More than 20 species of mussel (family Mytilidae) (1) make up the 2.9 million metric tonnes (mt) (2) of world production (natural and cultivated) every year. Of this, the UK produced 26,000 mt of blue mussels (*Mytilus edulis*) in 2012 (3). UK retail consumption in 2013 was around 4,000 mt (4).

The purpose of this guide is to give buyers background information on the responsible sourcing of farmed mussels.

### Sources and quantities

While feed is generally perceived to be a major constraint to aquaculture development, one-third of all farmed food fish production (20 million mt) is currently achieved without artificial feeding. Oysters, mussels, clams, scallops and other bivalve species are grown with food materials that occur naturally in their culture environment in the sea and lagoons (5).

Global bivalve mollusc production (capture and aquaculture) has increased substantially during the last few decades (6). Production reached around 15 million mt in 2012. Total aquaculture production of molluscs is represented by 5 main groups: clams, oysters, mussels, scallops, and abalones. Clam production during 2011 was 4.93 million tons; this was followed by oysters with 4.52 million tons; mussels with 1.8 million tons; scallops with 1.52 million tons; and finally abalones with aquaculture production of 395,000 tons (7).

Some of the main, globally cultured mussel species and their main producing countries are listed below (8) and details of 2013 mussel exports figures are listed on the next page: (8, 9)

- **Sea Mussels (Mytilidae spp)** - producers: Spain and China
- **Green Mussel (*Perna viridis*)** - producers: Thailand and the Philippines
- **Blue Mussel (*Mytilus edulis*)** - producers: Canada, Denmark, France, Ireland, Netherlands, UK
- **Chilean Blueshell Mussel (*Mytilus chilensis*)** - producer: Chile
- **Mediterranean Mussel (*Mytilus galloprovincialis*)** - producers: France, Greece, Italy
- **New Zealand Green Mussel (*Perna canaliculus*)** - producer: New Zealand
- **Korean Mussel (*Mytilus coruscus*)** - producer: Korea

### BUYERS' TOP TIPS

- Know your source of supply and only purchase mussels which are traceable throughout its entire production chain.
- Ensure product complies with the appropriate farming, processing and production standards.
- Mussels can accumulate naturally occurring marine biotoxins. In Europe suppliers have to demonstrate compliance with an end product standard and its traceability to source.
- Be aware of the social and environmental impacts.
Mussels are an internationally traded seafood (9), and import and exports figures for 2013 are detailed in Table 1. France is the largest importing nation (with almost 43,000 mt), and the majority of mussel exports originate from four countries: Chile, Spain, New Zealand and the Netherlands, which accounted for around 140,000 mt of exports in 2013.

**Table 1. Global mussel imports and exports, 2013 (9)**

<table>
<thead>
<tr>
<th>IMPORTS</th>
<th>(1 000 tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>42.8</td>
</tr>
<tr>
<td>Italy</td>
<td>29.0</td>
</tr>
<tr>
<td>USA</td>
<td>24.8</td>
</tr>
<tr>
<td>Belgium</td>
<td>20.5</td>
</tr>
<tr>
<td>Spain</td>
<td>20.7</td>
</tr>
<tr>
<td>Netherlands</td>
<td>17.9</td>
</tr>
<tr>
<td>Germany</td>
<td>9.6</td>
</tr>
<tr>
<td>UK</td>
<td>4.4</td>
</tr>
<tr>
<td>Russia</td>
<td>6.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EXPORTS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Chile</td>
<td>55.9</td>
</tr>
<tr>
<td>Netherlands</td>
<td>33.6</td>
</tr>
<tr>
<td>Spain</td>
<td>29.8</td>
</tr>
<tr>
<td>New Zealand</td>
<td>20.5</td>
</tr>
<tr>
<td>Denmark</td>
<td>12.4</td>
</tr>
<tr>
<td>Italy</td>
<td>10.5</td>
</tr>
<tr>
<td>Canada</td>
<td>12.4</td>
</tr>
<tr>
<td>Greece</td>
<td>10.4</td>
</tr>
<tr>
<td>China</td>
<td>6.3</td>
</tr>
<tr>
<td>Ireland</td>
<td>9.5</td>
</tr>
<tr>
<td>UK</td>
<td>5.9</td>
</tr>
</tbody>
</table>

**European Imports / Exports** (10)

In 2013, €98 million of prepared mussels were imported into the EU, of which €92 million came from Chile.

