



The Scottish Parliament  
Pàrlamaid na h-Alba

SPICe

The Information Centre  
An t-Ionad Fiosrachaidh

SPICe Briefing

Pàipear-ullachaidh SPICe

# Kelp harvesting

Alexa Morrison

This briefing provides an overview of kelp harvesting in Scotland, including summary information about kelp habitats, the policy and regulatory environment for different types of kelp harvesting and sustainability implications. The briefing focuses on wild kelp harvesting but also includes information on seaweed aquaculture.



12 November 2018  
SB 18-75

# Contents

<b>Executive Summary</b>	<b>3</b>
<b>Kelp species and habitats in Scotland</b>	<b>5</b>
Estimates of kelp distribution and abundance	6
<b>Ecosystem benefits of kelp habitats</b>	<b>8</b>
Blue carbon	8
Coastal protection	9
Threats to kelp forests	9
<b>Protection of kelp</b>	<b>10</b>
<b>Kelp harvesting</b>	<b>12</b>
Uses of kelp	12
Harvesting levels (global and Scotland)	12
Harvesting methods	13
Seaweed aquaculture (seaweed farms)	13
<b>Current regulatory requirements</b>	<b>15</b>
Harvesting rights and Crown Estate Scotland licensing	15
SNH advisory role	15
Marine licensing	16
<b>Sustainability of wild kelp harvesting</b>	<b>17</b>
2016 Marine Scotland Strategic Environmental Assessment	17
2018 Highlands and Islands Enterprise report	18
<b>Recent proposals for mechanical wild kelp harvesting on the West Coast</b>	<b>20</b>
<b>Commercial wild seaweed harvesting in other countries</b>	<b>21</b>
Norway	21
France	21
Ireland	22
USA (California)	23
<b>Bibliography</b>	<b>24</b>

# Executive Summary

Recent interest in the potential for large-scale harvesting of kelp in Scotland has required consideration of the sustainability implications of harvesting wild kelp habitats.

## Kelp habitats in Scotland and their importance

Kelps are large brown seaweeds. Kelp growth includes a holdfast (similar to a root but without penetrating the seabed), a stalk or *stipe*, and leaf-like fronds. Kelp beds or forests, composed mainly of *Laminaria hyperborea* (commonly known as cuvie or tangle), are found on rocky areas around the Scottish coast. They are less abundant along the east coast, and are particularly extensive around Skye and the adjacent mainland, the Outer Hebrides, Orkney and Shetland.

Kelp habitats are important for marine biodiversity. They support a wide range of species and provide nursery grounds for commercial fish and shellfish. Kelp is part of the 'blue carbon' cycle although the precise carbon sink function of kelp habitats is not yet well understood. Large kelp forests could also alleviate coastal flooding.

Kelp bed habitats are [Priority Marine Features](#) (with some exclusions), meaning they are considered to be of priority conservation importance and subject to a higher level of protection under the National Marine Plan. They are also listed as protected features within four [Marine Protected Areas](#) (MPAs).

## Kelp harvesting

Kelps are harvested for their alginates, chemicals with a wide range of applications in food production, pharmaceuticals, textiles, paper and biotechnology. Interest in harvesting kelp for use as a biofuel is also growing. Wild seaweed harvesting methods include hand cutting and gathering, trawling and dredging, or mechanical cutting. Approximately 20 countries are involved in harvesting brown seaweeds, totalling over 620,000 tonnes per year. In Europe, commercial kelp harvesting is carried out in Norway and France, with some smaller scale harvesting in Ireland.

Hand cutting is the most common method of kelp (and all seaweed) harvesting in Scotland. Since 2016, there has been a significant increase in small-scale license applications for seaweed harvesting received by SNH and Crown Estate Scotland. No Marine Scotland licences have been issued so far for removal of kelp from the seabed, but the first proposals for large-scale kelp harvesting have reached the pre-application stage.

Kelp aquaculture or 'farms' are where kelp is cultivated rather than harvested from wild habitat. Seaweed farming is not well developed in Europe, with a small number of sites, and in Scotland there are farms in research and development status. The Scottish Government published a Seaweed Cultivation Policy Statement in 2017 stating it is supportive of small-medium seaweed cultivation if environmental impacts can be mitigated.

## Current regulatory and licensing requirements

Marine Scotland is currently considering the need for further regulation or policy for wild seaweed harvesting following on from the publication of a [Wild Seaweed Harvesting Strategic Environmental Assessment \(SEA\)](#) in 2016 <sup>1</sup>.

Harvesting seaweed below the low tide mark requires a licence from Crown Estate Scotland (CES). SNH advises CES on the natural heritage aspects of proposals and provides best practice advice to hand harvesters (and would advise Marine Scotland on any marine licence application). A marine licence would be required from the Licensing Operations Team of Marine Scotland for removal of kelp from the seabed using a vessel or vehicle below the mean high-water spring mark.

In determining an application, Marine Scotland must have regard to the need to protect the environment and have a general duty under the Marine (Scotland) Act 2010 to "act in the way best calculated to further the achievement of sustainable development" in addition to relevant policies in the [National Marine Plan](#).

### **Sustainability of wild kelp harvesting**

The wild harvesting of kelp has sustainability implications for the species and associated ecosystem. Over-exploitation could lead to:

- Negative impacts on marine biodiversity;
- Loss of nursery grounds for juvenile invertebrates and fish;
- Reduced contributions to the marine carbon cycle;
- Disrupted transfer of organic materials between ecosystems;
- Reduced coastal protection from erosion and flooding.

In its SEA, Marine Scotland investigated the sustainability of large scale mechanical extraction of wild seaweed, in particular kelp. The SEA states that:

- Current small scale (i.e. artisanal) hand cutting or picking of wild seaweed in Scotland is unlikely to result in significant adverse environmental impacts;
- Significant adverse effects can occur as a result of large scale mechanised harvesting, primarily relating to impacts on habitats and the ecosystem services that they provide.

Highlands and Islands Enterprise (HIE) [commissioned a study in 2018](#)<sup>2</sup> to investigate the potential for mechanical harvesting of wild kelp. The report concluded that wild kelp may be harvested in Scotland with tolerable environmental impacts, but highlighted that developing a sustainable harvesting regime was complex, requiring stakeholder engagement. It also emphasised that any harvesting licences should be subject to requirements for high-quality monitoring of recovery of kelp habitats.

# Kelp species and habitats in Scotland

Kelps are large brown seaweeds (macroalgae) that grow on underwater rocks from low tide downwards, and can be found all around Scotland's coasts, as well as in cool temperate regions throughout the world. Kelps occupy rocky reefs from the low water mark to, in extreme cases, depths in excess of 40 m, as far down as sunlight allows.

Kelps common in Scottish waters include:

- *Laminaria digitata* (oarweed): the most conspicuous kelp on our seashores;
- *Laminaria hyperborea* (cuvie kelp or tangle): the main forest-forming kelp in Scotland;
- *Alaria esculenta* (winged kelp or dabberlocks): abundant on wave-exposed coasts;
- *Saccharina latissima* (sugar kelp): forms forests in sheltered areas e.g. sea lochs;
- *Saccorhiza polyschides* (furbelows kelp): a quick-growing, annual kelp.

