

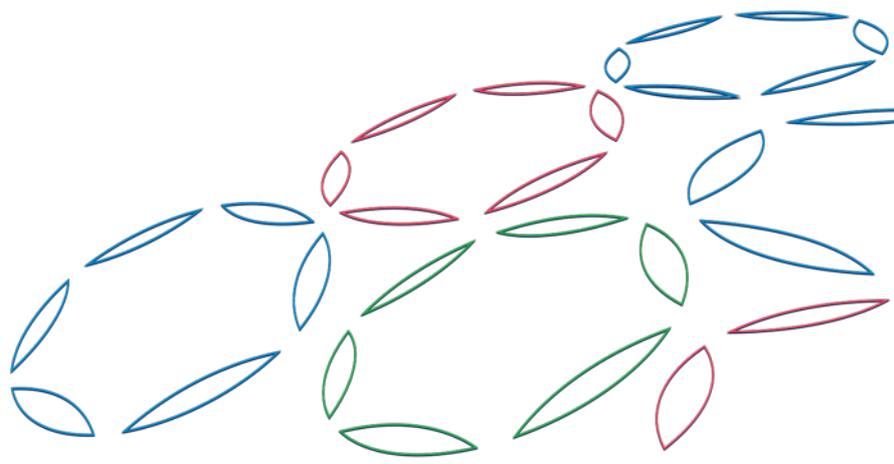


Markets for Sea Urchins: A Review of Global Supply and Markets

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Ágríp á íslensku:	<p>Framboð af ígulkerum á heimsvísu hefur minnkað síðastliðin ár vegna minnkandi veiði, eða frá um 120 þúsund tonnum árið 1995 til núverandi meðalársaflla sem er um 75 þúsund tonn. Afli hjá helstu veiðipjóðum s.s. Japan, Chile, Bandaríkjunum og að hluta Kanada hefur minnkað. Rússland og Perú eru að veiða meira en þau gerðu árið 1995 en engin nýr stór aðili hefur komið inn á markaðinn.</p> <p>Markaðurinn fyrir ígulker er mjög hefðbundinn þar sem Japan neytir um 80-90% af heildarheimsafllanum. Hjá sumum löndum sem veiða ígulker einkum í Chile, Nýja Sjálandi og á Filipseyjum er hefð innanlands fyrir neyslu. Í Evrópu, er notkun ígulker einnig hefðbundin einkum í Miðjarðarhafslöndunum Ítalíu, Frakklandi og á Spáni. Vegna vaxandi fólksflutninga m.a. innan Evrópu, eru víða hópar fólks sem þekkja ígulker og því geta í ýmsum löndum verið litlir staðbundir markaðir en þess utan þykja ígulker bæði óvenjuleg og spennandi.</p> <p>Líklega er þörf á Japansmarkaði fyrir góð ígulker á réttu verði, sérstaklega í ljósi þess að það er minna framboð inn á markaðinn. Það geta því verið möguleikar fyrir innkomu nýrra aðila á markaðinn t.d. frá NPA svæðinu (Northern Periphery and Arctic areas) að því gefnu að þeir finni hagkvæma flutningsleið til Japans og nái að tryggja stöðugt framboð ígulker af réttum gæðum. Þó verður að hafa það í huga að skilaverð mun ekki verða eins hátt og á Evrópumarkaði (Frakklandi), þar sem flutningskostnaður til Japan er hár, lægri verð fást fyrir innfluttar vörur í samanburði við innlendar og gera þarf ráð fyrir vinnslukostnaði ígulkeru fyrir sölu.</p> <p>Fyrir lönd eins og Ísland, Grænland, Írland og Noreg þá er augljósasti kosturinn að horfa til Frakklandsmarkaðar. Veiðar Frakka eru litlar nú miðað við landanir á tímabilinu 1970-1980 og framboð á ígulkerum frá öðrum löndum t.d. Spáni er lítið. Ísland hefur á undanförunum árum flutt út með góðum árangri ígulker á Frakkland og er nú stærsti birginn á markaðnum. Markaðurinn í Frakklandi er hins vegar lítil eða áætlaður um 350-450 tonn af ígulkerum á ársgrundvelli. Það getur verið þörf fyrir meira magn af ígulkerum á markaðinn á réttu verði þar sem markaðurinn var stærri á árum áður eða um 1.000 tonn.</p> <p>Ítalía getur einnig verið valkostur en fara þarf varlega þar sem stór hluti af ígulkerum á markaðnum á Ítalíu er frá ólöglegum eða óheimiludum veiðum.</p> <p>Það geta einnig verið möguleikar á sölu ígulkeru inn á staðbundna hágæða veitingahúsa markaðinn í Evrópu t.d. í Skandinavíu, Þýskalandi og Englandi. Þótt markaðurinn borgi vel þá er hann á sama skapi erfiður þegar kemur að stöðugri eftirspurn meðan ígulkerin eru af réttum gæðum á vertíð.</p>		
Lykilorð á íslensku:	<i>Markaður, ígulker, framboð og eftirspurn, fersk, frosin ígulkerahrogn,</i>		

<p><i>Summary in English:</i></p>	<p>Worldwide the supply of sea urchins has diminished in the last few years, from the peak landings of about 120 thousand tonnes in 1995 to the current levels of about 75 thousand tonnes. The traditional harvesters such as Japan, Chile, US and to a lesser level, Canada, have all experienced reduced catches. Russia and Peru are supplying larger quantities to the global market than they did in 1995, but no new major entrants have emerged in the last few years.</p> <p>The market for sea urchins is very traditional with Japan consuming about 80-90% of the total current global supply. There is a domestic market in many sea urchins harvesting countries, especially in Chile, New Zealand and the Philippines. In Europe, the market is also traditional and is mainly in the Mediterranean countries, Italy, France and Spain. Sea urchins seem to be novel and trendy and due to growing ethnic populations, small niche markets may exist in various countries, including those in Europe.</p> <p>There is likely an unmet demand on the Japanese market for good quality sea urchin products at the appropriate price, particularly with less current supply to the market. This may indicate options for a new entrant e.g. from the Northern Periphery and Arctic areas, if a logistic route from harvest to market can be economically established and high consistent quality product supplied. However, the value of this product will never be as high as in the European (French) market. This is due to the logistics of getting the product to Japan, the lower value placed on any imported product in this market and the need to add processing costs to product prior to selling in the market.</p> <p>For the NPA countries Iceland, Greenland, Ireland and Norway, supplying to markets such as France is the obvious choice; the production in France is low compared to the relatively high landings in the 1970s and 1980s and supply from other countries e.g. Spain appears small. Iceland has in the past years successfully exported green sea urchins to the French market and is currently the main supplier to the market. The overall French market appears however to be small, or estimated as 350-450 tonnes of whole sea urchins based on harvest and import figures. There may be an unmet demand on the market, assuming an appropriate selling price, as there are indications that the supply to the market has been about 1,000 tonnes in the recent past.</p> <p>There may be options to supply to Italy as well but care must be taken in export as a large part of the current supply in Italy may be from illegal or unlicensed fisheries.</p> <p>There may also be options to supply the apparent emerging high end restaurant niche market in various European countries such as in Scandinavia, Germany and England. Although this market may be lucrative, it is at the same time quite unpredictable when it comes to regular supply during harvest.</p>
<p><i>English keywords:</i></p>	<p><i>Markets, sea urchins, supply and demand, fresh and frozen urchin roe</i></p>

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Executive summary

Worldwide the supply of sea urchins has diminished in the last few years, from the peak landings of about 120 thousand tonnes in 1995 to the current levels of about 75 thousand tonnes. The traditional harvesters such as Japan, Chile, US and to a lesser level, Canada, have all experienced reduced catches. Russia and Peru are supplying larger quantities to the global market than they did in 1995, but no new major entrants have emerged in the last few years.

The market for sea urchins is very traditional with Japan consuming about 80-90% of the total current global supply or about 50,000 tonnes. There is a domestic market in many sea urchin harvesting countries, especially in Chile, New Zealand and the Philippines. In Europe, the market is also traditional and is mainly in continental Europe and in the Mediterranean countries, Italy, France and Spain. The overall market in Europe is not large; estimated by the authors to be about 3,000-3,500 tonnes for whole sea urchins. However, obtaining reliable information on market demand in individual countries, except Japan, proved difficult as little information is published. Additionally, some of the harvest may be illegally obtained and traded with little or no paper trail.

In this report, the key traditional markets for sea urchins are discussed as well as the current suppliers to the market. A special emphasis is placed on the European and, when possible, the NPA (Northern Periphery and Arctic) areas. The predominant EU countries for consuming sea urchin products are Italy, France and Spain. The markets with the greatest potential for establishing more trade are likely France and Italy.

No new emerging markets outside the traditional markets were observed in this study. However, sea urchins seem to be novel and trendy and due to growing ethnic populations, small niche markets may exist in various countries, including those in Europe. Additionally, there may be an emerging niche market for sea urchins or urchin roe in high end restaurants in various European countries. Consumer demand for sea urchins is driven by several key market factors including indulgence, innovation and experimentation, convenience, and health. Consumer demand and behaviour relating to sea urchins and roe consumption is discussed, particularly relating to retail products. Examples of retail products in Asia and the EU that are currently on the market and that fall into these strategic marketing categories and that likely utilise lower quality roe are featured.

There is likely an unmet demand on the Japanese market for good quality sea urchin products at the appropriate price, particularly with less current supply to the market. This may indicate options for a new entrant e.g. from the Northern Periphery and Arctic areas, assuming that a logistic route from harvest to market can be economically established and a high consistent quality product supplied.

However, the value of this product will never be as high as in the European market. This is due to the logistics of getting the product to Japan, the lower value placed on any imported product in this market and the need to add processing costs to the product prior to selling in the market.

For the NPA countries Iceland, Greenland, Ireland and Norway, supplying to markets such as France is the obvious choice; the production in France is low compared to the relatively high landings in the 1970s and 1980s and supply from other countries e.g. Spain appears small. Iceland has in the past years successfully exported green sea urchins to the French market and is currently the main supplier to the market. The overall French market appears however to be small, estimated as 350-450 tonnes of whole urchins based on harvest and import figures. There may be an unmet demand on the market, assuming an appropriate selling price, as there are indications that the supply to the market has been about 1,000 tonnes in the recent past. It is suggested that supply increases into the market be done gradually in order to avoid “boom and bust” price cycles.

There may also be options to supply other traditionally consuming countries with sea urchins such as Italy and Spain. However, care must be taken in exporting to Italy as a large part of the current supply may be from illegal or unlicensed fisheries. The catches in Spain have been relatively constant during the period 2010-2014 at about 500-750 tonnes. As Spain also exports, e.g. to France, it is possible that they are self-sufficient when it comes to sea urchins. Overall on the European market there may be opportunities not only in supplying whole sea urchins, but also in supplying roe e.g. from animals with low gonad yields or damaged urchins, for the variety of traditional dishes consumed, as well as for garnishes, dips, sauces, and pâtés.

There may also be options to supply the apparent emerging high end restaurant niche market in various European countries such as in Scandinavia, Germany and England. Although this market may be lucrative, it is at the same time quite unpredictable when it comes to regular supply during harvest.

1. Introduction

1.1. Introduction to the URCHIN project

The URCHIN project – *Utilisation of the Arctic Sea Urchin Resource* – is funded by the Northern Periphery and Arctic Programme 2014-2020. The project is a co-operation between Nofima (Norway; coordinator), Matís (Iceland), Galway Mayo Institute of Technology (Ireland), Marine Research Institute (Iceland), Arctic Caviar AS (Norway), Thorishólmi (Iceland) and Royal Greenland (Greenland). The project started in 2015 and will be completed in 2018.

The URCHIN project aims to utilise the sea urchin resource present in the Northern Periphery and Arctic (NPA) regions. The challenges of fishing, sustainable and responsible harvesting of stocks, legislation and supply chains for sea urchin products from isolated, peripheral and environmentally harsh and challenging areas in the Northern and Arctic region will be addressed. The challenges will be overcome through innovation and national and transnational technology transfer.

Currently there are small scale (<350 tonnes p.a.) intermittent fisheries for sea urchins in the Northern Periphery Area. This is despite there being enormous sea urchin resources present in the area. For example, in Norway the biomass of green urchin (*Strongylocentrotus droebachiensis*) is estimated to be a massive 80 billion individual animals or about 56,000 tonnes (Gunderson et al., 2010). There are several challenges that have prevented the development and expansion of sea urchin fisheries in the NPA area. These include environmental challenges to fishing, inadequate and inappropriate legislation and fisheries management and lack of technology and knowledge regarding sea ranching and roe enhancement of poor quality urchins. Research to overcome these challenges has been disparate and there has been no previous transfer of knowledge between the NPA partner countries.

