness; Busta Voe; Ness of Queyfirth, Yell Sound). Multiple other records currently have no fisheries measures in place.
- Lochs Linnhe, Leven and Eil - dense, continuous beds occur off Port Appin. Moore *et al.* (2012) also report a cluster of horse mussel beds in Loch Leven with abundant live horse mussels and beds to the east and west of the Annat Narrows at the head of Loch Linnhe where it enters Loch Eil.
- There are recent records of patches of horse mussel bed habitat over a fairly large area in the Sound of Gigha.
- Firth of Clyde - Seasearch divers recorded a 200 m long horse mussel bed off Gourock (near Greenock) in 2016 and again in 2017.
- Firth of Forth - records from three discrete locations running in a NE direction from the bridges at Inverkeithing: off Cramond in 1979 (Elliott & Kingston, 1987); off Inchkeith in 2010 (Thurstan *et al*., 2013) and off the Isle of May in 2002 (ERT Scotland, 2003).

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.

A large proportion of known horse mussel beds occur in Scottish waters and these habitats provide a range of ecosystem services including the formation of habitat for commercially important species (Kent *et al*., 2017) and carbon storage (Burrows *et al*., 2014). However, they are vulnerable to physical disturbance and increasing seawater temperature and have a low recovery potential. Horse mussel beds are an OSPAR T&D habitat, scarce both in north-west Europe and in Scotland with evidence of decline in Scotland. 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 horse mussel 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.

In a fisheries context, additional measures to protect horse mussel beds from pressures associated with towed bottom-contacting gears are recommended in the following seven areas: **Orkney**; **Shetland**; **Lochs Linnhe, Leven and Eil**; **Craignish to Gigha**; **Loch Long (Upper)**; **Gourock**; and, **Dornoch Firth**. The recommendations for horse mussel 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.

Areas where additional fisheries management should be considered to avoid a signficant impact on national status of this PMF are focussed on dense continuous beds outside protected areas and encompass all forms of bed (e.g. scattered clumps, thin layers or dense raised hummocks) in different environmental conditions (where known). The majority of records occur in coastal areas such as sea lochs and embayments, which are thought to be a source of recuits for other areas (Mackenzie *et al*., 2018), although beds also occur away from the coast, in more exposed areas.

Horse mussel beds in the **Craignish to Gigha** area may be important for connectivity with Irish Sea populations. Island populations (e.g. Copinsay in **Orkney**) may act as stepping stone beds to maintain population connectivity; such beds should also be a priority for management.

Given the predicted climate change trend for suitable horse mussel habitat to be restricted to more northerly locations (Gormley *et al*., 2013), protection of horse mussel beds in the north of Scotland, including **Shetland** and **Orkney** would add resilience to existing measures. The northern extent of the Copinsay bed in Orkney has not been defined and may be connected to records further north (e.g. off Stronsay) or to habitat patches in-between that have not been surveyed.

The horse mussel bed records within the **Dornoch Firth** are tagged as ‘managed’ on the map provided because proposed measures would prohibit bottom-contacting fishing gear. However, a derogation is proposed for the Tain blue mussel dredge fishery to continue on its current basis providing that it satisfies a Habitats Regulations Appraisal. Formalising spatial restrictions to protect the recently mapped horse mussel bed and associated fragile sponge communities in the outer part of the estuary should also be considered. Some knowledge gaps remain where the bed extends into an MOD area within the Dornoch Firth. The responsible approach taken by Highland Council and Tain Community Council in resting the blue mussel fishery until 2005 levels of stocks are reached again; stipulating the need for a future stock assessment survey that can inform HRA; and, in identifying the horse mussel bed as a sensitive area to be avoided if the fishery re-starts (The Highland Council, 2017) is recognised and welcomed.

Knowledge gaps and other records

Knowledge gaps - Many horse mussel beds have not been mapped and their full extent and current condition are unknown. Records off **Islay** and **East Skye** are from the mid-1970s (Farrow *et al*., 1979) and 1980s (Hiscock, 1982; Holt, 1988; Hiscock & Covey, 1991) and new survey work would be required to determine their continued presence and status.

A seabed habitat grab sampling survey undertaken in the **Firth of Forth** in 1979 recorded a horse mussel bed supporting '*a local but substantial population of adult horse mussels*' off Cramond. It was further noted that this benthic community '*is now known to occupy much of the central region of this part of the firth*' (Elliott & Kingston, 1987). Transient populations of large numbers of very small juvenile horse mussels (up to 1312 per m^2) were also recorded in 1979 at several stations in the region of the bridges.

Diving survey work undertaken in 2010 to assess the current status of seabed habitats at 11 historic dredge survey stations (Fulton, 1896) recorded live horse mussels and horse mussel shell debris at one location off Inchkeith (Thurstan *et al*., 2013). A horse mussel bed was also recorded off the Isle of May in 2002 (just outside the Isle of May MPA). The density of live mussels was not clear from the remote video footage (ERT Scotland, 2003). New survey work would be required to confirm the current status of horse mussel beds in the firth.

Other records - A considerable area of suitable habitat for horse mussel beds is predicted in Orkney and Shetland (outside the areas suggested above) as well as in sea lochs on the west coast and the Outer Hebrides (Gormley *et al*., 2013). However, historic survey effort is low in these areas, particularly along the north-west coast. Opportunistic sampling could determine the presence of horse mussel beds.

Data confidence

Available records span 1974 to 2015. Surveys vary in scope from Seasearch (carried out by volunteer divers), studies undertaken to support development proposals, dedicated PMF validation surveys (e.g. 2012 SNH/MSS Shetland benthic camera survey) and academic research (e.g. Heriot-Watt University surveys). Records come from both diving and remote video surveys. Multibeam data were used to assess the extent of the Noss Head bed.

Horse mussel bed records in Shetland were cross-checked against the results of survey work undertaken by the North Atlantic Fisheries College (NAFC) Marine Centre UHI (Shelmerdine *et al*., 2014). The maps provided in this paper include provisional new records of the PMF not currently held in the database. A process to incorporate relevant, confirmed PMF data, collated as part of the Shetland Islands Marine Spatial Plan (SIMSP) is in development. These records will be mobilised via future updates to the Marine Scotland MAPS NMPi (National Marine Plan interactive) online tool (http://maps.marine.gov.scot/).

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