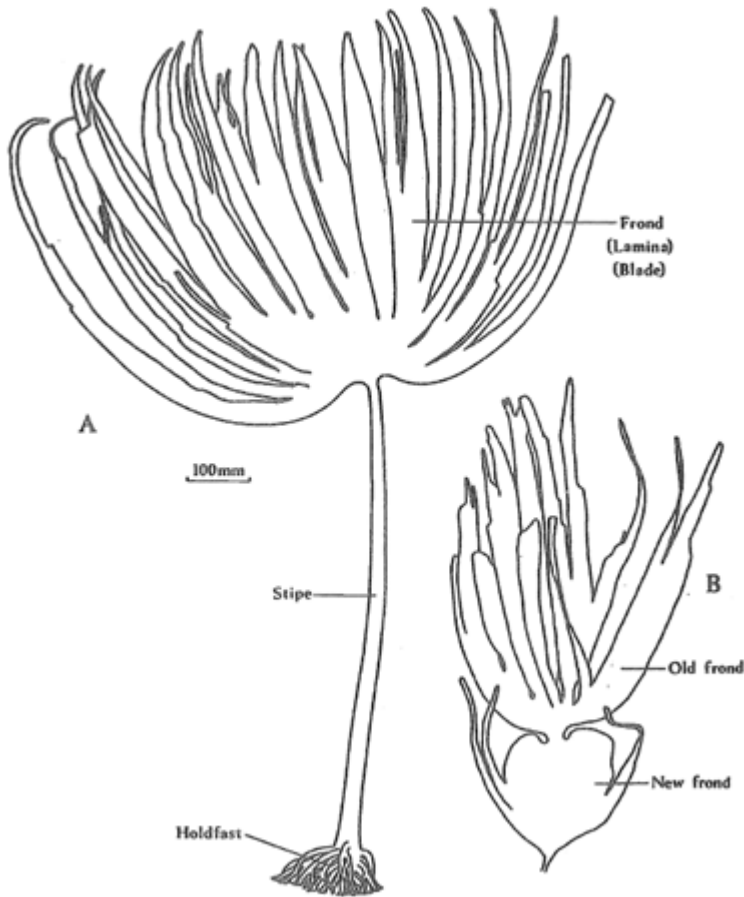
Kelp growth includes the development of a holdfast, a stalk or *stipe*, and one or more leaf-like fronds, totalling several metres overall for European kelp (California giant kelp can reach 60 metres). Kelps have no roots. They attach to rock or stones on the seabed with their branched holdfasts (similar to a root but without penetrating the seabed, see images below). Plants often grow together in kelp beds or forests.



Kelp holdfast and stipe with starfish (left - SNH, Sue Scott) and cuvie forest (right - SNH, Paul Kay)

Kelp growth involves expansion from the meristem (tissue where growth can take place), for example at the base of the frond. Many kelp species are short-lived perennials, growing new fronds each year. Loss of or damage to the meristem prohibits regrowth of the plant.

Recent interest in the potential for large-scale harvesting of kelp in Scotland has required consideration of the sustainability implications of harvesting wild kelp habitats.



Drawing of kelp Synopsis of Biological Data on *Laminaria hyperborea*. FAO Fisheries Synopsis No. 87, 1971<sup>3</sup>

## Estimates of kelp distribution and abundance

Kelp forests, composed mainly of *Laminaria hyperborea*, are found on suitable rocky areas around the Scottish coastline. They are less abundant along the east coast, and particularly extensive around Skye and the adjacent mainland, the west coast of the Outer Hebrides, Orkney and Shetland<sup>4</sup>.

Estimates of kelp cover (where kelps exceed 20% total cover of the habitat) suggest that they cover 2,155 km<sup>2</sup> of the seabed around the coast of Scotland<sup>5</sup>. A 2018 report produced for Highlands and Islands Enterprise<sup>2</sup> estimated the amount of habitat for the main kelp species around the Scottish coast. It predicted a total biomass of:

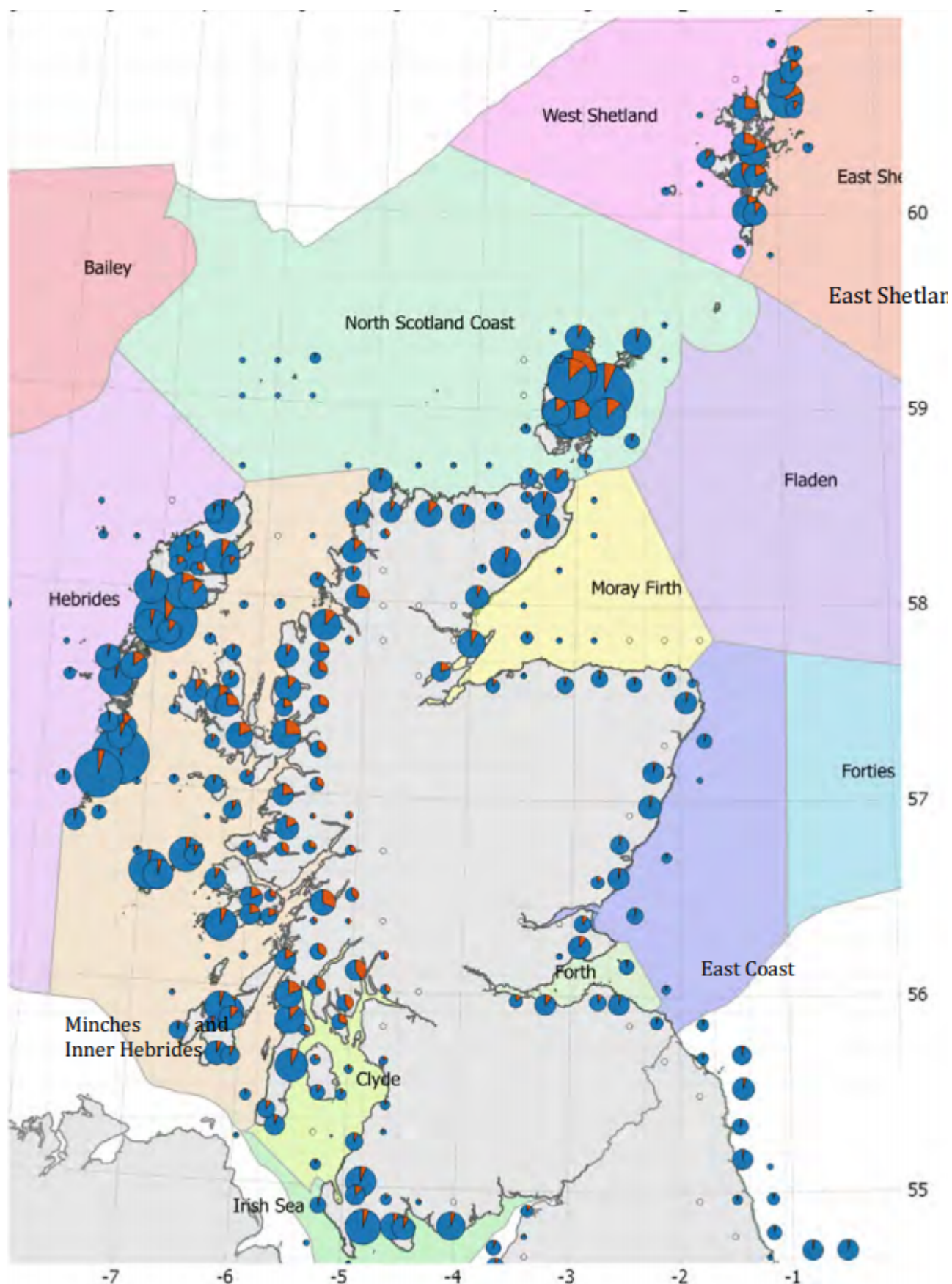
- 20 Mt for *Laminaria hyperborea*
- 2.5 Mt for *Saccharina latissima*
- 0.19Mt for *Saccorhiza polyschides*
- 0.16Mt for *Laminaria digitata* (NB These are modelled estimates - not based on survey)

6.5 Mt of *Laminaria hyperborea* was predicted to be in a 'harvestable area', where biomass may exceed 5 kg/m<sup>2</sup><sup>i</sup>. The figure below shows estimated distribution around the coast.

---

<sup>i</sup> This describes only where kelp may be, not whether environmental factors make areas favourable to harvest.

## Estimated kelp biomass across Scotland.



Estimated kelp biomass across Scotland. Pies show relative proportions of *Laminaria hyperborea* (blue) and *Saccharina latissima* (orange) in 20km grid squares, scaled to total biomass Wild Seaweed Harvesting as a Diversification Opportunity for Fishermen. A report by SRSL for HIE, pp. 171. Retrieved from: <http://www.hie.co.uk/common/handlers/download-document.ashx?id=0336008d-db41-4b61-a9bd-6bfcbd31c876> (accessed 30th October 2018), 2018<sup>2</sup>

# Ecosystem benefits of kelp habitats

Scottish Natural Heritage describe kelp habitat as one of the most productive and dynamic ecosystems on Earth and the Scottish equivalent of tropical coral reefs <sup>6</sup>.