The URCHIN project aims to gather the existing expertise from Norway, Iceland, Ireland and Greenland, together with knowledge from Canada to optimise the fishing of high value sea urchins in Northern and Arctic areas. Furthermore, roe enhancement technology from Norway for roe fattening to increase the value of low value sea urchins once they have been harvested in the northern arctic regions will be developed and implemented in Greenland and Iceland. The project will also investigate sea ranching to repopulate areas that have been extensively overfished in the past in Ireland. Issues regarding the provision of adequate legislation and fisheries management will be identified and legislative organisations will be provided with the appropriate knowledge to provide sensible and sustainable management of sea urchin fisheries. The project will also estimate market capacity for sea urchin roe as well as identify logistic routes from the NPA to markets.

1.2. Scope of the report

The objective of this report is to identify the key markets for sea urchin products and potential opportunities for products that are unique from the Northern peripheral and arctic region. In the report, current markets for live sea urchins and roe are described as well as potential new emerging markets. A specific focus is placed on markets in close proximity to the NPA area. This report fulfils Activity 6.1 (deliverable 6.1.1) from the URCHIN project.

2. The Global market

2.1. Introduction

The global market demand for sea urchins at current prices can be estimated at 60,000-70,000 tonnes annually. This is based on the FAO harvest figures for 2014 (76,242 tonnes) and the assumption that not all of the harvested catch can be marketed, e.g. due to small size, damage etc. It should be stressed that obtaining reliable figures on the size of the global market has proven to be difficult and the above figures are the authors' estimation. Further, world harvest volume of sea urchins is difficult to determine because the data made available to the Food and Agriculture Organization (FAO) from producing nations almost certainly underestimates landings, especially prior to the 1980's. The accuracy is further compromised because the production of other echinoderms is sometimes aggregated with the sea urchin data and the FAO cannot readily filter the differences (FAO, 2016). The harvest of sea urchins peaked in 1995 at about 116,367 tonnes suggesting that there may be an unmet world demand for urchins assuming supply at the right price (FAO, 2016; Eckhardt, 2016).

Most of the sea urchins are consumed in traditional markets, the largest and most dominant global market being Japan with about 90% of the world demand. In Japan sea urchins have a traditional role in cuisine and are considered a delicacy served in sushi bars, restaurants and at wedding banquets/parties with a small portion for household consumption (Sun & Chiang, 2015). Urchin roe has been popular in Mediterranean cuisine for centuries, consumed in a variety of ways such as blended into sauces, with pasta, breads or used as an ingredient in various dishes. Sea urchins have also found popularity outside the traditional markets with increasing ethnic populations and the growing popularity of sushi restaurants. In recent years, the high value low volume restaurant trade has had increased interest in sea urchins; although this market is highly lucrative, it may be highly fluctuating in terms of quantity needed. Novel uses of sea urchins have also been reported, e.g. incorporations into a custard or ice-cream (Pols, 2014). In 2016, one of the top ten food trends were sea urchins due to their unique flavour (Nestlé, 2016).

Prices for both live sea urchins and processed sea urchin roe are highly dependent on a number of factors, these include (Ásbjörnsson, 2011; Sun & Chiang, 2015; James et al., 2017):

- Appearance, Colour & Quality
- Species & Region of harvest
- Flavours & Textures
- Demand & Distribution
- Form & Processing

Sea urchin species have various names and translations amongst different European countries (Table 1) and the product can be prepared and sold in markets, restaurants, and for retail in various forms, and under different names.

Table 1. Names for sea urchins. Adapted from (Ásbjörnsson, 2011) **and** (Proville, 2009).

Language	Corresponding name
Danish	Søpindsvin
Norwegian	Kråkebolle
French	Oursins écinides
Faroese	Ígulker
Icelandic	Ígulker, Skollakoppur
Spanish	Erizo de Mar
German	Seeigel
Italian	Ricci di Mare
Portuguese	Ourico do Mar
Greek	Achinos
Greenlandic	Eqqussat

2.2. Market demand

Various types of sea urchins are harvested for their roe globally (Table 2). Green sea urchin (*Strongylocentrotus pulcheriius*), red sea urchin (*Strongylocentrotus franciscanus*), and purple sea urchin (*Strongylocentrotus intermedius*) are the species of highest demand globally. *Pseudocentrotus depressus*, *Heliocidaris crassispina*, and *Strongylocentrotus droebachiensis* are also in good demand but lower grade *Strongylocentrotus* species are generally utilised for value added fermented products (Bledsoe & Rasco, 2006).

Table 2. Distribution of sea urchin species (Williams, 2002).

Common name	Scientific name	Distribution
Edible sea urchin Kina	<i>Anthocidaris crassipina</i>	Japan, Korea, China
	<i>Echinometra spp.</i>	Circumtropical
	<i>Echinus esculentus</i>	North Atlantic
	<i>Evechinus chloroticus</i>	New Zealand
Purple sea urchin	<i>Glyptocidaris crenulatus</i>	China
	<i>Heliocidaris erythrogramma</i>	Australia
Chilean sea urchin	<i>Hemicentrotus pulcherrimus</i>	Japan, Korea, China
	<i>Loxechinus albus</i>	Chile & Peru
Stony sea urchin	<i>Lytechinus variegates</i>	West Atlantic & Caribbean
	<i>Paracentrotus lividus</i>	Atlantic & Mediterranean
	<i>Psammechinus miliaris</i>	Northeast Atlantic
	<i>Pseudocentrotus depressus</i>	Japan, Korea
Green sea urchin	<i>Strongylocentrotus droebachiensis</i>	Circum-polar (north)
Red sea urchin	<i>Strongylocentrotus franciscanus</i>	NE Pacific (Alaska to California)
	<i>Strongylocentrotus intermedius</i>	Japan, Russia, Korea
	<i>Strongylocentrotus nudus</i>	Japan, China
	<i>Strongylocentrotus pallidus</i>	Russia
	<i>Strongylocentrotus polyacanthus</i>	Russia
	<i>Strongylocentrotus purpuratus</i>	NE Pacific (Alaska to California)
Purple sea urchin	<i>Tripneustes gratilla</i>	Circumtropical (all oceans)

Worldwide, the greatest consumption of sea urchins occurs in Japan, France, and Korea, respectively (Liego, 2014-2015). In Europe, France, Italy and Spain are the leaders in terms of sea urchin consumption (Monfort, 2002). There is a large domestic market in many sea urchin producing countries, notably in Chile, New Zealand and the Philippines (Andrew et al., 2002). New Zealand is an interesting case as the domestic demand is greater than the annual supply of about 800 tonnes of sea urchin (*Evechinus chloroticus*) (James et al., 2016). The purple sea urchin species favoured in France, *Paracentrotus lividus*, is harvested from the Atlantic and Mediterranean areas as well as in Ireland. *Sphaerechinus granularis* (purple sea urchin) is mainly harvested in the Netherlands and France. *Psammechinus miliaris* (stony sea urchin) is mainly harvested from the Atlantic coast of France (Monfort, 2002).

2.3. Variation in sea urchin roe quality

The size of the sea urchin roe, the flavours and the texture vary depending on species and time of year (Phillips et al., 2010). *Strongylocentrotus droebachiensis* (green sea urchin) roe are yellow/orange in colour and are described as having a rich, slightly sweet, briny flavour with a lingering aftertaste. This species, also known as *Ezo baifun*, is harvested in Hokkaido, Japan, and it is prized by the locals. *Strongylocentrotus droebachiensis* harvested in Hokkaido have a very sought after flavour profile and this is attributed to the sea urchins diet of the macro algae kombu (Belson, 2013). Compared to the

green sea urchin (*S. droebachiensis*), the purple sea urchin (*Strongylocentrotus intermedius*) is considered nuttier and sweeter in flavour and is found in Japan and California. Murasaki roe, *Strongylocentrotus purpuratus*, is considered the smoothest of sea urchins and is found in the northeast region of the United States as well as Honshu, Japan (Lowry, 2005). It is described as having a sweet taste and mustard yellow colour (Belson, 2013). In Ireland, *Paracentrotus lividus* is known for its orange roe, rich, delicate, and slightly saline flavour (Salter, 2014).

2.4. Global harvest (production) and trade

The global sea urchin harvest in 2014 was approximately 76,242 MT and consisted of live, fresh, chilled, and frozen forms of sea urchins (FAO, 2016). The above figure also contains in some cases harvest of other echinoderms as some countries such as Peru, Korea, Spain and New Zealand aggregate catches of sea urchins with other echinoderms and FAO cannot readily filter the difference. Chile has been the dominant producer of sea urchins although their production has fallen in recent years. The production of urchins in Japan, USA and Canada has remained relatively steady in recent years. Russian production has fluctuated considerably but during the period 2011-2014 their production was higher than that of Japan and USA (Figure 1).

The sea urchin species that are harvested in the greatest quantities are *Loxechinus albus* (*Chilean sea urchin*) and *Strongylocentrotus spp.* In 2001, these two species were 55% and 68% of total landings respectively (Sonu, 2003).

Sea urchins produced by aquaculture (rearing from eggs to market) or roe enhancement (capture of wild adults and increasing the size and quality of the roe) presently account for less than 0.01% of the approximately 75,000 MT of urchins sold every year worldwide (James et al., 2017).

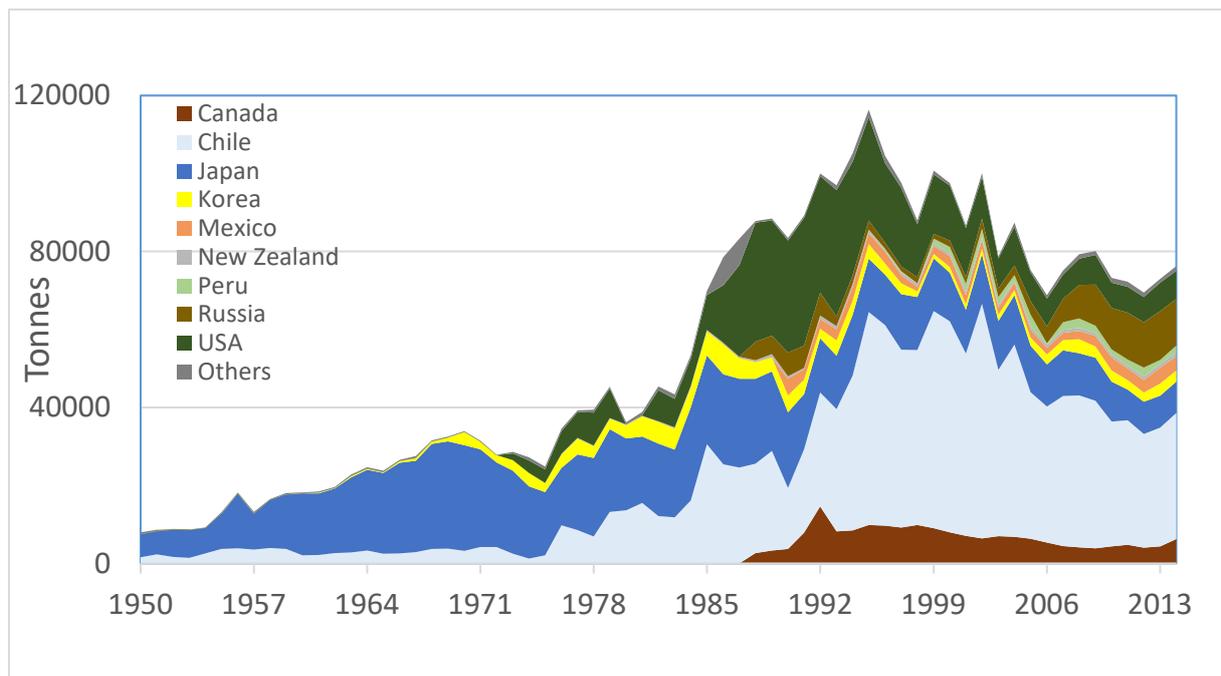


Figure 1. Global landings of sea urchins (FAO, 2016).

2.4.1. Suppliers to global markets

Total landings and harvest numbers associated with global suppliers are merely estimates due to various factors. Some countries may include other echinoderms, such as sea cucumbers, in their reported values. Underreporting or lack of reporting sea urchin harvest numbers is quite common according to global sea urchin status reviews (Sun & Chiang, 2015; Gibson et al., 2002). It is also important to consider that current values as of 2016 or 2017 were difficult to find or were not available. Thus, a lack of comprehensive information regarding global supply and specific countries and trends must all be considered when evaluating supply to markets.

Key supplier volumes and prices are reported mainly prior to 2014 in this report. Thus, supplier rankings may have changed. Information shared is focused on the significant sea urchin market forms which are fresh, chilled sea urchins and live sea urchins. The supplier information not only relates to Japan but other global markets these countries may sell into.

2.4.2. Country rankings

Chilean sea urchins (*Loxechinus albus*) harvest accounts for approximately 50 percent of global landings. Other main global harvesters are Russia, Japan, the United States (Maine, California, Washington), and Canada (mainly British Columbia). The main sea urchin harvested by these suppliers is *Strongylocentrotus* sp. (*S. intermedius*, *S. franciscanus*, and *S. droebachiensis*) (Sun & Chiang, 2015). The key suppliers to Japan between 2004 and 2005 for fresh chilled or frozen roe were Chile, the U.S.,

and Canada with exports of 3,012 tonnes, 1,254 tonnes and 467 tonnes, correspondingly (Figure 2). Significant suppliers of live sea urchins between 2004 and 2005 were Russia, North Korea, the U.S., and Canada with corresponding approximate import to Japan of 10,500 tonnes, 735 tonnes, 432 tonnes, and 157 tonnes (Figure 3) (Anonymous, 2006).