In 2012, about €875 million bivalves were exported by EU countries. Almost 90% of this export consists of intra-EU trade. The product with the highest export volume in 2013 was fresh / chilled mussels (€183 million), and Spain (29,000 mt) and the Netherlands (33,600 mt) were the main exporters (9).

**UK**

In terms of the UK retail sector, mussels ranked 18th in the top 35 retail species in the 52 weeks running up to August 2014. The UK retail volume of mussels was 3,600 mt, worth £21.49 million over this same period (4).

Small quantities of mussels were landed in UK ports by UK vessels in 2013 (i.e. 5,000 mt) (4). However domestic aquaculture production of mussels produced 26,000 mt in 2012. Production came from all four nations (listed below), and 2012 total production was worth £27.3 million (3): Wales – 8,996 mt; Scotland – 6,277 mt; England – 5,965 mt; Northern Ireland – 4,782 mt.

**Product characteristics**

Mussels are available all year round, and new technologies such as vacuum packaging make mussels even more accessible to the consumer. Mussel meat has a medium texture, and strong, earthy flavour. Remove the ‘beard’ (aka the abyssal thread’), simply steam in the serving sauce, and discard any mussels that do not open (23). Large mussels are packed (10) in bags of 5 or 10 kg, while smaller bags of 1 kg that are directly distributed to retail are also produced. Smaller mussels produced in Spain or Chile often are sold in polybags. They are processed whole and cleaned, cooked with or without the shell (mussel meat), sometimes also half shell.
Biology

Mussels are a type of bivalve mollusc; they have two shells which hinge together. Mussels living in different habitats have different characteristics. Those living inter-tidally have thicker shells (to protect them from the more dynamic nature of this environment, e.g. wave and tidal action), and may exhibit a longer shelf-life than those which are submerged continuously.

There are local regulations governing minimum landing size for wild harvest fisheries but, generally cultivated mussels are not regulated in this way. Mussels are sourced from both wild and farmed origin. Juveniles or ‘spat’ used for farming (i.e. those for seeding the structure on which they will grow), are most often collected from the wild and natural settlement. However predicting the occurrence, time, location and size of any spat-fall is difficult, and there are many environmental variables to be taken into account. This introduces a level of uncertainty and unreliability and often results in there being fluctuations in the supply of mussels to the processors, retailers and eventually the consumers (11). Hatchery production is possible, and may be a method by which a reliable supply of spat can be supplied to mussel farmers.

Cultivation methods and systems

Mussels can be harvested from wild or cultivated stocks. Site selection for cultivating mussels is extremely important and factors include:

- Substrate
- Depth of water
- Salinity
- Temperature
- Exposure to air, wind and currents
- Food availability

Wild harvest

Mussels grow naturally in large beds either subtidally or between the tides. Wild harvest of mussels occurs in many areas, harvested on a large-scale by towed dredge or small-scale by hand-raking at low tide. For all scales of operations there is a requirement to meet water quality and food safety regulations.

Seabed and suspended culture

Mussel farming can be carried out by cultivation on the seabed or by using suspended culture. The first method involves locating and fishing seed mussel of around 10mm shell length from offshore beds and then relaying in a more productive, protected location, termed a ‘lay’ (12).
In Wales, Northern Ireland, The Wash, North Norfolk and Poole Harbour mussel production is mostly derived from this type of culture, within restricted Several Order fisheries (9), i.e. a person or company is granted legal ownership of the mussels in a given area of seabed in order to enable their cultivation.