The sheltered areas beneath kelp are important habitats for marine biodiversity. They support a range of species including sea anemones, sea firs, sea squirts, sponges and a variety of seaweeds. Within the UK alone, more than 1800 species of flora and fauna have been recorded from kelp-dominated habitats <sup>7</sup>. Kelp forests have been found to provide nursery grounds for commercial fish and shellfish and can support species at higher trophic levels (further up the food chain) including cetaceans, seals, otters and birds.

Kelp periodically sheds and regrows its frond e.g. the perennial *Laminaria hyperborea* produces a new frond each winter/spring while shedding its old frond. Kelp can also be dislodged in stormy conditions. Shed fronds provide organic material which provide food and nutrients to other marine life as well as supporting kelp regrowth. Beach cast (washed ashore) kelp provides habitat for wader birds which forage in decaying weed.

Kelp plays a role in nutrient cycling through absorbing nutrients which are returned when the seaweed organic matter decays. Seaweed biodiversity and cover are also used as indicators for assessing the ecological status of Water Framework Directive water bodies (which kelp cover and diversity contribute to), which aims to achieve good ecological status in all inland and coastal waters.

## Blue carbon

In 2017, SNH published an 'Assessment of Blue Carbon Resources in Scotland's Inshore Marine Protected Area Network' <sup>8</sup>. Regarding blue carbon and the importance of coastal marine habitats, the report states:

“ Blue carbon storage and sequestration varies between habitats, and although some of the carbon is stored in biological components, such as plants (kelp forests, seagrass beds, seaweed) or animals..., the carbon stored in marine sediments... is sequestered over much longer timescales, and contains considerably larger stocks of carbon. Coastal marine habitats (i.e. those habitats in the area extending from the shore to the continental shelf break) alone are estimated to sequester over 50% of total marine carbon. ”

The precise carbon sink function of kelp habitats is not yet well understood <sup>7 9</sup>. Kelp are producers of organic carbon, but kelp habitats are on rock so do not accumulate sediment. Instead dead material is exported from kelp beds into other habitats. A previous SNH review of blue carbon habitats estimated that kelp habitat produces 1.73 MtC/yr<sup>ii</sup>, but the proportion of this carbon that is sequestered (stored) in the long term, for example in coastal sediment, is as yet unknown <sup>9</sup>.

Further research to improve understanding of carbon capture processes in kelp, and integration to marine policy objectives and management plans, has been suggested as a

---

ii For comparison, the main producer of carbon entering long-term storage in sediments in the marine environment was found to be phytoplankton at 3.9 MtC/yr



priority in order to "ensure Scotland's blue carbon contribution remains viable and secure in an uncertain environmental future" <sup>8</sup> .

## Coastal protection

Large kelp forests (e.g. those west of the Outer Hebrides) could prevent and alleviate damage caused by coastal flooding and storms by acting as a buffer, reducing the wave energy reaching land. Norwegian kelp forests have been reported to reduce wave heights by up to 60% <sup>10</sup> . Beach-cast seaweeds also provide nutrients to dune habitats which protect the coast from severe weather. Smale et al (2013) <sup>7</sup> states:

“ Kelp forests alter water motion and provide a buffer against storm surges through wave damping and attenuation and by reducing the velocity of of breaking waves. In doing so, kelp forests reduce coastal erosion... However, compared with other coastal habitat..., there is a paucity of information on the degree of storm protection offered by kelp forests.”

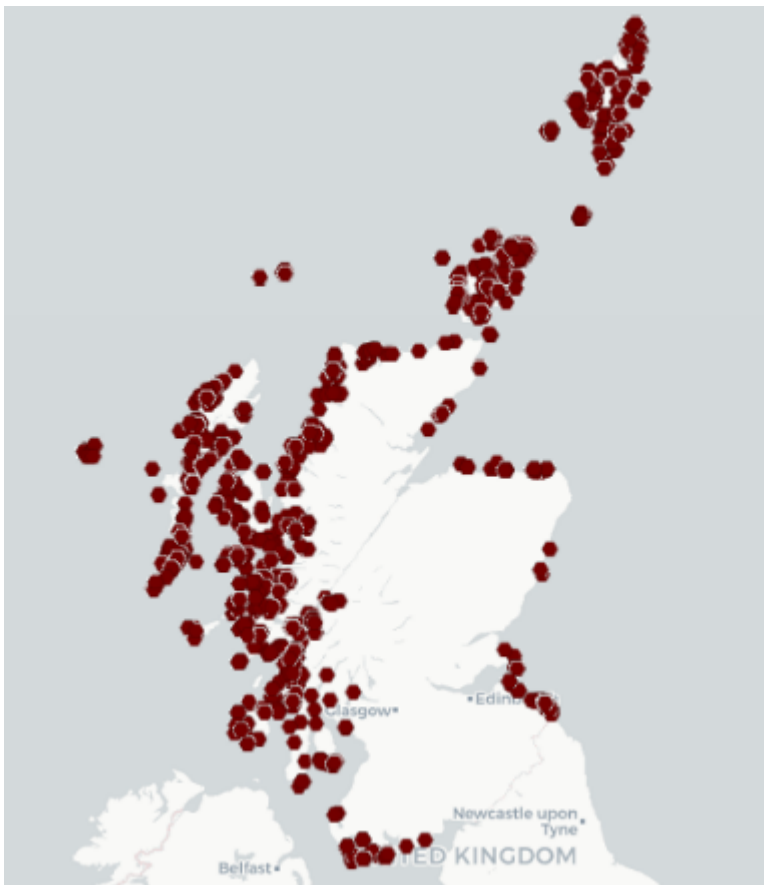
## Threats to kelp forests

Threats to kelp forests around Scotland were reviewed by Smale et al. (2013) <sup>7</sup> . The authors saw the main threats to kelp habitats as: climate change, increased turbidity and nutrient loading from coastal runoff, effects of the removal of top predators by fishing or other human activities, and harvesting and cultivation. There is also potential for overgrazing by herbivores, usually sea urchins, which could be caused by removal of predators that control urchin numbers <sup>9</sup> .

# Protection of kelp

Kelp bed habitats are [Priority Marine Features](#) (with some exclusions <sup>11</sup>), a focused list of 81 habitats and species of priority conservation importance adopted by the Scottish Government to focus action to conserve Scotland's marine natural heritage (see map below of known kelp PMF distribution <sup>iii</sup>).

Kelp habitats are also listed as protected features within four [Marine Protected Areas \(MPAs\)](#) <sup>iv</sup> designated under the Marine (Scotland) Act 2010, meaning management measures must be implemented to conserve them. Some Special Areas of Conservation (SACs) contain protected habitat features that may support kelp habitats, meaning the Government has a duty to ensure they are in favourable conservation status.



Distribution of kelp Priority Marine Features. Source: National Marine Plan interactive. This should not be interpreted as a comprehensive map of kelp PMFs as the full distribution of PMFs is not known.

The [National Marine Plan \(NMP\)](#) sets out Scottish Government policy with regard to Priority Marine Features. General Policy 9 of the NMP says that development and use of the marine environment must not result in significant impact on the national status of Priority Marine Features. Where planned developments or use have potential to impact PMFs, mitigation, including alternative locations, should be considered. Actions should also be taken to enhance the status of PMFs where appropriate.

Kelp habitat is also mentioned in the NMP under two further general policies:

---

<sup>iii</sup> This should not be interpreted as a comprehensive map of kelp PMFs as the full distribution of PMFs is not known.  
<sup>iv</sup> Fetlar to Haroldswick, South Arran, Wester Ross and Wyre and Rousay Sounds

- GEN 5 Climate change: Marine planners and decision makers must act in the way best calculated to mitigate, and adapt to, climate change. It states:  
  
“ Reducing human pressure and safeguarding ecosystem services such as natural coastal protection and natural carbon sinks (e.g. seagrass beds, **kelp** and saltmarsh) should be considered. ”
- GEN 8 Coastal process and flooding: Developments and activities in the marine environment should be resilient to coastal change and flooding, and not have unacceptable adverse impact on coastal processes or contribute to coastal flooding. It states:  
  
“ The protective role of geodiversity, geomorphological and natural features such as **kelp beds**, biogenic reefs and sandbanks should also be considered alongside opportunities for recovery and enhancements.”