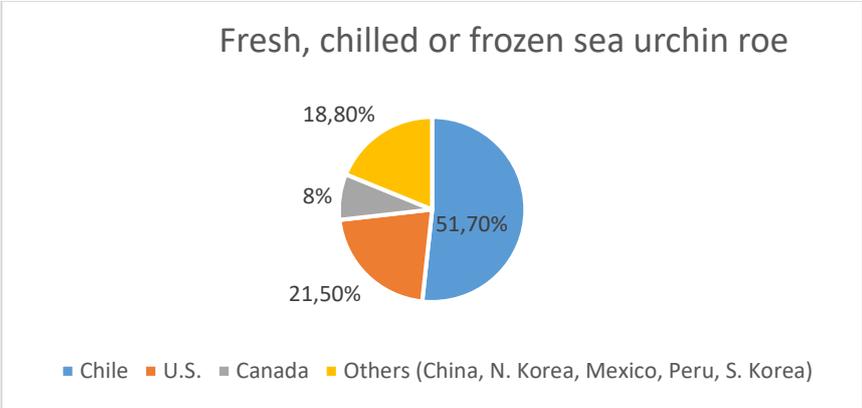


Figure 2. Estimated percentage of product imported into Japan by major suppliers of fresh, chilled or frozen sea urchin roe (adapted from (Anonymous, 2006)).

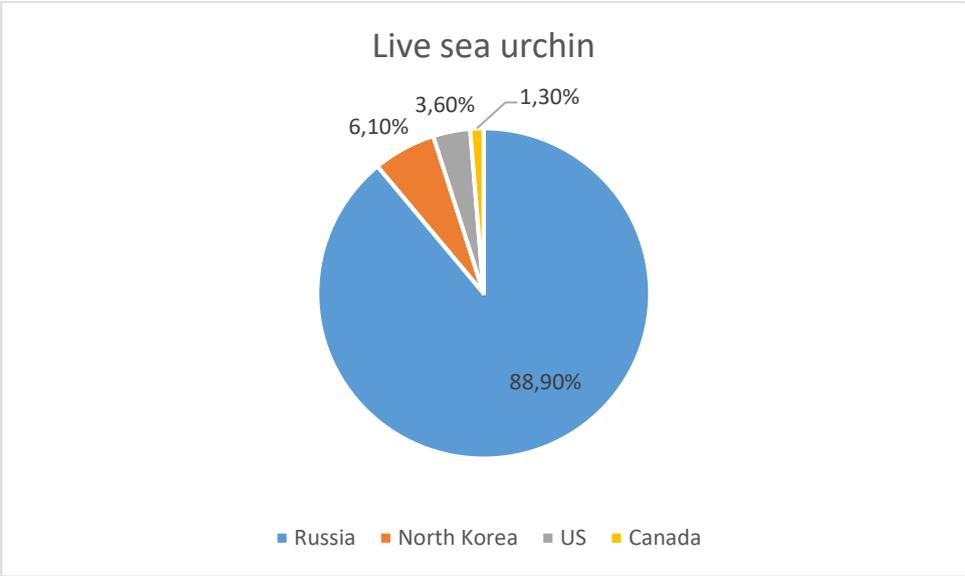


Figure 3. Estimated percentage of product imported into Japan by major suppliers of live sea urchin (adapted from (Anonymous, 2006)).

2.4.3. Chile

There is a long tradition of consuming sea urchin in Chile with an estimated demand for less than 3,000 tonnes annually (Andrew et al., 2002). Chilean sea urchin harvest is though predominantly allocated to the Asian market; however, imports into the U.S. markets have been reported (Moskin, 2009). Chile

is the largest supplier of sea urchins worldwide and the main supplier of frozen urchin roe globally; in 2014 the landings were 32,343 tonnes (FAO, 2016).

Shipping requires several stops until finally reaching Japan, thus frozen sea urchin roe is the best-selling market option for Japan. The frozen roe is also imported into Canada and the U.S. (Sun & Chiang, 2015). Chilean fresh, chilled export in 2004 to Japan was reported by the Canadian Trade Commissioner - Tokyo as 559 metric tonnes (Anonymous, 2006) with the previous years in 2002 and 2003 being 640 and 690 metric tonnes.

2.4.4. United States

The United States is a large global exporter of sea urchins to Japan; however, it is also a significant importer of sea urchins from Canada and Chile (Anonymous, 2006). The total landings of sea urchins in U.S. was 6.691 tonnes in 2014 (FAO, 2016).

The U.S. estimated fresh, chilled roe export to Japan as approximately 930 tonnes in 2004 according to the Canadian Trade Commissioner (Anonymous, 2006). The Pacific coast (California, Washington, and Oregon) exports a significant amount of their red sea urchin harvest, *Strongylocentrotus franciscanus*, to Asia. Maine is a key U.S. supplier of green sea urchin, *S. droebachiensis*. Processed Maine green sea urchins are shipped to New York and then to Japan. A small volume of Maine sea urchins reaching Japan is then exported to other Asian markets such as Taiwan, Hong Kong, China, and Singapore (Sun & Chiang, 2015). In 2014, the Maine harvest was approximately 900 metric tonnes with a market value of 5.4 million USD (4.83 million €) (Anonymous, 2015a). California harvested 13 million pounds, approximately 5.9 million tonnes in 2013, worth 9.8 million USD (8.77 million €) (Anonymous, 2013). United States products are known to be of high quality relative to Japanese domestic product and can demand a higher price. For instance, California product may be sold at ¥12,000 (96.46 €)/ tray relative to average quality pricing of ¥4,000 (32.15 €)/ tray. The U.S. is known to supply Japan with high quality fresh product and the US products compete with Japan's domestic sea urchin supply (Reynolds & Wilen, 2000). For the U.S. to have this type of high quality precedence on the global and Japanese market, there must be significant marketing, consistent quality, and gained buyer loyalty. This all takes time and investment (Anonymous, 2006).

2.4.5. Canada

Eastern Canada lacks sea urchin processing facilities and thus must export all sea urchins, mainly live, to the North East Coast of the U.S. for processing and then for shipment to Japan. The West Coast of Canada is able to process their fresh roe harvest and export to China, Japan, Hong Kong, and Taiwan. The West Coast harvest is approximately 70% of the total Canadian harvest. British Columbia predominantly harvests red sea urchins, while New Brunswick harvests green sea urchins (Sun &

Chiang, 2015). Seventy percent of the Canadian harvests are green sea urchins. It is estimated that Canada supplies Japan with 460 metric tonnes of sea urchins per year (Anonymous, 2006). Canada is the predominant supplier of live sea urchin to the United States (Sun & Chiang, 2015). The total landings of Canadian sea urchins in 2014 were 6,227 tonnes (FAO, 2016).

2.4.6. Russia

Russia is not only considered the largest supplier of live sea urchins to Japan but is also a key global supplier of bulk frozen or processed sea urchin products (Anonymous, 2006). The total landings of sea urchins for the Russian Federation in 2014 were 11,915 tonnes (FAO, 2016). Other countries supplying frozen and processed bulk sea urchin roe are Chile, China, and Korea (Reynolds & Wilen, 2000).

Lack of regulation, illegal practices, and under reported harvest numbers occur globally. In a particular region of Russia, the Kuriles, it is estimated that 10,000 tonnes of sea urchin are harvested each year; however, it is believed that 80% of this catch is illegally obtained or is not reported. In 2000, highly competitive, low cost sea urchin began to infiltrate the market from the Kuriles. In view of the overfishing trends in Russia as well as in Chile there may be an opportunity to introduce lower quality or less known sea urchin sources into the market (Anonymous, 2006).

2.4.7. Korea

In 1999, it was reported that the total catch was approximately 1,500 tonnes. Forty percent of the catch is exported to Japan or other parts of Asia. Women, known as Hae-nyeo or women of the sea caught 90% of the S. Korean catch in 1999. In 2004, total metric tonnes reported for fresh, chilled sea urchins imported into Japan from N. Korea and S. Korea were 136 and 492 metric tonnes, respectively. The total landings of echinoderms for the Republic of Korea in 2014 was 2,839 tonnes (FAO, 2016).

2.4.8. China

Similar to many statistics reported, the China harvest information is underestimated or unclear as other echinoderm catch numbers are reported along with sea urchin harvest values. In 1999, FAO reported 300 tonnes per year. However, for the same year it was reported by Japan Import Statistics that there was an import of 382 tonnes of sea urchin roe from China into Japan (Andrew et al., 2002). In 2014 the landings of sea urchins were reported as 180 tonnes by FAO.

China is considered the fourth largest supplier of fresh, chilled roe to Japan. In 2004, approximately 235 metric tonnes of fresh, chilled sea urchin export was reported by the Canadian Trade Commissioner (Anonymous, 2006).

2.4.9. Mexico and Peru

The total landings of sea urchins in Mexico according to FAO were 3,670 tonnes in 2014. The landings for echinoderms in Peru were 1,869 tonnes (FAO, 2016). Total fresh, chilled sea urchin roe exported from Mexico and Peru to Japan in 2004, were 113 tonnes and 51 tonnes, respectively (Anonymous, 2006).

2.4.10. Australia

South Australia strictly harvests *Heliocidaris erythrogramma*. Other areas of Australia also harvest *Centrostephanus rodgersii* and *Heliocidaris tuberculata* (Anonymous, 2015b). The current demand for Australian sea urchins, particularly from Hong Kong, surpasses the supply that divers can harvest. The amount being sought by buyers is 4 times higher than the amount actually harvestable in one month's time by the divers (Brown, 2014).

Landings of 18-35 tonnes of sea urchins were reported during the period 2004-2006; however, no landings were reported for the last few years (FAO, 2016).

2.4.11. NPA countries

Iceland

Iceland is one of the largest supplier of wild caught sea urchins in Europe based on harvest figures (Figure 4). Having said that, there is a significant unlicensed and illegal fishing carried out in various European countries making harvest difficult to estimate.

In 2015, the catch in Iceland was 276 tonnes and preliminary figures for 2016 are 341 tonnes (Directorate of Fisheries, 2017). The harvest season is from September until April. No fishing is carried out in spring when spawning occurs and during the summer when the gonad yield is low.

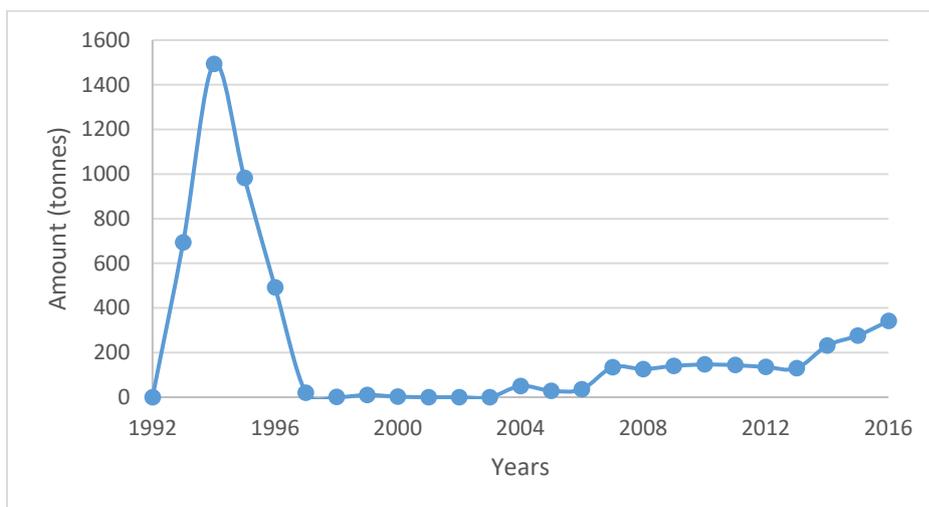


Figure 4. Catches of sea urchin (*Strongylocentrotus droebachiensis*) in Iceland (Directorate of Fisheries, 2017).

Fishery background

The green sea urchin (*Strongylocentrotus droebachiensis*) is commonly found in Iceland; it can be found all around the island except possibly at the south coast. Currently, the fishing area for sea urchins in Iceland is in the inner part of Breidafjörður.