In suspended culture (13), the mussels are cultivated on a system of ropes and floats (Plate 1), where they grow until harvest 18 - 24 months later. About 4,000 mt of rope grown mussels are produced in the UK, predominantly in Scotland, but also in Cornwall.

Mussels that are produced in other countries may have different methods of cultivation (Figure 1). In France they are grown on posts (bouchot) (14) and in Spain they are predominantly cultivated on ropes suspended from rafts.

Figure 1. Production cycle of Mytilus edulis (15)
Water quality and management standards

Microbiological contamination

Microbiological contamination can occur from two main sources – bacteria and viruses. Bacteria usually have a short residence time in the mussel, and low levels can be removed by a process termed purification or depuration. Viruses (16) can have a longer residence time in the mussel. Both bacteria and viruses are deactivated by approved heat processing. In the UK, the responsibility for ensuring food safety rests with the supplier who has to demonstrate that end product standards are met, and EU Regulations legally define the obligations of food businesses to ensure shellfish placed on the market is safe to eat (17).

Classification and treatment

In order to reduce these risks bivalve mollusc (shellfish) harvesting areas are classified according to the extent of contamination shown by monitoring *E. coli* in shellfish flesh (18). Treatment processes are stipulated according to the classification status of the area. The classification categories are detailed in Table 1.

Surveys of bacterial levels in mussels are undertaken and it is the results of these which determine classification, either Grade A, B, C or prohibited categories. In all cases, the health standards in Annex III of EC Regulations 853/2004 and the microbiological criteria adopted under EC Regulation 2073/2005 must be met. Molluscs must not be subject to production or collected in prohibited areas (18). The levels of contamination found in the mussels and their required subsequent treatment are shown below and described in Table 2.

In the UK, the Food Standards Agency (FSA) coordinates the national testing programme for the occurrence of harmful algae, bacteria, viruses and toxins in shellfish. Mussel samples from each growing region are tested for the presence of biotoxins. Areas may be closed if threshold levels of biotoxins are reached – this information is kept up to date on the FSA website (19). This high level of surveillance gives food safety assurance to the industry and confidence to the customers.

Environmental considerations

Successful, sustainable mussel cultivation means the maintenance of healthy environmental conditions and well-managed operations to ensure sustainable use of space.

As with all intensive mariculture (aquaculture in sea water) cultivation has the potential for substantial environmental effects depending on the location and scale of operation. The effects of bivalve aquaculture on the environment are often considered less important compared to those of finfish culture. However, bivalves due to their natural characteristics are considered...
keystone species in the ecosystem and therefore they have the ability to affect the surrounding environment in both negative and positive ways (20):

**Negative impacts**

- Suspended culture can cause changes in local water quality, water movement and sediment dynamics that can affect both planktonic and seabed communities, particularly in enclosed bays with limited water exchange
- Predator removal and intensive harvesting during seabed culture also has effects on seabed communities
- High-density cultivation can also promote the incidence and spread of parasites and diseases

**Positive impacts**

- Buffer estuaries and coastal ocean waters against excessive phytoplankton blooms
- Remove inorganic sediments from suspension, counteracting water turbidity
- Enhancement of water clarity can increase growth of sea grasses, important nursery habitat for many fish, crustaceans and molluscs.

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**Table 1. Classification of bivalve mollusc (shellfish) harvesting areas (18)**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Maximum concentration E.coli in mussel flesh</th>
<th>Restriction</th>
<th>Other conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade A</td>
<td>&lt; 230 cfu of E.coli/100g</td>
<td>Can be sold for direct human consumption</td>
<td>Fresh sales: must be alive and healthy at point of consumer purchase</td>
</tr>
<tr>
<td>Grade B</td>
<td>&lt;4,600 cfu of E.coli/100g in 90% of the samples</td>
<td>Cannot be sold direct for human consumption; must be purified (depurated), relayed or heat treated</td>
<td>Approved purification (depuration) for fresh sales or approved heat treatment</td>
</tr>
<tr>
<td>Grade C</td>
<td>&lt;46,000 cfu of E.coli/100g</td>
<td>Cannot be sold direct for human consumption; must be relayed (for a minimum of two months) or heat treated to remove microbiological contamination</td>
<td>Re-laying in higher grade water classification for a prolonged period (two months) or approved heat treatment</td>
</tr>
<tr>
<td>Prohibited – unclassified</td>
<td>Levels undetermined or greater than 46,000 cfu of E.coli/100g</td>
<td>Cannot be harvested for human consumption</td>
<td></td>
</tr>
</tbody>
</table>