# Kelp harvesting

Wild kelp can be harvested or gathered for personal or commercial use, with harvesting carried out by hand or mechanically. This must be distinguished from kelp aquaculture or 'farms', where kelp is cultivated i.e. grown commercially rather than harvested.

## Uses of kelp

Kelps are harvested for their alginates, chemicals with a wide range of applications in the food, textile, pharmaceutical and other industries. Interest in evaluating the large-scale harvesting potential of seaweed (including kelp) in Scotland for use as a biofuel is also growing (see further information below on aquaculture).

Cast kelp or 'tangle' has been utilised by generations of Scots industrialists, farmers and crofters for manufacturing and agricultural purposes, especially in the Highlands and Islands <sup>6</sup>. Kelp ash was produced on a large scale, particularly in Orkney and the Western Isles, in the early 18th century for use in glass and soap manufacture. At its peak, between 1780 and 1830, the industry employed several thousand people. With the discovery of other materials, the industry declined.

Storm-cast kelp has also been collected by farmers and crofters for fertilising machair soils, a tradition that still continues notably in the Uists. This makes a contribution to maintaining machair (low-lying grassy areas found on part of the northwest coastlines of Scotland, in particular the Outer Hebrides) and the biodiversity it supports.

A 2016 report identified 27 seaweed-related businesses in the UK, of which 16 use seaweeds harvested in the UK <sup>12</sup>. The majority of these businesses produce seaweeds for food or condiments and cosmetics. Other products based on seaweeds and produced in the UK include animal feed and supplements, chemicals such as hydrocolloids (gums), fertilisers and nutraceuticals (e.g. dietary supplements).

## Harvesting levels (global and Scotland)

Global seaweed production (not just kelp) has more than doubled between 2000 and 2014, from 10.5 to 28.4 million tonnes, the majority currently from Asian aquaculture <sup>12</sup>. Approximately 20 countries are involved in harvesting wild brown seaweeds, totalling over 620,000 tonnes per year, with landings of Chilean and Norwegian kelp accounting for 60% <sup>13</sup>. In Europe, commercial harvesting of kelps is currently carried out in Norway and France, with some smaller scale harvesting in Ireland.

SNH state that commercial wild seaweed harvesting is having a revival in Scotland. Since 2016, there has been a significant increase in the number of consultations for wild seaweed harvesting in Scotland received by SNH and Crown Estate Scotland (CES).

Commercial wild seaweed harvesting can range in scale from a few kilos of hand-harvested seaweed to thousands of tonnes harvested mechanically. Whilst some mechanical harvesting of seaweed other than kelp does occur in Scotland, it is not of equivalent scale to kelp harvesting for example in Norway and France, **and there is**

**currently no large scale mechanical harvesting of kelp in Scotland.** No Marine Scotland licences have been issued so far for removal of kelp from the seabed.

Scotland's wild seaweed harvesting industry is currently centred on the Western Isles, where the harvesting of egg wrack (*Ascophyllum nodosum*) is commonly undertaken by hand, although limited mechanised harvesting also takes place. A number of larger scale wild seaweed harvesting operations either take place or are proposed on private land on North Uist, Lewis and Harris (with some Crown Estate licensing interests). There are commercial harvesting operations in Caithness and Fife and some smaller scale harvesters across the west coast.

SNH was consulted on approximately 40 proposals between 2016-2018, ranging from proposals to harvest a few kilos to hundreds of tonnes. Seaweed production from wild harvest across the UK, in 2013, was estimated at around 2,000-3,000 dry tonnes<sup>12</sup>. The majority of proposals are for harvesting on CES intertidal land or seabed.

## Harvesting methods

Hand cutting is currently the most common method of kelp (and all seaweed) harvesting in Scotland, and hand harvesters often harvest a mix of species of kelp and other seaweeds. Wild seaweed harvesting methods can be categorised into different groups (see the table below).

### Commercial wild harvesting methods (adapted from the Marine Scotland SEA<sup>14</sup>)

Method	Description
Hand cutting or picking	Harvesting living species by hand at low tide using tools such as serrated sickles or scythes.
Trawling/ Sledging/ Dredging	Using a device which tears plants larger than a certain size from the substrate and leaves smaller plants for re-growth. Devices include the Norwegian kelp dredge designed to harvest <i>Laminaria hyperborea</i> and the Scoubidou, designed to harvest <i>L. digitata</i> . These devices operate on rocky substrate, so differ from other forms of dredging (e.g. scallop dredging) that physically disturb the substrate, although some physical disturbance of the substrate will still occur in deploying these methods.
Mechanical 'hedge' cutting	Specialised vessels called mechanical seaweed harvesters that work close to the shore and cut the living seaweed as the stalks float above the seabed. These vessels include the Norwegian suction/cutter harvester which is designed to harvest <i>Ascophyllum nodosum</i> (intertidal seaweed - not a kelp species).
Hand gathering	The collection of beach-cast species by hand.
Mechanical gathering	The collection of beach-cast species using tractors or mechanical excavator

## Seaweed aquaculture (seaweed farms)

While small-scale harvesting of wild seaweed for food, feed and fertiliser has been carried out for centuries in Scotland, seaweed farming does not have a long history. In recent years, there has been increasing interest in seaweed aquaculture, mainly driven by research into whether seaweeds could become a source of biofuels.

Seaweed farming is not well developed across Europe. A small number of commercial seaweed aquaculture sites can be found in France and Spain, and on a pilot basis in

Ireland, Norway and the UK (which include kelp cultivation). Seaweed aquaculture is currently limited in Scotland to pilot farms in research and development status.

It has also been suggested that expanding seaweed aquaculture could increase 'blue carbon' sinks, if suitable areas can be identified and sustainability issues addressed <sup>15</sup>. Capuzzo and McKie (2016) <sup>12</sup> state that seaweed aquaculture in the UK:

“ could contribute to meet the demand for algal biomass; however, factors such as lack of information on operational costs, potential biomass yields and ecological effects of seaweeds farms, as well as unclear regulatory context (particularly for marine licensing), are perceived to limit the development of the seaweed aquaculture industry. ”

The Scottish Government published a [Seaweed Cultivation Policy Statement](#) in 2017 <sup>16</sup>. It does not contain specific policy on kelp, but states that in principle the Scottish Government is supportive of small-medium farm seaweed cultivation, subject to regulatory consideration and policies in Scotland's National Marine Plan. It also states that any applications should demonstrate that mitigation measures have been considered to prevent adverse environmental impacts

Small-medium cultivation is described as "a similar size to a typical mussel farm, with up to 30 x 200m lines", at which scale the supporting Strategic Environmental Assessment indicated there is likely to be limited environmental impact.

Some recent literature also highlights the potential for commercial seaweed aquaculture to enhance ecosystem services (e.g. supporting biodiversity and carbon storage), but generally highlighting that knowledge gaps need to be addressed to assess and manage risks <sup>17 18</sup>.

The [Scottish Association for Marine Science](#) (SAMS) is currently participating in an EC funded project called GENIALG (GENetic diversity exploitation for Innovative Macro-ALGal biorefinery), a partnership across six EC countries exploring the feasibility of producing large, sustainable volumes of sugar kelp and another seaweed in farms, for a range of products such as cosmetics, pharmaceuticals and speciality chemicals. They are also researching integrated approaches to seaweed, shellfish and fish aquaculture.

Recent research has been published on methods of seaweed cultivation tested in the Faroe Islands with the aim of developing a profitable method in the Atlantic Ocean in exposed locations. Non-destructive harvests (where part of the seaweed is left to regrow) were carried out in a two-year growth period. The work demonstrated that large-scale kelp cultivation is possible using this method of harvesting <sup>19</sup>.