Utilisation of sea urchins in Iceland started in 1983 by divers. Diving was too labour intensive and not economically viable and lasted only for 6 years. Harvesting by dredging started in 1993 with maximum landings in 1994 (approx. 1,500 tonnes) with export mostly to Japan. The Japanese market closed temporarily in 1996 due to an outbreak of *E.coli*. In 1997, only 20 tonnes of sea urchins were harvested and it is likely that the stock in the Breidafjörður area was overfished at that time (James et al., 2016). No or minor landings of sea urchins were reported from 1998 until 2003 when one small company, (Thorisholmi, Stykkisholmur), started harvesting sea urchins. During the period 2004 until 2006, the company established markets for the products and routes to markets, secured their customer base and from 2007 until 2013 harvested about 140 tonnes of sea urchins annually. From 2014 onwards, the catch in Iceland has been increasing, reaching 280 tonnes in 2015 (Directorate of Fisheries, 2017). This amount is just about the maximum catch advised by the MFRI (Marine and Freshwater Research Institute) for the area.

The first assessment of sea urchin resources in the fishing area in Breidafjörður was carried out in 2015. The whole area investigated was 9.7 km², but urchins of good quality, meaning high gonad content, were only observed in 37% of that area. In 63% of the fishing grounds in the Breidafjörður area, the sea urchins are either too small or containing an economically unviable level of roe content (6-8%) which prevents these areas from being harvested. It is estimated that around 120 tonnes of sea urchins could be harvested in these areas annually (Thorarinsdóttir, 2017) and they may provide an ideal opportunity for roe enhancement in Iceland.

The harvest of the green urchin in the Eyjafjörður area to the north has also been considered; however, it was concluded that the area is not likely to be economically viable as the gonad yield of the urchins only reached the 10% limit during a short duration of the year (Ásbjörnsson, 2011).

Markets and routes to market

There is no tradition in consuming sea urchin roe in Iceland and the domestic market is negligible. All the harvest of urchins is therefore exported. On average, 110 tonnes of live whole chilled sea urchins were exported per annum during the period 2010 to 2015 (Table 3). In 2015, 116 tonnes of live sea urchins were exported with the value of 809,704 €. The routes to European markets are relatively simple from Iceland with daily flights to many of the larger cities.

Table 3. Export volumes of whole, chilled urchin (Statistics Iceland, 2016).

YEAR	Amount (kg)	Value (€)	€/kg
2001	0		
2006	495	1.922	3,9
2010	106.109	670.661	6,3
2011	112.535	702.068	6,2
2012	106.716	711.544	6,7
2013	101.752	681.519	6,7
2014	117.330	743.002	6,3
2015	116.047	809.704	7,0

The value of Icelandic live, whole, sea urchins has been increasing, with a reported attained market value of 7€/ kg in 2015. The French market accounted for 96% of the total Icelandic sea urchins harvest in 2015 (Table 4). Other markets of interest for the Icelandic live sea urchins have been UK, Spain, Belgium, The Netherlands and Switzerland (Statistics Iceland, 2016).

Table 4. Live, or fresh sea urchins exports from Iceland by country in 2015 (Statistics Iceland, 2016).

Country	Amount (kg)	Value (€)	€/kg
France	110.849	771.642	7,0
Spain	3.000	23.869	8,0
Belgium	750	5.077	6,8
Holland	306	2.631	8,6
Denmark	466	2.349	5,0
Sweden	278	1.853	6,7
Norway	227	1.195	5,3
Switzerland	87	533	6,1
Finland	21	215	10,2
USA	18	148	8,2
Germany	21	121	5,7
China	24	71	2,9
	116.047	809.704	7,0

Products, processed sea urchins and value added products

Export totals for processed sea urchins (chilled or frozen roe) was 5,220 kg in 2015 with a total value of 180,000€ and an attained market value of 34.5€/ kg (Table 5). The export of frozen roe to France started in 2014 and has remained relatively steady from that year.

Some of the exported frozen sea urchin roe, also known as coral is used in tarama production and to a smaller extent for sauces; some of the products are repacked into jars and sold on the French retail market.

Table 5. Sea urchin roe, chilled and frozen exports from Iceland (Statistics Iceland, 2016).

YEAR	Amount (kg)	Value (€)	€/kg
2012	0	0	0,0
2013	10	10	1,0
2014	3.894	131.765	33,8
2015	5.220	180.004	34,5
2016	4.842	164.989	34,1

Opportunities and industry barriers

Iceland in the 1990s experienced a “boom and bust” cycle in the harvest of sea urchin; many small companies experienced difficulties or went into bankruptcy at that time. Since then the approach has been more cautionary; one company, Thorisholmi, has built up expertise in the harvesting of sea urchins and has found areas where long term harvest of good quality urchins can be carried out. Additionally, by taking small steps in finding markets, securing customers and establishing routes to market, the company has set up an economical business in the export of live sea urchins from Iceland. Currently the company has found markets for frozen roe and is expanding its operation and turnover.

The success of Thorisholmi is likely to attract interest and attention by other fishing operators in Iceland. The fishing area with sea urchins of high gonad yield in the Breidafjordur area is however at its exploitation limit. Any increase in export of sea urchins or urchin roe from Iceland can therefore only be achieved through finding new urchins fishing areas with high gonad yield, or by roe enhancement using sea urchins from barren areas. The partners within the URCHIN project have met with the Icelandic Ministry of Fisheries and recommended that the number of fishing licences be limited for the Breidafjardar area and suggested that pioneers in sustainable use of the sea urchin resource be granted some exclusivity to prevent overfishing and to ensure long-term economic exploitation of the resource.

Norway

Although there are several species of urchins found in Norway, the only species that is found in commercial size and quantities is the green sea urchin, *Strongylocentrotus droebachiensis*. There is no tradition of consuming sea urchins in Norway. As a result there is a very limited domestic market for sea urchin roe and a very limited history of fishing and exporting of sea urchins.

Fishery background

Currently, sea urchin fishing in Norway is still sporadic and intermittent despite the lucrative value of sea urchin roe on both domestic and export markets and the enormous estimated biomass of *S. droebachiensis* (estimated at a massive 80 billion individual animals, or 56,000 tonnes) (Gunderson et al., 2010). The total annual catch has been sporadic (between 10-100 tonnes annually) and the current annual harvest is less than 10 tonnes with the one long term fishing company (Arctic Caviar AS) being

the only company to consistently fish urchins for over a decade and a small number of other companies harvesting sea urchins. Considerable efforts have been made in the past to develop a hatchery production of the Norwegian green sea urchin as well as developing commercial scale roe enhancement, these are described in the Nofima Internal Report 7/2017 published in April 2017 (James et al., 2017).

Markets and routes to market

Currently there are no processed or value added urchin products on the market from Norway.

Sea urchins harvested in Norway have virtually all been sent into the European market, mostly to small exclusive end users such as high end restaurants in Scandinavia, Germany and France. The routes to European markets are relatively simple from Norway with good flight connections throughout. The route to Asian markets such as Japan is more difficult. A recent trial shipment of live sea urchins from Tromsø in Norway took 39 hours to reach the processor in northern Japan. The urchins were alive and well on arrival but this is likely to be close to the limit of live transport (James et al., 2017). The roe from these urchins was sold in the Tsukiji market for 1,000 to 2,000 ¥/ 100 g of roe, equating to 10.5 NOK (1.2€) / individual sea urchin or 30€/kg (James et al., 2017). This was the first attempt to send Norwegian enhanced sea urchins into Japan so the results of the trial (in terms of market value) should be treated with caution (James et al., 2017).

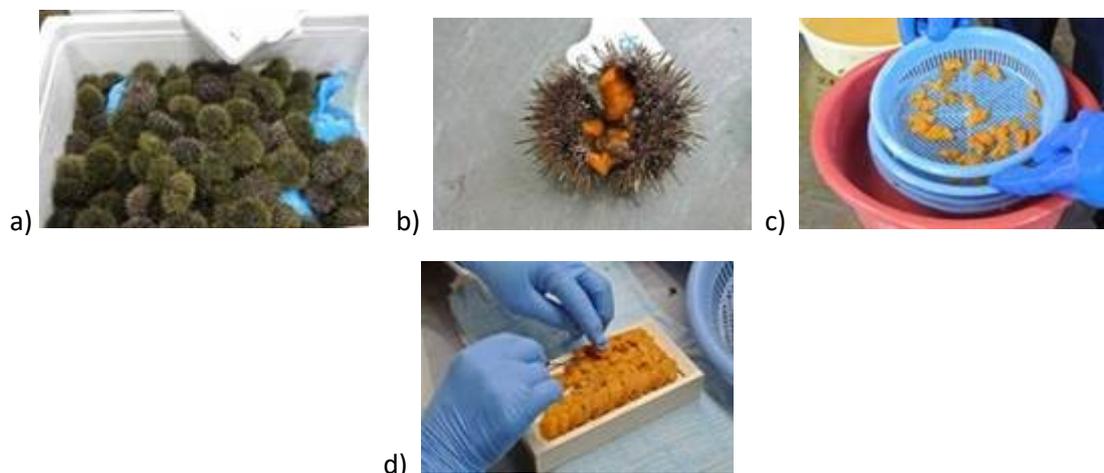


Figure 5. Green sea urchins from Norwegian enhancement trial a) opening b) and c) processed and d) packing in trays at Tsukiji market (James et al., 2017).

Opportunities and industry barriers

There have been a number of barriers that have stopped the development of a sea urchins fishery in Norway in the past. These barriers include the following: the lack of a traditional fishery for sea urchins, little expertise in fishing benthic invertebrates, SCUBA diving (the traditional method of collecting sea urchins) being expensive and logistically challenging, the challenging environmental conditions,

(particularly in winter) and the logistics of sending urchins from remote locations. Additionally, despite the large biomass of sea urchins in Norway, many of them are found at very high densities and these sea urchins have little roe content and subsequently no commercial value.

Ireland

Ireland has two species of sea urchins that have a commercial value, *Psammechinus miliaris* and *Paracentrotus lividus*. The latter is the only species that is commercially harvested. Fishing and harvesting is conducted by divers using SCUBA and harvesting can take place in the intertidal zone where conditions suit (Heffernan, 1999).

Paracentrotus lividus, the European edible purple sea urchin, inhabits the rocky intertidal zone and can be found to a maximum depth of water of 20 meters (Heffernan, 1999). This species of sea urchin is prized on European markets for its roe and has been extensively harvested throughout its geographical range from the Mediterranean and western Atlantic coasts of Europe (Lawrence & Lawrence 2014; Cook et al., 2007). The species has a distinct harvest season which in Ireland is from October until April; later harvest is possible; however operators run the risk of the sea urchins spawning during transport to market (James et al., 2016).

Fishery background and legislation

The purple sea urchin fishery in Ireland occurred from the 1970s up to and including the mid-1990s, and the fishery collapse which followed occurred during the mid-1990s. The significant scale of the fishery peaked in 1976 at 350 metric tonnes, however 400 - 500 metric tonnes have been reported in exports, but rapidly declined in the years following due to overfishing resulting in minimal harvests.

Irish production started to drop in 1991 from over 100 tonnes to 5 tonnes in 1996 and since then Irish production has remained stagnant. In the last few years (2010-2014), FAO reports no landings of sea urchins (FAO, 2016). Currently the low volume that is harvested is mainly sold to the niche restaurant trade both domestically and for export.

Official FAO statistics (FAO, 2016) for Irish sea urchin production make sobering reading, significant overall decrease in production since the 1990s, with only a very slight upturn in production in 2001 compared to 2000. What is important to note, however, is that in the 1970s Irish sea urchin landings were in the region of 500 tonnes per annum. It cannot be stressed enough how vulnerable the species is to overfishing and exploitation when you take the experience of the Irish fishery into account (Watson & Stokes, 2004).

Markets and routes to market

Currently there are no processed or value added urchin products on the market from Ireland.

The main market for sea urchins harvested in Ireland has always been the French and European market, with the traditional routes of airfreight and road being used to ship the sea urchins. Watson and Stokes, 2004, found that the price of air freight with Aer Lingus during the 1980s was dependent on the amount of sea urchins in the hold. The extensive amount of sea urchins harvest in Ireland during the boom years were all absorbed by the French seafood markets. In Boulogne-Sur-Mer and Rungis in Paris, the market acceptance of Irish sea urchins is very high and routes to markets are well defined.

Opportunities and industry barriers

As a part of the Blue Growth strategy, aquaculture is identified as a profitable option for sustainable sea urchin production. Ireland’s National Strategic plan for sustainable aquaculture development (Table 7) reported that there are competitive advantages in researching and developing the culture of commercially important sea urchins. Implementation of aquaculture techniques and methods while establishing clear markets entry points will be key.

Table 7. Potential competitive advantages in producing the species in Ireland such as range extension outlook of Irish novel, luxury species including urchins (DAFM, 2015).

Competitive advantage	Species	Strength	Opportunity	Threat
Range extension	Abalone, sea urchins, bivalves, seaweed for human consumption.	Some Irish seafood companies are becoming highly efficient and achieving critical scale to be major suppliers to international buying centres in Europe but also internationally.	Being in daily contact with the most important international buyers it is relatively feasible for these companies to extend product range to include novel species in the spirit of coopepetition.	It would be crucial to secure consistently high quality from small dispersed producers of novel species in order for coopepetition to work.