Seed mussels taken from unclassified areas and relayed for ongrowing cannot be harvested for at least six months.
### Table 2. Harvested mussels to market.

Depending on Shellfish water classification (A, B, C or prohibited) certain procedures must be adhered to enable harvested mussels to enter the market.

<table>
<thead>
<tr>
<th>Cultivated mussels – On ropes or seabed</th>
<th>Wild grown mussels – Dredged or hand raked</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NO harvesting permitted in prohibited areas</strong></td>
<td></td>
</tr>
<tr>
<td>Harvesting</td>
<td>Relaying</td>
</tr>
<tr>
<td>Raking, dredging or harvesting from ropes</td>
<td>For a minimum of 2 months in either A or B category waters</td>
</tr>
<tr>
<td>De-clumping and grading</td>
<td>Harvesting rope</td>
</tr>
<tr>
<td>Mussels are clumped together when growing in their natural habitat. In this mechanical process the mussels are separated and selected by size.</td>
<td>Grown mussels</td>
</tr>
<tr>
<td></td>
<td>Harvesting cultivated mussels</td>
</tr>
<tr>
<td></td>
<td>Crop inspection</td>
</tr>
<tr>
<td><strong>Category A</strong></td>
<td><strong>Category B</strong></td>
</tr>
<tr>
<td>No treatment required</td>
<td>→ Approved heat treatment</td>
</tr>
<tr>
<td></td>
<td>Purification (depuration) for 42 hours</td>
</tr>
<tr>
<td></td>
<td>Packing and dispatch as live product</td>
</tr>
<tr>
<td></td>
<td>Packing and dispatch as a processed product</td>
</tr>
</tbody>
</table>
Certification and standards

Certification is a voluntary process that allows a supplier to demonstrate responsible sourcing practices by: minimising impact on the environment; making the best use of locally available resources; making informed choices regarding labour rights in the developing world; complying with national legislation and ensuring the best use of feed and therapeutic products.

Sustainability certification is becoming increasingly important in the EU and in the UK. Although the main focus is currently on wild caught fish and farmed products like shrimp or pangasius, it is expected in the long term that the capture and farming of bivalves will also need to be certified to maintain access to the EU market, at least in northern Europe (10). Several fisheries for mussels, clams, scallops, and oysters already have been certified by the Marine Stewardship Council (MSC) (21). Furthermore, in 2012 the Aquaculture Stewardship Council (ASC) developed a standard for the certification of cultured bivalves (22).

There are also supply chain standards. Responsible practice in the chilled and frozen supply chain depends on correct catching, gutting, washing, chilling or freezing, processing and handling practices throughout the chain. There are standards which cover these aspects from capture to retailer: The British Retail Consortium (BRC) Global Standard & Safe & Local Supplier Approval (SALSA) certification. Designed to raise standards in the seafood processing and wholesaling sectors.

New labelling rules

At the end of 2014 new EU ‘Labelling of Fishery and Aquaculture Products’ (FAPs) came into force. Now all wild fishery and farmed aquaculture products marketed within EU (both the EU and non-EU products) will display mandatory and voluntary information about the product for final consumers and mass caterers (23, 24).

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This is one of a series of responsible sourcing guides for aquaculture

See: http://www.seafish.org/industry-support/aquaculture
REFERENCES