Marine Scotland consider that this method could be applicable to Scotland, although the method would require testing and adjustment to fit local environmental conditions. Caution should also be exercised in comparing these methods with wild kelp harvesting proposals which may target different species and products.

# Current regulatory requirements

Marine Scotland (on behalf of Scottish Government) is currently considering the need for further regulation or policy for commercial wild seaweed harvesting following the publication of the [Wild Seaweed Harvesting Strategic Environmental Assessment \(SEA\) in 2016](#)<sup>14</sup>.

Due to the growing number of wild seaweed harvesting consultations, and the limited regulation of foreshore harvesting, SNH are also developing more guidance for harvesters.

The following sections set out how wild seaweed harvesting is currently permitted and licenced in Scotland.

## Harvesting rights and Crown Estate Scotland licensing

The foreshore (area between the edge of high and low tides) can be privately owned in Scotland, meaning harvesters need permission from the owners to remove seaweed. Approximately 50% of the foreshore is owned by Crown Estate Scotland (CES). Harvesting seaweed below the low tide mark requires a licence from CES.

CES operate a [Harvesting Licence Options \(HLO\) process](#) which was introduced in response to increasing competition for rights to harvest wild seaweed for commercial purposes. It applies to larger scale hand harvesting proposals in the CES owned foreshore (mean high water spring tides - mean low water spring tides<sup>v</sup>) and/or immediately adjacent accessible seabed, up to 100m beyond mean low water spring tides. Lower intensity harvesting that is considered likely to fall well within sustainability thresholds is subject to a different application process.

All CES licences require documented confirmation from SNH that proposals do not present any evident unacceptable environmental risk. For moderate to large scale removal, monitoring and reporting of resource recovery is required and SNH are consulted on these outputs. For proposals exceeding in the region of 10 wet tonnes, CES may require and SNH advise a stock biomass assessment to establish the available resource, and a sustainable harvesting strategy and monitoring may also be required. For harvesting proposals that qualify for the Harvesting Licence Options process, stock assessments and harvesting and monitoring strategies are essential.

## SNH advisory role

SNH advises the Crown Estate Scotland on the natural heritage aspects of proposals. Best practice advice currently provided to hand harvesters includes to:

- Avoid disturbing wildlife including breeding birds and seals in designated seal haul outs;

---

<sup>v</sup> The highest and lowest level that spring tides reach on average

- Cut fronds well above the point of growth and always leave the holdfast attached;
- Harvest sparsely. Take less than one third of a plant to allow for regrowth;
- Harvest during the active growth season and after reproduction if possible;
- Avoid denuding entire patches of one species in one growth season;
- Rotate harvesting areas to allow ample time for recovery;
- Biosecurity advice to manage risk of spread of invasive non-native species.

Land owners do not have to consult SNH about harvesting on private (intertidal) foreshore, unless it is a Site of Special Scientific Interest (SSSI). Gathering or harvesting kelp from within an SSSI may require SNH consent, depending on the features of the site and if it is an [Operation Requiring Consent](#). For Natura sites (Special Protection Areas and Special Areas of Conservation), SNH also consider whether proposals could affect interests of sites at some distance away e.g. harvesting might affect foraging areas used by breeding seabirds. They would also consider impacts on features of MPAs, the status of Priority Marine Features, or [European Protected Species](#), such as otters and cetaceans.

## Marine licensing

A marine licence would be required for removal of kelp and other seaweeds from the seabed using a vessel or vehicle below the mean high-water spring mark. Part 4 of the [Marine \(Scotland\) Act 2010](#) sets out the requirement for marine licences to be granted by Scottish Ministers in respect of any 'licensable marine activity'. Licensing functions are delegated to the Licensing Operations Team of Marine Scotland by Scottish Ministers.

Section 21 (1) of the Act includes a list of licensable marine activities which includes, "To use a vehicle, vessel, aircraft, marine structure or floating container to remove any substance or object from the seabed within the Scottish marine area." Marine Scotland currently consider this removal activity to be the most appropriate 'marine licensable activity' category to apply. However, the activity, if involving dredging, could also be considered to be dredging, a separate 'licensable marine activity' under section 21(7).

In determining an application for a marine licence, Scottish Ministers must have regard, amongst other things, to the need to protect the environment (section 21(4)). SNH would also provide advice to Marine Scotland for relevant marine licence applications as a statutory consultee. The Act also places a general duty on Scottish Ministers and public authorities, when exercising any function that affects the Scottish marine area, to "act in the way best calculated to further the achievement of sustainable development, including the protection and, where appropriate, enhancement of the health of that area...".

Vessel based kelp removal or dredging may not trigger a legal requirement for an Environmental Impact Assessment (EIA), as kelp harvesting is not covered by the project categories listed in the EIA Directive. However, under section 25 of the Marine Act, Scottish Ministers may require an application for a marine licence to supply information "as in their opinion may be necessary to enable them to determine the application". Burrows et al (2018) recommend that an EIA approach should be followed even if not legally required



# Sustainability of wild kelp harvesting

The wild harvest of kelp has sustainability implications for the species targeted, associated ecosystem services and functions provided by wild kelp habitats. Over-exploitation could lead to potentially significant, negative effects or risks including:

- Negative impacts on marine biodiversity including loss of habitat and/or food sources for a range of plants and animals;
- Loss of nursery grounds for juvenile invertebrates and fish;
- Reduced contributions to the marine carbon cycle;
- Disrupted transfer of organic materials between ecosystems and removal of nutrients;
- Reduced coastal protection from erosion and flooding (Marine Scotland, 2016).

The techniques used and intensity of exploitation influence the recovery capacity of cut seaweed beds and the associated ecosystem<sup>13</sup>. Smale et al (2013)<sup>7</sup> states:

“ The demand for kelp for human consumption, alginate production, aquaculture feed, and (potentially) biofuel has increased in recent decades and will almost certainly continue to grow. Direct removal of kelps has major implications for kelp population structure, whole community dynamics, and wider ecosystem functioning. There is some evidence to suggest that due to the rapid recruitment and growth of kelps and their associated species, industrial-scale wild harvesting of kelps can be achieved sustainably. For example, in both Norway and Chile, some 130,000-200,000 tonnes is extracted annually and has been for some time. However, while a limited natural harvest may be sustainable if properly managed with appropriate fallow periods, the potential for impact on the other services provided by kelp may be considerable. Although kelps recruiting into harvested areas may reach pre-perturbed densities and sizes within a few years, their associated assemblages may take considerably longer to recover.”

## 2016 Marine Scotland Strategic Environmental Assessment

In 2016, Marine Scotland consulted on a [Strategic Environmental Assessment \(SEA\)](#) of wild seaweed harvesting to investigate the sustainability of large scale extraction, in particular kelp<sup>14</sup>. The SEA states:

- Current **small scale (i.e. artisanal) hand cutting** or picking of wild seaweed in Scotland is "unlikely to result in significant adverse environmental impacts", and therefore can continue to be undertaken sustainably through existing practices (i.e. landowner permissions) and consultation with SNH<sup>vi</sup>.

---

vi SNH state that small seaweed harvesting operations do have the potential to result in significant impacts for some protected sites and interests, e.g. repeated disturbance of roosting birds. They suggest broader regulation is required to encompass hand harvesting, which would also inform cumulative impact assessments of large scale activities.

- Significant adverse effects can occur as a result of **large scale (i.e. industrial) mechanised harvesting** of seaweeds including kelp, primarily relating to impacts on habitats as well as on the ecosystem services that they provide (including coastal protection and carbon sequestration), and that these impacts may be further exacerbated in the future with the predicted effects of climate change.

With regard to harvesting practices, the SEA states that:

"Harvesting practices, most notably the extent and scale of harvesting (i.e. frequency of harvesting, the proportion of a seaweed community harvested, and the proportion of an individual plant harvested) and the species harvested have been identified as key factors in ensuring plant regeneration and recovery of harvest areas, and ensuring the sustainability of the resource and the biodiversity it supports."