The output of juvenile production of *P. lividus* since 2010 has been in excess of 1.5 million saleable seed sea urchins from one sole company (Dunmanus Seafoods Ltd.). One main species of sea urchin (*P. lividus*) has been researched for aquaculture production since the early 1990s where the majority of information on production for the European industry has been developed in Ireland (Hannon et al., 2014). With increased demand for juveniles from farms for on-growing at economic selling prices, the improvement of aquaculture techniques is the main focus of the current production in Ireland which is leading Europe’s aquaculture production of sea urchins. Commercial scale on-growing at sea or in land based operations will be the core of growth as an economically viable scale needs to be reached for the industry to be developed to build critical mass. Appropriate licensing arrangements need to be established in Ireland for the development of the industry, as of now this is the biggest industry barrier to full viable commercial production. Dunmanus Seafoods Ltd. has been a European leader in the production of sea urchin on a commercial scale and the world’s longest running commercial hatchery for sea urchins (DAFM, 2015).

3. Sea urchin markets by countries

The following section describes the sea urchin markets in individual countries. These can be divided into Asian and European markets. In the discussion on Europe, a section is included on Northern Periphery and Arctic (NPA) countries.

3.1. Asia

3.1.1. Japanese market

Japan dominates the world sea urchin market, consuming approximately 80-90% of global supply (Sun & Chiang, 2015). The domestic market has been estimated as about 50,000 metric tonnes where about 8,000-10,000 metric tonnes are landed domestically and the rest imported (Figure 6). Not only is Japan the epi-centre of global sea urchin demand, but it is also a predominant influencer of sea urchin consumption. Sea urchin roe is a premium food in Japan where it is eaten raw as sashimi, served with rice as sushi or preserved in bottles mixed with brine or alcohol and salt (Andrew et al., 2002). Sea urchins are highly sought after for sushi and Japanese sushi bars have been reported to sell sea urchins (domestically known as uni) for over 50 USD (44.65 €)/ kg (this is only for the highest quality sea urchin roe from the best producing areas in Japan). Sushi trains in Japan are increasing demand for roe dishes (Sun & Chiang, 2015). In Japan, the highest grade of urchin roe possesses a yellow-orange colour with a “custard” texture and a distinct roe flavour that does not have an alum taste from processing. Among the traditional ways of serving roe are as part of sushi dishes, boiling in seawater, baking, and as an ingredient in a variety of soups (Sun & Chiang, 2015).

Fishery background

There are over 100 species of sea urchin in Japan, of which six are harvested for human consumption. The species most harvested are *Strongylocentrotus nudus* and *S. intermedius* harvested in the northern regions of Japan. *Strongylocentrotus nudus* is the most commonly harvested sea urchin in Japan and may account for up to 40-45% of the total commercial harvest (Anonymous, 2006). The other species include *Strongylocentrotus pulcherrimus*, *Anthocidaris crassispina*, *Pseudocentrotus depressus*, and *Tripneustes gratilla* (Sonu, 2003).

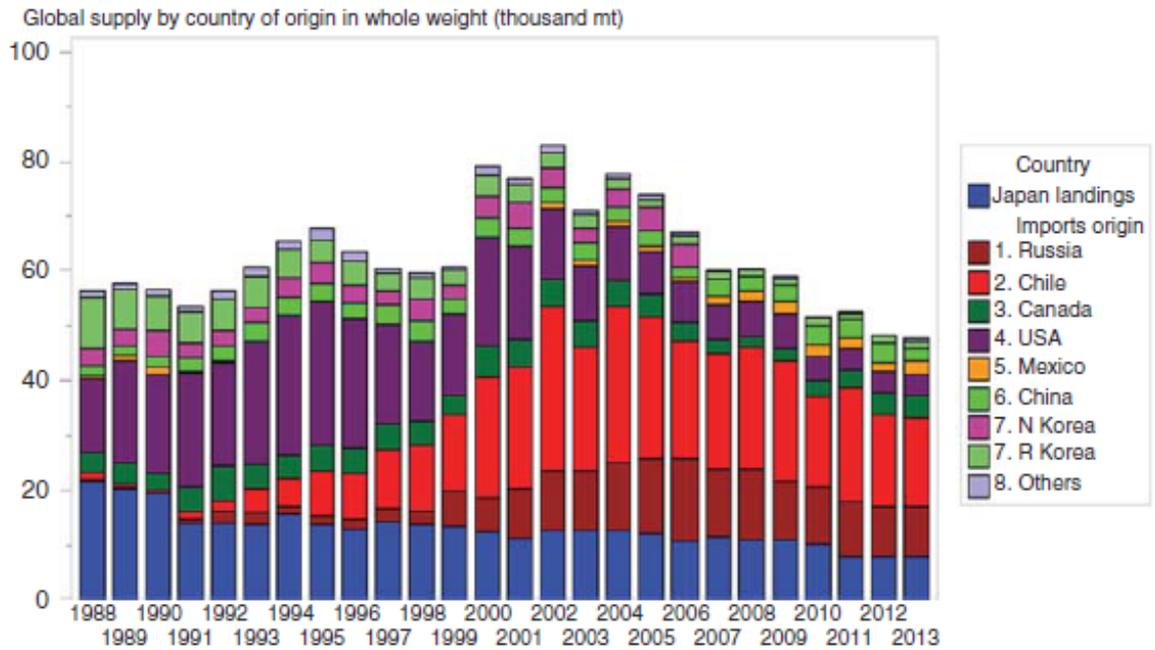
Japan was considered the largest global harvester of sea urchins until the 1980s. From the 1980s landings have decreased rapidly and were only recorded as 8,053 tonnes in 2014 (FAO, 2016). Due to high demand and a decrease in the Japanese sea urchin supply, the United States became the largest supplier to Japan. In the late 1980s to 1994, Maine, USA was the largest sea urchin (*S. droebachiensis*) supplier to Japan. Following the decline of sea urchin supply in the USA (both from the Pacific coast (*S. franciscanus*) and Maine), Japan has relied on imports from various countries such as Russia and Chile.

Japan customs report an estimated demand of approximately 50,000 metric tonnes (whole weight) per year. This volume is worth approximately 300 million USD (267 million €) (Sun & Chiang, 2015).

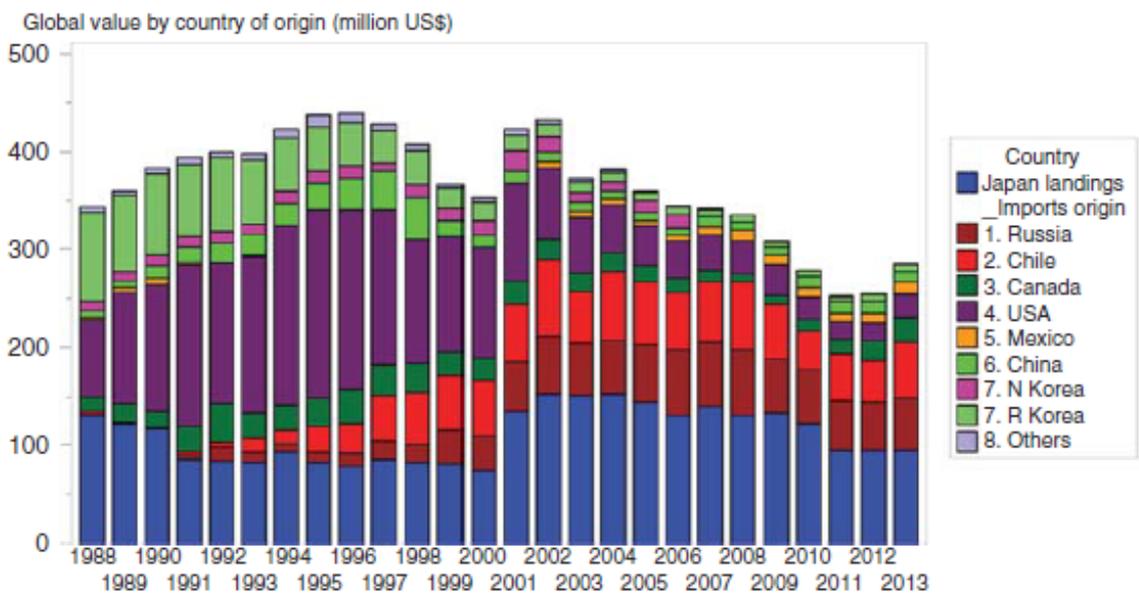
Sea urchin imports into Japan

As is the case in many countries around the world, urchins caught locally have the highest market value. Even within Japan, there are significant differences in quality and price with approximately half of Japan's domestic volume of sea urchins being harvested from the Island of Hokkaido where quality is considered to be very high. However, because demand always outstrips production from the domestic fishery, imported sea urchins are in significant demand in Japanese markets, particularly when sea urchins are out of season (Frost and Sullivan, 2015). The off-season for harvesting urchins in Japan ranges from spring to autumn. During this period the key suppliers to the main Japanese markets are Russia, Chile, Canada, and the United States as well as Mexico, China, North and South Korea (Anonymous, 2006).

Russian sea urchins, *S. intermedius*, are the most similar in roe quality to roe found in the Hokkaido and Sanriku regions of Japan, thus commanding a higher price relative to other global sea urchin suppliers such as Chile and Canada. Russia is a significant supplier of sea urchins to Japan in the off season. The USA (Boston) sea urchin *S. droebachiensis* demands the second highest market price due to its sought after colour of yellow/ orange and taste. Canadian red sea urchins (*S. franciscanus*) and green sea urchins (*S. droebachiensis*), are darker and more brown in colour, thus commanding a lower price. There has been an increase in availability of Chilean sea urchins (*Loxechinus albus*) on Japanese markets, however they command a relatively low price (CAD 2.50 (1.66€)/ kg) while Canadian, Russian, and Japanese sea urchins sell for CAD 25-55 (16.62-36.55 €)/ Kg, CAD 100 (66.46 €)/ kg, and CAD 300-400 (200-265 €)/ kg, respectively (Anonymous, 2016a).



(a)



(b)

Figure 6. a) Total Japan supply of sea urchins (whole weight) by country of origin. b) Global value of sea urchins in Japan by country of origin, from Japan Customs (Sun & Chiang, 2015).

Market opportunities and routes to market

Sea urchin value for the Japanese consumer equates to premium quality at the lowest price possible and domestic product is considered superior. For global suppliers trying to get into the Japanese market, there are standards to compete with including zero-defects and portioned products (Anonymous, 2006).

Product types

Japanese sea urchin products come in various forms (Figure 7).

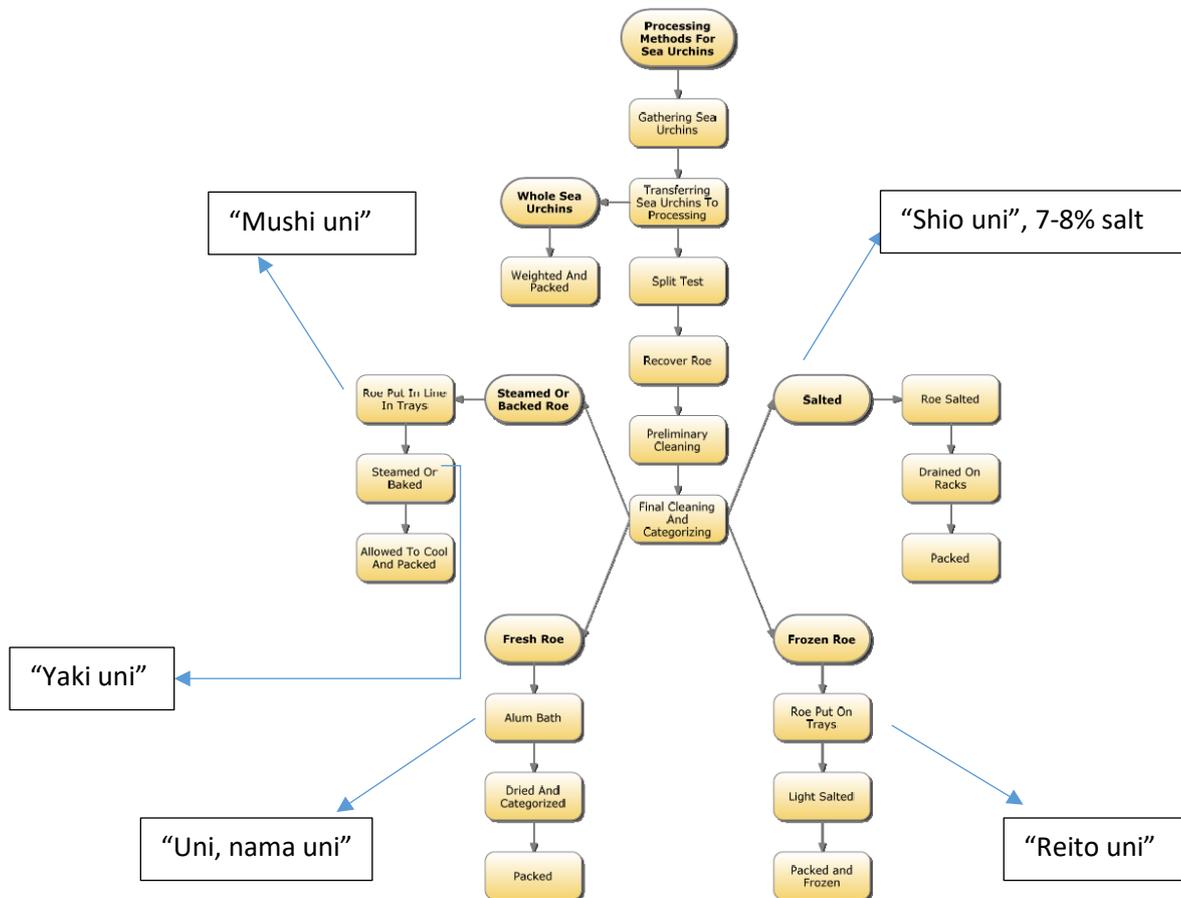


Figure 7. Japanese descriptions for sea urchin and urchin roe products. Adapted from (Ásbjörnsson, 2011).