Coastal areas that were thought to be particularly sensitive to harvesting include:

- Coastal areas that are wave exposed and prone to erosion (e.g. Uists);
- Designated sites that could potentially support kelps (i.e. SACs, PMFs and MPAs);
- Seal haul out sites;
- Charted archaeological features (wrecks) and Historic Marine Protected Areas;
- Areas where beach cast seaweed is used by crofters.

The SEA found no evidence that small-scale hand cutting has significant environmental effects, but highlighted the potential for significant cumulative effects of multiple activities.

## 2018 Highlands and Islands Enterprise report

Highlands and Islands Enterprise (HIE) commissioned a study to investigate the potential for medium to large-scale harvesting of wild kelp in Scotland using mechanical techniques<sup>2</sup>. Factors in favour of developing kelp harvesting in Scotland were considered to include the quality and volume of available *Laminaria hyperborea*, considered to be appropriate for high quality alginate processing, and the fact that cultivation cannot be presently seen as an alternative as *Laminaria hyperborea* is not commercially cultivated here.

The report reviews evidence of environmental impacts (mainly from Norway and France) and makes a number of recommendations regarding the development of regulatory systems. Recovery of wild kelp after harvesting needs to be considered both in relation to recovery of the kelp resource itself, and recovery of associated biodiversity. It states:

" Harvesting temporarily removes the kelp habitat and results in measurable reductions in associated biota. The kelp itself recolonises and regrows within a few years, but harvesting leads to a more restricted size and age range in the recovering stands compared with unharvested areas. Re-colonisation of the harvested areas is possible, providing there are sufficient source populations nearby. However, full recovery may not be seen within the inter-harvest periods typically applied in Norway. Impacts of harvesting kelp on commercial fish populations are currently difficult to evaluate."

Other sustainability implications raised include possible conflict with other marine users including fisheries, tourism, fish farms, and marine renewables.

Designing a sustainable harvesting regime was described as being complex, needing to take into account site-specific factors, preventing a 'one-size-fits all' strategy, although general principles can be applied.

The report recommends that Scotland follows the practice in Norway, including:

1. Sector-based management in which sectors are open for one year followed by four to five years of fallow until the next harvesting period.
2. Harvesting in strips one nautical mile wide such that no strip borders one that has been previously harvested. If possible, each harvested strip should be bounded by permanently fallow (unharvested) strips to ensure proximity to intact forests.

In discussing the length of harvesting cycles however, the review notes that a five-year cycle may not allow for full recovery of animal and plant life, and continuous monitoring will be required to demonstrate recovery to an agreed level. It also recommends 'adaptive management', where high-quality monitoring of kelp beds guides plans.

The report assessed the diversification potential for Scottish fishing vessels and estimated that 10-15 m long vessels (about 10% of the Scottish fleet) could feasibly convert to kelp harvesting, although many vessels would not be suitable due to space limitations. Fishermen could also participate indirectly, for example through providing local knowledge or vessels for surveys.

Regarding the potential economic value of seaweed harvesting in Scotland, the report states:

“ Scottish seaweed harvesting appears to be relatively low value at the raw material stage, but very high value in downstream effects. For example, at £40 t<sup>-1</sup> of wet seaweed: A 10,000 t industry would be of negligible total value (£400,000) and may not be proportionate to the risks it may pose to the marine (operating and natural) environment, or the costs to mitigate and monitor such activity. Even a large harvesting operation of 50,000 t may at such a price come to £2m (in fact, Scottish harvesting costs would likely be higher, meaning primary harvesting would likely be closer to £3-5m). However, if the sole intention is that a very high value manufacturing and pharmaceutical industry of a scale in the £100m (the range may be between £100- 500m after 10 years) can be enabled through that relatively low value harvesting, then appropriate compliance and monitoring / management costs should be viable over the total Value Chain.”

Regarding the development of licensing systems, the report states:

“ a broader challenge is the social acceptability of harvesting seaweed - use of seaweed in Scotland is a traditional activity, but modern harvesting is an unfamiliar process to coastal communities. Attention should be paid early on in the process to ensuring the full benefits of any activity are communicated to stakeholders, possibly with direct benefits agreed.”

# Recent proposals for mechanical wild kelp harvesting on the West Coast

The first proposals for large-scale mechanical wild kelp harvesting in Scotland have reached the pre-application stage. Advice was sought from the Licensing team of Marine Scotland based on a scoping report submitted in July 2018. Marine Biopolymers are seeking to obtain five-year marine licences to harvest *Laminaria hyperborea* from a range of locations around the west coast of Scotland, with the aim of converting kelp into high value products for pharmaceutical and other markets. By year 5, they anticipate having the capacity to harvest up to 30,000 tonnes of kelp per year.

The harvesting technique proposed is similar to that used in Norway, using a comb-like harvesting head, trawled through the kelp bed. The report states that the harvesting method "typically removes entire kelp plants including holdfasts, although juvenile plants are largely left in situ..."<sup>20</sup> .

The Licensing team of Marine Scotland (MS-LOT) issued scoping advice<sup>21</sup> to the prospective applicant in October 2018 and stated that they received over 2350 stakeholder representations on the proposal. The advice states:

“ MS-LOT, having considered the consultation responses, and in accordance with previously given advice, considers the current application area too large. MS-LOT therefore recommends consideration of smaller areas for application and re-evaluating the scope of assessments based on the environmental and stakeholder characteristics of the location and resubmission of the Scoping Report to address the specific characteristics of each area applied for.”

SNH raise [in their comments](#)<sup>22</sup> that:

“ There is currently a lack of data exploring the potential impacts of kelp harvesting in Scottish waters and precaution should be used when inferring impacts on kelp from studies from elsewhere.”

The proposals triggered significant interest from stakeholders including individuals, representatives of coastal communities, inshore fisheries groups and NGOs. Scottish Environment LINK stated in relation to the proposals that:

“ our current knowledge on the health, abundance, and distribution of seaweed habitats in Scottish waters is insufficient to accurately assess whether harvesting can be carried out sustainably.”<sup>23</sup> ”

Concerns raised by stakeholders include that the method proposed will result in the total removal of plants resulting in unacceptable impacts on ecosystems, and that the length of time proposed between harvests will not allow for ecosystem recovery.

Scottish Environment LINK have also called on the Scottish Government to establish a clear definition of sustainable seaweed harvesting that relates to the whole ecosystem, applying an 'ecosystem-based' management approach.

# Commercial wild seaweed harvesting in other countries

Mechanical harvesting of seaweed beds has been carried out in a number of countries for decades, including Norway, France and the USA. The development of the mechanisation of seaweed harvesting occurred in the 1970s in France and Norway in response to increasing demand for alginates. The following sections summarise the regulatory systems in selected countries and regions.

## Norway

Norway leads the harvest of seaweed from wild stocks in Europe <sup>13</sup>, annually harvesting 130,000 - 180,000 tonnes of brown seaweed including kelp species. The right to harvest seaweed belongs to the state and is prohibited unless permission is granted. Regulations for harvesting of seaweed in Norway were commenced in 1995 under its Marine Resources Act. The purpose of the Regulations <sup>24</sup> is to ensure sustainable use, defined as use that will produce economic growth and better living conditions for people without destroying natural resources, the environment or preventing future generations from fulfilling their needs.

The Regulations include the following requirements and definitions:

- Management plans designate areas for harvest under an explicit cycle, and locked areas where it is prohibited to harvest in all or part of the year;
- Areas are considered to be suitable for harvesting where the resource and ecosystem can withstand the strain of harvesting;
- Regional Fisheries Directorates may establish regional regulations on where and when it is permitted to harvest seaweed in each region;
- Regional Directorates may open areas for harvesting seaweed for up to 5 years at a time if it is likely that the resource and ecosystem can withstand the strain;
- Regional Directorates may make regulations regarding the tools that can be used for harvesting seaweed and regulate the use of machinery;
- Mechanical vehicles including trawlers used for seaweed harvesting must be registered in the Fisheries register of vessels for seaweed harvesting.

An appointed committee, comprised of industry representatives, fishermen's associations and marine research institutes, oversee the industry.

## France

Approximately 60,000 tonnes of seaweed is harvested annually in France, the majority from wild stocks <sup>25</sup>. The beach, foreshore and sea are controlled by the state and

seaweed gathering is regulated at a regional and national scale. In Brittany, where most harvesting takes place, there is a special working commission on seaweed harvesting.

Part of France's fishing legislation (Order n°2009-0329) covers the sustainable exploitation of seaweed at sea. Kelp harvested by boats requires a harvesting licence. The French Research Institute for the Exploitation of the Sea monitors the kelp harvest and advises administrations involved.

*Laminaria digitata* is one of the most harvested species. Total landings are dictated by the processing industry in relation with their capacity to process fresh algae. The total amount of seaweed required by the industry is agreed and divided among boats. For *Laminaria hyperborea* the total annual catch is fixed at a maximum level. There are fixed harvest areas, and each area is closed for 5 years following harvest.

## Ireland

In Ireland, following the Foreshore Act 1933 all persons or companies, seeking to harvest wild seaweed (with some exceptions e.g. if a right is attached to the property) must obtain a license from the Department of Housing, Planning and Local Government. The process for obtaining a licence includes an assessment by the Marine Licence Vetting Committee.

In 2005, the National Parks & Wildlife Service commissioned an expert review of mechanical kelp harvesting <sup>26</sup>. It concluded:

“ Even well managed kelp harvesting puts substantial ecological pressure on natural kelp beds by increasing disturbance levels and removing resources from the ecosystem. Such activities are not compatible with the conservation objectives of, and should not be permitted in NATURA 2000 sites. In non-designated areas, well managed and controlled kelp harvesting could be envisaged but experience to date in the Irish inshore zone gives no grounds for optimism that 'owned in common' resources can be managed rather than over exploited and then abandoned. Any kelp harvesting project must be carefully monitored throughout its lifetime. Possible unwanted side effects include the replacement of *Laminaria hyperborea* first by *L. digitata* and then *Sacchoriza polyschides*, removal of biomass necessary for other trophic levels and the elimination of older plants of all species. Despite economic limitations there is a reasonable case for encouraging research on the cultivation of kelp for harvesting rather than relying on wild populations.”

A licence to mechanically harvest kelp in Bantry Bay in Cork was approved in principle in 2011 and pre-harvest licence conditions were fulfilled in 2017. The applicant was an Irish biotechnology company. The granting of this licence has divided opinion amongst local people and environmental groups. The licence covers an area of approximately 750 hectares (1800 acres), less than 5% of the total area of the bay. The conditions require a monitoring programme to begin after three years to assess recovery of the habitat.

In March 2018, [a \(non-binding\) motion was passed in the Dáil Éireann](#) <sup>27</sup> (lower house of the parliament of Ireland), calling on the Irish Government to develop a national seaweed strateg, taking into account the interests of traditional harvesters, the potential for sustainable job creation, interests of local communities, and climate change commitments. It also called for the suspension of all current harvesting licences pending the publication of a strategy.

## USA (California)

The <sup>28</sup> California Department for Fish and Wildlife state that there are 87 administrative kelp beds located off California and surrounding islands, which contain mainly *Macrocystis pyrifera* (giant kelp) or *Nereocystis luetkeana* (bull kelp). Commercial harvesters must purchase an annual kelp harvester license and abide by regulations <sup>28</sup>. Certain species and areas (including state marine reserves and parks) are prohibited from commercial harvest, and kelp beds are classified into management areas (open, leasable, lease only, and closed). Licensees must keep records of landed kelp and produce harvest plans.

Regulations also prohibit removal of certain species of kelp from the seafloor. Section 165 (d)(1)(A) of the California Code of Regulations (Harvesting of Kelp and Other Aquatic Plants) states:

“ All agar-bearing plants must be harvested by cutting, except that drift or loose plants may be picked up by the harvester. Agar-bearing plants may be cut no closer than two inches to the holdfast and no holdfast may be removed or disturbed.”

Agar-bearing plants included are *Gelidium*, *Pterocladia*, *Gracilaria*, *Iridaea*, *Gloiopeltis* or *Gigartina species* i.e. the legislation is aimed at a different set of species to kelp found in Scotland.

# Bibliography

- 1 Marine Scotland. (2016). *Wild Seaweed Harvesting Strategic Environmental Assessment Environmental Report*, written by ABP Marine Environmental Research Ltd. (ABPmer). Retrieved from: <https://beta.gov.scot/publications/wild-seaweed-harvesting-strategic-environmental-assessment-environmental-report/> (accessed 30th October 2018).
- 2 Burrows M.T., Fox, C.J., Moore, P., Smale, D., Sotheran, I., Benson, A., Greenhill, L., Martino, S., Parker, A., Thompson, E., Allen, C.J. (2018). *Wild Seaweed Harvesting as a Diversification Opportunity for Fishermen. A report by SRSL for HIE*, pp. 171. Retrieved from: <http://www.hie.co.uk/common/handlers/download-document.ashx?id=0336008d-db41-4b61-a9bd-6bfcbd31c876> (accessed 30th October 2018).
- 3 Kain, J. (1971). *Synopsis of Biological Data on Laminaria hyperborean*. FAO Fisheries Synopsis No. 87.
- 4 Fuller, I. (1999). Kelp Forests, SNH publication.. Retrieved from: <https://www.nature.scot/sites/default/files/2018-10/Publication%201999%20-%20Scotland%27s%20Living%20Landscapes%20-%20Kelp%20Forests.pdf> [accessed 9 November 2018].
- 5 Burrows, M.T., Smale, D., O'Connor, N., Van Rein, H and Moore, P. (2014). *Marine Strategy Framework Directive Indicators for UK Kelp Habitats Part 1: Developing proposals for potential indicators*. JNCC Report No. 525. SAMS/MBA/QUB/UAberr for JNCC, JNCC Peterborough. Retrieved from <http://jncc.defra.gov.uk/page-6820> [accessed 9 November 2019].
- 6 Fuller, I. (1999). Kelp Forests, SNH publication.. Retrieved from: <https://www.nature.scot/sites/default/files/2018-10/Publication%201999%20-%20Scotland%27s%20Living%20Landscapes%20-%20Kelp%20Forests.pdf> [accessed 9 November 2018].
- 7 Smale, D. A., Burrows, M. T., Moore, P., O'Connor, N., & Hawkins, S. J. (2013). *Threats and knowledge gaps for ecosystem services provided by kelp forests: a northeast Atlantic perspective*. *Ecology and Evolution*, 3(11), 4016-4038. DOI: 10.1002/ece3.774. Retrieved from: [https://pure.qub.ac.uk/portal/files/5970848/Smale\\_et\\_al\\_13.pdf](https://pure.qub.ac.uk/portal/files/5970848/Smale_et_al_13.pdf) [accessed 29th October 2018].
- 8 Burrows, M., Hughes, D., Austin, W. E. N., Smeaton, C., Hicks, N., Howe, J., Vare, L. (2017). *Assessment of Blue Carbon Resources in Scotland's Inshore Marine Protected Area Network*. Scottish Natural Heritage. Retrieved from: <https://pure.uhi.ac.uk/portal/files/2073380/957.pdf> (accessed 30th October 2018).
- 9 Burrows M.T., Kamenos N.A., Hughes D.J., Stahl H., Howe J.A. & Tett P. (2014). *Assessment of carbon budgets and potential blue carbon stores in Scotland's coastal and marine environment*. Scottish Natural Heritage Commissioned Report No. 761..
- 10 Mork, M. (1996). *Wave attenuation due to bottom vegetation in Waves and Nonlinear Processes in Hydrodynamics*, eds J. Grue, B. Gjevik, and J. E. Weber (Oslo: Kluwer Academic Publishing), 371–382. Retrieved from: [https://link.springer.com/chapter/10.1007%2F978-94-009-0253-4\\_30](https://link.springer.com/chapter/10.1007%2F978-94-009-0253-4_30) [accessed 9 November 2018].