Live sea urchins are the most sought after in Japan. An average import of 20,000 metric tonnes was reported in 2013, worth approximately 175 (155 €) million USD (Figures 8 and 9). The import of live sea urchins into the Japanese market accounts for approximately 65-70% of all sea urchin imports (including processed sea urchins), followed by fresh and chilled, frozen, and lastly, dried, salted or brined product (Sun & Chiang, 2015) (Figures 8 and 9). The live sea urchins are processed by domestic companies which are trusted by buyers in Japan due to their quality control and good reputation for premium products (Anonymous, 2006).

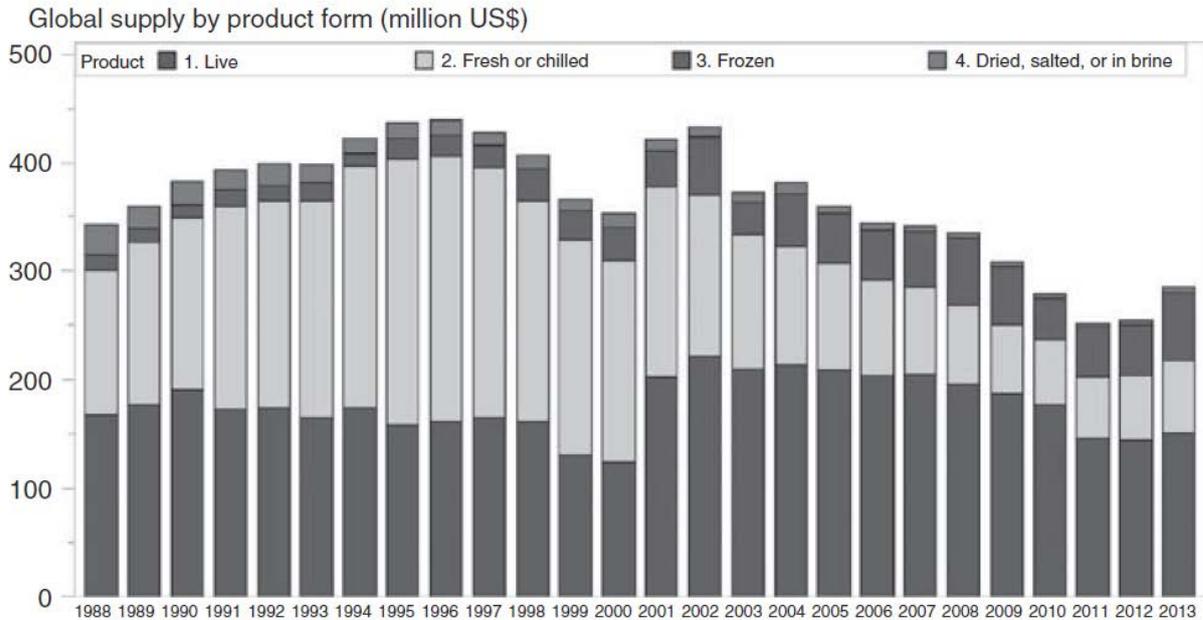


Figure 8. Japan sea urchins import value by product, based on whole animal weight and assuming approximately 10% yield factor from Japan Customs (Sun & Chiang, 2015).

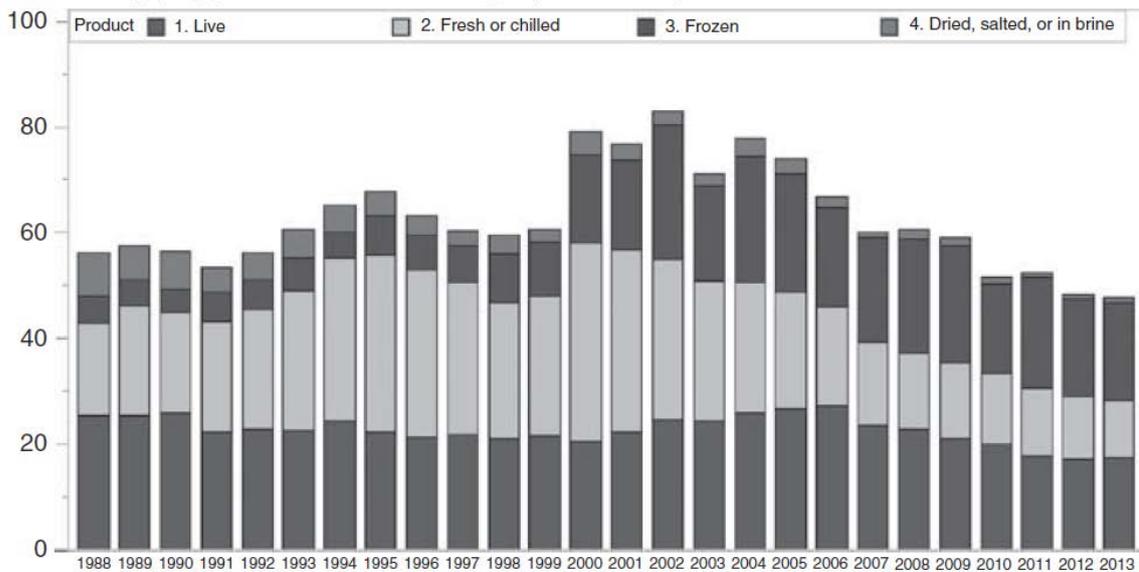


Figure 9. Japan sea urchins imports volumes according to product form, based on whole animal weight and assuming approximately 10% yield factor from Japan Customs (Sun & Chiang, 2015).

Fresh or chilled roe sells for approximately two-thirds of the price of live urchins (Sun & Chiang, 2015). Fresh, high quality grade roe imported into Japan will bring the most value on the market as live sea urchins from global markets may not easily compete with live domestic products. The delicate roe must be treated with the utmost care but still the shelf-life of the product is only a few days in a chiller. Sushi shops buy a majority of the roe, displaying the product in chilled cabinets. The roe is presented in traditional, wooden trays. Appearance is a critical aspect of roe quality and to safeguard the

aesthetics in presentation, the whole roe is always placed on top of the damaged or broken pieces (Anonymous, 2006).



Figure 10. Packed tray of roe and bulk pack (to the right) of red sea urchin (Anonymous, 2006).

Frozen Roe. Freezing is an acceptable method for keeping the processed roe. The freezing increases the shelf-life assuming appropriate freezing method and storage facilities but at the same time the ice crystals formed during the freezing affect the quality of the roe. On thawing, a drip loss occurs and the roe has lost its firmness. The frozen roe usually sells at about 25-50% of the value of fresh roe (Anonymous, 2006). Frozen shipments of processed sea urchin roe predominantly come from Chile (*L. albus*) and freezing is the common practice in Chile because of the distance involved. Canada and other countries will freeze roe when supply is in excess of demand (Anonymous, 2006). Frozen sea urchin products are mainly designated for retail sales while a small portion is allocated to restaurants.



Figure 11. Frozen and vacuum packed roe from Chile (Anonymous, 2006).

Processed roe. The least profitable category due to less demand is dried, salted, and brined sea urchin product. The dried, salted and brined sea urchin product is created from an accumulation of various sea urchins that are of low quality or yield as well as by-products (Sun & Chiang, 2015). Fermented sea

urchin roe paste is a product that can be created from lower quality product and is known in Asia as neri uni and tsubi uni. A waterier product is called mizu uni and it is prepared by adding salt, 30-40%, and is “dry cured”. Doro uni is another preparation and it is made by first adding alcohol to the roe following by draining and addition of salt (25-30%) (Bledsoe & Rasco, 2006).

Pricing and market

Pricing is highly influenced by product category, species of sea urchin, as well as country of origin. Cumulative data from Japan Customs and FAO in 2013, based on whole animal weight and 10% yield factor, indicated that market prices for sea urchin live, fresh or chilled, frozen, and dried /salted/ or brined were 8-9 USD (7-8 €)/ kg, 6 USD (5.3 €)/ kg, 3 USD (2.68€) / kg, and 4 USD (3.57 €)/ kg, correspondingly (Figure 12).

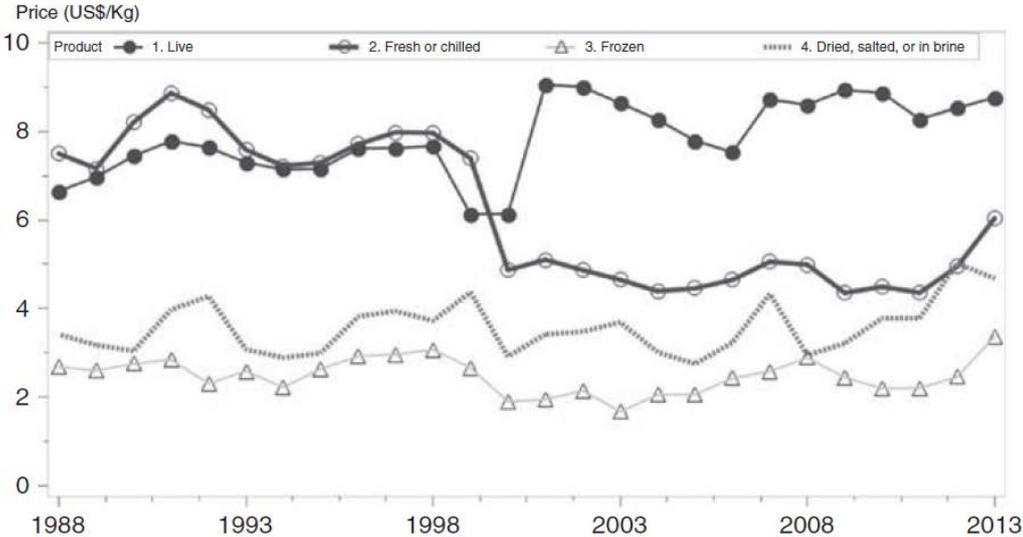


Figure 12. Prices in Japan by product, based on whole animal weight and assuming approximately 10% yield factor, FAO and Japan Customs (Sun & Chiang, 2015).

The largest Japanese seafood and sea urchin market is the Tsukiji market, supervised by the Tokyo Metropolitan Central Wholesale Market (Figure 13). This is also the largest sea urchin market in the world (Belson, 2013). Because of its size and importance in Japan, the daily auction of sea urchin roe sets the daily price for most sea urchin roe sold in the various markets throughout Japan.



Figure 13. Processed sea urchin roe being inspected prior to the morning auction at Tsukiji (left) and sea urchin roe packaged for sale at Tsukiji (right)(Images courtesy of Dr. Philip James).

There is a significant difference in demand and price amongst different species of sea urchin roe as shown in Table 8. Domestic large white and red sea urchins command the highest price, ranging from 248 USD (221 €/KG) for large white sea urchin and 177 USD (157 €/)KG for large red urchin. In 2013, the Tsukiji market value for grade AA green sea urchin roe, *S. droebachiensis*, was approximately 67 USD (60 €/) kg (Royal Greenland, 2016).

Table 8. Tokyo Metropolitan Central Fish Market Daily Prices, 12.2.2014 (Royal Greenland, 2016).

Tokyo Metropolitan Central Fish Market Daily Prices – Tuesday 02/12-2014					
Origin	Name Size	Supply tonnes	Minimum JPY / DKK	Maximum JPY / DKK	Average JPY / DKK
Japan	Red Large 300g	308	3200 / 161,51	20000 / 1009,43	6200 / 312,92
Japan	Red Medium 150g	103	2000 / 100,94	4200 / 211,98	2700 / 136,27
Japan	White Large 300g	20	24000 / 1211,32	42000 / 2119,81	28000 / 1413,20
US West Coast	Large 300g	72	2800 / 141,32	3500 / 176,65	3200 / 161,51
US East Coast	100g Pack	216	800 / 40,37	1200 / 60,57	1000 / 50,47

Green Sea Urchin er billigst på Tsukiji-markedet – JPY 1000 pr. 100g (DKK 50,33)
AA kvalitet 2013 avrg pris: US \$ 67,33 / DKK 402,88
Frossen rogn avrg pris: US \$ 37,15 / DKK 222,30
Levende sopindsvin avrg pris: US \$ 6,31 / DKK 37,75
Estimeret indhandlingspris pr. kg: DKK 6,36

Table 9. Japan import statistics. (2010-2014). (1) North sea urchin, Chile sea urchin, Red sea urchin, Green sea urchin, etc. (2) Other species of sea urchin (Ziemer, 2015).