- 11 SNH. (2016). *Commissioned Report 406: Descriptions of Scottish Priority Marine Features (PMFs)*.
- 12 Capuzzo, E. and McKie, T. (2016). *Seaweed in the UK and abroad – status, products, limitations, gaps and Cefas role. A report by the Centre for Environment, Fisheries & Aquaculture Science*. Retrieved from: [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/546679/FC002I\\_\\_Cefas\\_Seaweed\\_industry\\_report\\_2016\\_Capuzzo\\_and\\_McKie.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/546679/FC002I__Cefas_Seaweed_industry_report_2016_Capuzzo_and_McKie.pdf) (accessed 29th October 2018).
- 13 MacMonagail, M., Cornish, L., Morrison, L., Araújo, R. and Critchley, A.T. (2017). *Sustainable harvesting of wild seaweed resources*, *European Journal of Phycology*, 52:4, 371-390, DOI: 10.1080/09670262.2017.1365273. Retrieved from: [https://www.researchgate.net/publication/320306943\\_Sustainable\\_harvesting\\_of\\_wild\\_seaweed\\_resources](https://www.researchgate.net/publication/320306943_Sustainable_harvesting_of_wild_seaweed_resources) (accessed 29th October 2018).
- 14 Marine Scotland. (2016). *Wild Seaweed Harvesting Strategic Environmental Assessment Environmental Report, written by ABP Marine Environmental Research Ltd. (ABPmer)*. Retrieved from: <https://beta.gov.scot/publications/wild-seaweed-harvesting-strategic-environmental-assessment-environmental-report/> (accessed 30th October 2018).
- 15 Duarte CM, Wu J, Xiao X, Bruhn A and Krause-Jensen D. (2017). *Can Seaweed Farming Play a Role in Climate Change Mitigation and Adaptation?* *Front. Mar. Sci.* 4:100. doi: 10.3389/fmars.2017.00100. Retrieved from: <https://www.frontiersin.org/articles/10.3389/fmars.2017.00100/full#B59> [accessed 7th November 2018].
- 16 Marine Scotland. (2017). *Seaweed Cultivation Policy Statement*. Retrieved from: <https://beta.gov.scot/publications/seaweed-cultivation-policy-statement-2017/pages/2/> (accessed 30th October 2018).
- 17 Buschmann, A.H., Camus, C., Infante, J., Neori, A., Israel, A., Hernández-González, M.C., Pereda S.V., Gomez-Pinchetti, J.L., Golberg, A., Tadmor-Shalev, N., Critchley, A.T., (2017). *Seaweed production: overview of the global state of exploitation, farming and emerging research activity*, *European Journal of Phycology*, 52:4, 391-406, DOI: 10.1080/09670262.2017.1365175. Retrieved from: [https://www.researchgate.net/publication/320306944\\_Seaweed\\_production\\_overview\\_of\\_the\\_global\\_state\\_of\\_exploitation\\_farming\\_and\\_emerging\\_research\\_activity](https://www.researchgate.net/publication/320306944_Seaweed_production_overview_of_the_global_state_of_exploitation_farming_and_emerging_research_activity) (accessed 29th October 2018).
- 18 Macleod, A., Campbell, I., Sahlmann, C., Neves, L., Funderud, J., Overland, M., Hughes, A., Stanley, M. (2018). (n.d.) *The environmental risks associated with the development of seaweed farming in Europe - prioritizing key knowledge gaps*, *Frontiers in Marine Science*, accepted, in revision..
- 19 Bak, U.G., Mols-Mortensen, A.M., and Gregersen, O. (2018). *Production method and cost of commercial-scale offshore cultivation of kelp in the Faroe Islands using multiple partial harvesting*. *Algal Research*, Vol 33, Pages 36-47. Retrieved from: <https://doi.org/10.1016/j.algal.2018.05.001> (accessed 29th October 2018).
- 20 ABPmer. (2018). *Wild Seaweed Harvesting Scoping Report AMPmer Report No. R.3007. A report produced by ABPmer for Marine Biopolymers Ltd, July 2018*. Retrieved from: [http://marine.gov.scot/sites/default/files/r3007\\_wild\\_seaweed\\_harvesting\\_scoping\\_report\\_17july2018lr\\_0.pdf](http://marine.gov.scot/sites/default/files/r3007_wild_seaweed_harvesting_scoping_report_17july2018lr_0.pdf) (accessed 29th October 2018).

- 21 Marine Scotland Licensing Operations Team. (2018). *Scoping Advice Letter to Marine Biopolymers Ltd (2018)* Retrieved at: [http://marine.gov.scot/sites/default/files/mbi\\_scoping\\_advice\\_-\\_signed\\_-\\_03\\_oct\\_2018\\_redacted\\_0.pdf](http://marine.gov.scot/sites/default/files/mbi_scoping_advice_-_signed_-_03_oct_2018_redacted_0.pdf) [accessed 9 November 2018].
- 22 SNH scoping report comments. (2018). Retrieved from Retrieved at: [https://www.nature.scot/sites/default/files/2018-08/Consultation%20-%20MBL%20-%20kelp%20harvesting%20-%20west%20coast%20of%20Scotland%20-%20scoping%20-%20SNH%20response\\_0.pdf](https://www.nature.scot/sites/default/files/2018-08/Consultation%20-%20MBL%20-%20kelp%20harvesting%20-%20west%20coast%20of%20Scotland%20-%20scoping%20-%20SNH%20response_0.pdf) [accessed 9 November 2018]
- 23 Scottish Environment LINK (2018). (n.d.) *Consultation Response to the Wild Seaweed Harvesting Scoping Report by Marine Biopolymers Ltd. By the Scottish Environment LINK Marine Group.* Retrieved from: [http://www.scotlink.org/wp/files/documents/SE\\_LINK\\_Response\\_Marine-Biopolymers-Scoping-Report\\_2018.pdf](http://www.scotlink.org/wp/files/documents/SE_LINK_Response_Marine-Biopolymers-Scoping-Report_2018.pdf) (accessed 30th October 2018).
- 24 Norwegian Regulations For Harvesting Seaweed. Retrieved from: <https://www.global-regulation.com/translation/norway/5962732/regulations-for-harvesting-seaweed.html> [accessed 9 November 2018]. (1995, undefined).
- 25 Mesnildrey, L., Jacob, C., Frangoudes, K., Reunavot, M., Lesueur, M. (2013). *Seaweed industry in France. Report Interreg program NETALGAE.* Retrieved from: <https://core.ac.uk/download/pdf/52846263.pdf> (accessed 30th October 2018).
- 26 Kelly, E. (ed.). (2005). *The role of kelp in the marine environment. Irish Wildlife Manuals, No. 17. National Parks and Wildlife Service, Department of Environment, Heritage and Local Government, Dublin, Ireland.* Retrieved from: <https://www.npws.ie/sites/default/files/publications/pdf/IWM17.pdf> [accessed 7th November 2018].
- 27 Dáil Éireann Sustainable Seaweed Harvesting Motion. (2018, undefined). Retrieved from Retrieved from: <https://www.oireachtas.ie/en/debates/debate/dail/2018-03-08/15/>
- 28 California Department for Fish and Wildlife webpage. (2018, undefined). Retrieved from Commercial Harvest of Kelp and Other Marine Algae. Retrieved from: <https://www.wildlife.ca.gov/Conservation/Marine/Kelp/Commercial-Harvest>

Scottish Parliament Information Centre (SPICe) Briefings are compiled for the benefit of the Members of the Parliament and their personal staff. Authors are available to discuss the contents of these papers with MSPs and their staff who should contact Alexa Morrison on telephone number 85416 or [Alexa.Morrison@parliament.scot](mailto:Alexa.Morrison@parliament.scot).

Members of the public or external organisations may comment on this briefing by emailing us at [SPICe@parliament.scot](mailto:SPICe@parliament.scot). However, researchers are unable to enter into personal discussion in relation to SPICe Briefing Papers. If you have any general questions about the work of the Parliament you can email the Parliament's Public Information Service at [sp.info@parliament.scot](mailto:sp.info@parliament.scot). Every effort is made to ensure that the information contained in SPICe briefings is correct at the time of publication. Readers should be aware however that briefings are not necessarily updated or otherwise amended to reflect subsequent changes.