Unit: Mt, JPY/kg(CIF)	2010			2011			2012			2013			2014		
	QTY	UNIT PX	TOTAL PX												
	Mt.	JPY/kg(CIF)	JPY												
FRESH CHINA ①	292	3.677	1,073,684	313	3.605	1,128,365	180	4.526	814,680	128	5.651	723,328	163	6.415	1,045,645
FRESH CANADA ①	244	4.883	1,191,452	297	4.844	1,438,668	278	5.304	1,474,512	280	6.533	1,829,240	306	7.433	2,274,498
FRESH USA ①	410	5.348	2,192,680	460	4.925	2,265,500	262	5.390	1,412,180	288	6.563	1,890,144	207	7.626	1,578,582
FRESH CHILE ①	136	3.449	469,064	95	3.642	345,990	73	3.986	290,978	49	5.504	269,696	32	5.414	173,248
FRESH KOREA ②	20	5.688	113,760	21	5.251	110,271	30	5.042	151,260	13	6.722	87,386	10	7.835	78,350
FRESH ① TOTAL	1,341	4.633	6,212,853	1,299	4.490	5,832,510	872	5.106	4,452,432	829	6.251	5,182,079	770	7.041	5,421,570
FROZEN CHILE ①	1,517	2.367	3,590,739	1,992	2.286	4,553,712	1,585	2.578	4,086,130	1,578	3.601	5,682,378	1,698	4.041	6,861,618
FROZEN OTHER ①	170	2.267	385,390	100	2.277	227,700	54	2.526	136,404	92	3.497	321,724	122	3.893	474,946
FROZEN ① TOTAL	1,687	2.267	3,824,429	2,092	2.277	4,763,484	1,639	2.526	4,140,114	1,670	3.497	5,839,990	1,820	3.893	7,085,260
FROZEN ② TOTAL							210	2.594	544,740	168	3.255	546,840	208	3.445	716,560
FRESH RUSSIA (Shell on)①	9,555	568	5,427,240	9,524	538	5,123,912	9,002	569	5,122,138	9,054	611	5,531,994	8,098	703	5,692,894
FRESH CANADA (Shell on)①	95	989	93,955	74	938	69,412	32	1,054	33,728	76	1,180	89,680	97	1,383	134,151
FRESH USA (Shell on)②	79	814	64,306	49	825	40,425	53	662	35,086	80	788	63,040	44	940	41,360
FRESH ① TOTAL (Shell on)	9,739	575	5,599,925	9,734	542	5,275,828	9,042	570	5,153,940	9,217	618	5,696,106	8,230	714	5,876,220

One of the players in the Japanese sea urchin market is Maruki Co. Ltd, importing approximately 300-400 tonnes/year of live sea urchins from various major commercial fisheries, including South America (Chile), Russia, USA, Canada, and China (Royal Greenland, 2016). In 2014, the major supplier of whole, live sea urchins was Russia while Canada provided the majority of fresh, processed sea urchin roe (Table 9). Chile has dominated the total Japanese import market for frozen roe products, as shown in Table 9 and Figure 14, as well as the dried, salted, or brined category (Sun & Chiang, 2015).

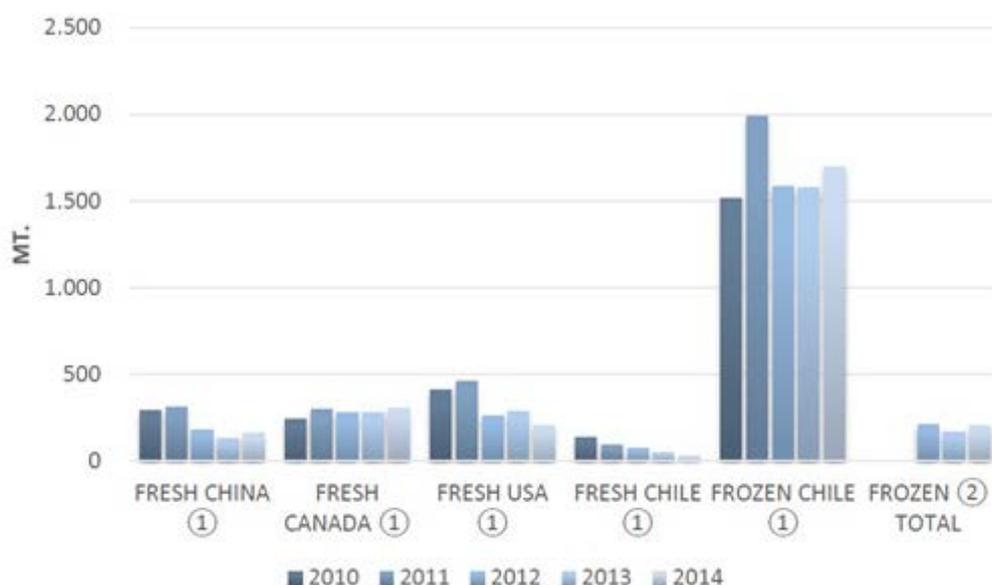


Figure 14. Established Japanese import market (metric tonnes) for sea urchin roe (2010-2014) (1) North Sea, Chile, Red Sea, Green Sea Urchin, etc. (2) Other kinds of Sea Urchin (Ziemer, 2015).

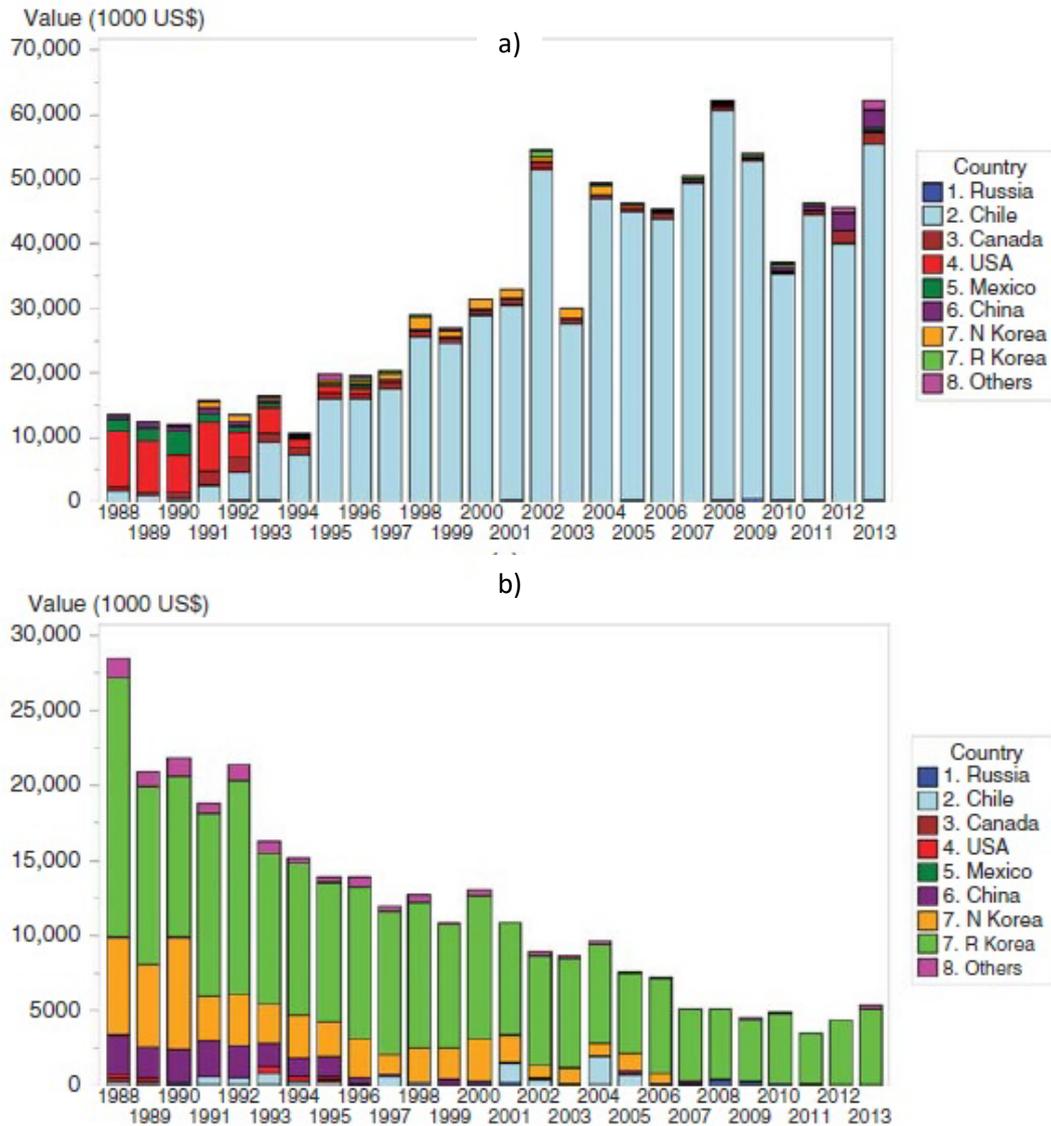


Figure 15. Total value of a) Japanese imports of frozen sea urchin roe by country of origin and b) Japanese imports of dried/salted/brined sea urchin roe by country of origin (Sun & Chiang, 2015).

The total value of imported frozen sea urchin roe has increased considerably in the last few years as shown in Figure 15 although the quantity has remained relatively stable. The total import value of processed roe has however decreased steadily from 1988 (Fig 15b).

Japanese buyers and wholesalers of roe in the Tsujiki market consider various factors including colour, size of roe, texture, presentation, season, origin, and quality. Sea urchins are sold into luxury supermarkets and department stores commonly in 120 to 150 g trays. Marketing flow and distribution of sea urchin into the Japanese market is shown in Figure 16.

Lower grades of sea urchin roe are brown in colour and bitter in taste. High quality urchin roe ranges in colour from vibrant orange to yellow and has a delicate ocean flavour. Product presentation can

serve as an efficient and powerful way of attracting buyers as well as establishing their loyalty (Sun & Chiang, 2015).

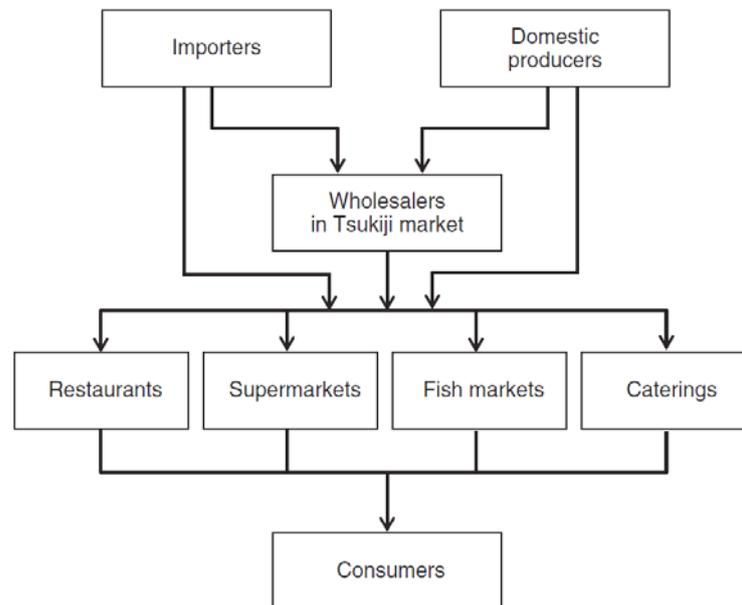


Figure 16. Marketing flowchart for sea urchins in Japan (Sun & Chiang, 2015).

Possible option to entry from the NPA area

In 2015/2016, as part of the Urchin project, Royal Greenland Individually Quick Froze (IQF) sea urchin roe from Greenland (*S. droebachiensis*) and its quality was assessed as B grade in Japan with an estimated market value of 5,000- 5,400 ¥ (40-43 €)/kg. The lower quality grading of the IQF roe from Greenland is due to roe shape (deformation) and excessive moisture relative to other products on the market (Ziemer, 2015). The taste and colour of the roe were acceptable. Draining the product properly will be a key process in increasing the quality of the roe during the thawing process. On the basis of the indicated price, the cost of harvesting, processing and shipment to market, Royal Greenland currently does not consider it commercially viable to utilise the green urchin resource in Greenland for the Japanese market (Ziemer, 2015).

However, there are options on the Japanese market for new entrants especially in view of declining fisheries by major suppliers. The key in entering the market is working with companies already established on the market. There may be options for operators in the NPA to develop a value added frozen product as well as brined, salted products to be supplied globally and specifically to the Japanese market. Shipment of whole live sea urchins may be possible assuming the logistic route is viable.

3.1.2. Other Asian countries

Although China is a large supplier of sea urchins to the Japanese market there may be options in supplying China with sea urchins. High tariffs (14%) as well as Import Goods and Services Tax (17%) add to the total cost of importing sea urchins (Anonymous, 2014; Pols 2014). Japanese restaurants in China and Hong Kong are now commonly serving sea urchin roe.



Figure 17. China market retail example in pre-packaged tray (Anonymous, 2014).

China is a large important market for processed sea urchin roe. The product is considered a luxury food, given as a gift and eaten for special events. Seafood gift boxes during the holidays (spring festival, golden week) are retailed as limited additions (Figure 18).



Figure 18. Celebrating seafood: Fresh seafood gift boxes for special occasions in China. Sea urchin is a gift during holidays (The Futures Company, 2014).

Increased standards of living and improvements in the economy have created demand for quality seafood, including sea urchin roe in Korea. Typical roe products are available on the market (Figure 19).



Figure 19. Typical offerings in Korea through online purchase a) brined b) canned c) frozen (TradeKorea, 2017).

3.2. European markets

The European fishery for sea urchin can be roughly divided into the southern fishery for the warm water species, *Paracentrotus lividus* and the northern fishery of *Strongylocentrotus droebachiensis*. These two fisheries have a very different history, with the southern fishery for *P. lividus* being in a state of flux since the 1990s when there was a rapid decline and near collapse of the fishery. This was due to the lack of fisheries controls and management (James et al., 2016; Gibson et al., 2002). In contrast, the northern fishery for *S. droebachiensis* is underutilised. In some NPA countries (e.g. Norway) sea urchins are considered an environmental pest as they dominate ecosystems and create huge monoculture 'urchin barrens'. Within the NPA there are examples of small-scale fisheries that have been successful, e.g. in Iceland. One of the primary differences between the northern and southern fishery is that there is a long and historical tradition of harvesting and eating sea urchins in the south of Europe, whilst this is not the case in the north. This combined with harsh environmental conditions in the north has meant that there is an abundance of sea urchin biomass available in the NPA for harvesting.

Despite the traditional practices of sea urchin harvesting in different regions in southern Europe, there is limited information regarding total landings from different regions or the main European countries. In many instances, catch statistics and data are not collected or published such as for sporadic sales to restaurants (James et al., 2016).

There is an established market for sea urchin roe in the Mediterranean region due to its historic and traditional inclusion in dishes in different regions. Markets in Europe range in size with the largest being the French, with typical wholesale entry points either at Rungis in Paris or Boulogne-Sur-Mer in the north. France is considered the largest market for sea urchins outside of Japan. There is also a wholesale seafood market in London, England - Billingsgate. All these wholesale markets act as hubs

for the sale of sea urchins coming in from various places from Europe, including that of the NPA. From these entry points the sea urchins go mainly for the HoReCa (hotels, restaurant and catering) markets where they are commonly enjoyed in a variety of dishes; most of the remainder goes to fish shops. Retail sales of urchin or urchin roe are minimal but still some preserved or canned roe can be found in European retailers e.g. in Carrefour, Auchan and Leclerc at various locations in France, especially before Christmas. Typical retail price of pasteurised urchin roe in 50 g glass jars is 100-120 €/kg (Monfort, 2002).

3.2.1. France

There is limited information collected or formally published regarding the sea urchin market in France and it has proven difficult to find reliable information on e.g. market size. France is considered the largest sea urchin market in Europe and the second largest market for sea urchins globally after Japan. The overall market has been estimated at 900-1,100 tonnes of whole sea urchins (Lines & Hammervold, 1988). The main demand is for whole live sea urchins (90%) that enter the market through the seafood markets in either Rungis (Paris) or in Boulogne-Sur-Mer. They are bought by wholesalers, that later sell and distribute the goods mainly to the restaurant sector (that use them e.g. as part of “plateaux des fruits mer”) but also to fish shops (Lines & Hammervold, 1988). The main consumption of sea urchins takes place in three regions that is in Bretagne, Paris and in the Mediterranean region (Côte d'Azur, Provence). The consumption is seasonal due to the seasonal roe yield and the main consumption is in the Christmas period; Easter may also have high consumption.

Fishery background

Sea urchin fisheries in France are one of the oldest in the world. Now they mainly supply the markets in Paris and Marseille (Andrew et al, 2002). The species that is favoured is the purple sea urchin, *P. lividus*. Landings in France peaked in 1945 when 1,145 tonnes were landed, almost all of it from the Mediterranean fishery (Andrew et al., 2002). Sea urchins are also caught off the coast of Brittany, however due to demand for sea urchins and improved fishing technology, sea urchins from that area were overfished in the early 1970s (Southward and Southward, 1975). Figure 20 shows that the catches in France have declined from about 450 tonnes in 1974 to about 75 tonnes in 2011. FAO reported landings of sea urchin for France as 67, 105 and 83 tonnes for the years 2012, 2013 and 2014 respectively (FAO, 2016).

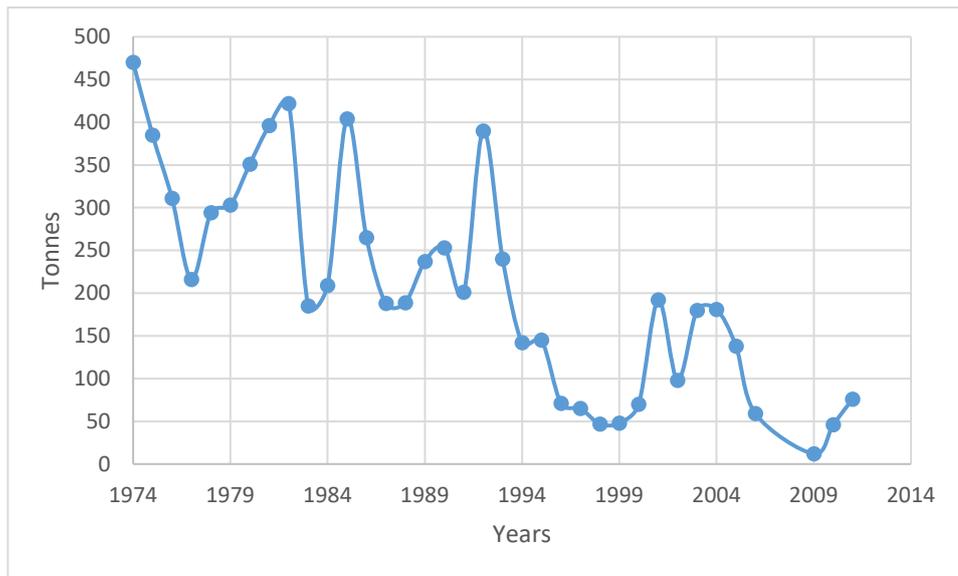


Figure 20. Production of sea urchins in France (Eurostat, 2014).

From the 1970s purple sea urchins (*P. lividus*) were also supplied to the French market from the west coast of Ireland, imports peaked in 1976 (at 350 metric tonnes) and has since then rapidly declined due to overfishing (Watson & Stokes, 2004).

Markets and routes to market

It is possible to utilise information from wholesale market transactions to identify the quantity of sea urchins entering the market and thus estimate the demand. French imports come from both countries that have a fishery and countries that do not. EU imports (including that into France) of sea urchins are allocated a commodity number (HTS code for custom purposes). Table 10 shows that in years 2013 and 2014 the total import of sea urchins to the French market was 141 and 146 tonnes and the average price was 7.5 €/kg. Iceland is the main supplier with about 100 tonnes both years with an average price of about 7.6 €/kg. Spain is also a large supplier. These figures match the export figures of whole sea urchins from Iceland (Tables 3 and 4). Import figures for 2015 and 2016 for France of whole live urchins were 170 and 186 tonnes respectively (France Import Statistics, 2017).

The import and production quantities for 2013 (Table 10; (FAO, 2016)) indicate only 246 tonnes of sea urchins in total as the amount sold in the French market; similarly for year 2014, 229 tonnes in total. The market size has previously, also using import data and harvest figures, indicated a much larger market of close to 1,000 tonnes (Lines & Hammervold, 1988). It is possible that there may be some unreported imports of sea urchins into France, but it is more likely that the demand for the product has simply decreased due to lack of supply of the local product traditionally consumed (*P. lividus*) and similar products e.g. from Ireland. It is likely with less harvest and increased imports, that prices have

increased and have led to less demand. Sea urchins are high value products and are only consumed as an exclusive item; they are not a product eaten every day.

There is some import of sea urchin roe, especially for tarama production but also for the HoReCa and the retail market. The import is likely to be small or less than 10 tonnes on an annual basis or equivalent to about 100 tonnes of live weight sea urchins (assuming 10% roe yield). Based on the import data and harvest figures for sea urchins the authors suggest that the French market is now much reduced and is actually smaller than the Italian market due to reduced supply or about 350-450 tonnes annually.

Table 10. Import of live, fresh or chilled sea urchins, amount (kg) and value (€). (Commodity number: 030821, Sea Urchins (*Strongylocentrotus Spp.*, *Paracentrotus Lividus*, *Loxechinus Albus*, *Echichinus Esculentus*), Live, Fresh Or Chilled (France Import Statistics, 2017).

	2013			2014		
	Amount (kg)	Value (€)	Unit Price (€)	Amount (kg)	Value (€)	Unit Price (€)
Iceland	96.027	737.127	7,7	103.971	792.059	7,6
Spain	41.011	295.446	7,2	38.906	285.313	7,3
FRANCE	3.146	17.796	5,7	2.175	14.484	6,7
Ireland	961	6.536	6,8	522	3.449	6,6
GB	0	392	0,0	582	4.480	7,7
FO	0	34	0,0	165	2.558	15,5
Belgium	36	392	10,9	0	0	
Italy	0	0	0,0	66	635	9,6
Denmark	0	0	0,0	5	60	12,0
Senegal	6	34	5,7	0	0	0,0
Norway	1	11	11,0	0	0	0,0
TOTAL	141.188	1.057.768	7,5	146.392	1.103.038	7,5

The standards in the French market are high for whole live sea urchins and include: A 40-50 mm diameter size, at least 10% roe, negligible iodine taste, preferred packaging of 5 kg polyester or wax seals, extensive spikes, and no exudate from the mouth. To import urchins into France, the country of origin must have a “Parite sanitary” (Fish health certificate) label (Royal Greenland, 2016).

As indicated previously, the purple sea urchin (*P. lividus*) is in higher demand than the green sea urchin (*S. droebachiensis*) and likely to fetch higher prices than the green urchin; however, assuming the sea urchins from Ireland are purple urchins, Table 10 indicates that they are actually sold at similar prices or even lower than that of green urchins.



Fig 21. Green sea urchin from Iceland (at 28€/kg) at a delicatessen retail outlet in Paris (16th of March, 2017) (Image courtesy of Dr. Guðmundur Stefánsson).

Products, processed sea urchins and value added products

Retail sales of preserved or canned sea urchin roe has not penetrated the French market and only a few products are available at retail level and often only seasonally. Sea urchin roe is however used as an ingredient in various food products, most notably in tarama. Tarama is the French version of the traditional Greek dish, taramasalata. It is basically an emulsion consisting of sugar-salted and smoked cod roe and vegetable oil but with various other ingredients such as lemon juice, breadcrumbs and colourants. Popular products on the French market may as well contain ingredients such as smoked salmon, crab, trout roe or sea urchin roe. Tarama is sold in various weights (50, 100, 200 and 250 grams) and packaging (glass and plastic), in preserved, pasteurised or sterilised form. The preserved product may have a shelf life of 4-6 weeks, while the pasteurised product can have an approximate shelf life of 6 to 12 month. Sterilised products have a shelf life of up to 2 years when held under recommended storage conditions (0-2°C) (Monfort, 2002).



Figure 22. Tarama with sea urchin (Comptoir du Caviar, 2017).

3.2.2. Italy and Sardinia

The purple sea urchin (*P. lividus*), is commonly used in Italy for various food incorporations: pizza, pastas, croutons, etc. Italy is one of the largest consuming sea urchin European countries; approx. 2,000 tonnes of urchins are consumed annually based on a recent observation (Carboni et al., 2013). This would make Italy by far the largest market for sea urchins in Europe and at least twice the size of the French market even when it was at its peak. It is difficult however to estimate harvest numbers due to significant unlicensed and illegal fishing.

Sardinia, the second-largest island in the Mediterranean Sea, is an autonomous region of Italy. Sea urchins are widely consumed in Sardinia as traditional food. Approximately 1,888 tonnes of sea urchin (30 million sea urchins) are consumed in Sardinia equalling a gross value of 10 million € (U.S. \$13.2 million) (Carboni et al., 2012). With 1.7 million inhabitants, Sardinia's annual per-capita consumption is about 1.1 kg; about four times the Japanese consumption (Carboni et al., 2013).

Fishery background

The Mediterranean island of Sardinia imposes fisheries protection on its endemic population of *P. lividus*, fishing season is between 1st November until April 30th with a total allowable catch of 3000 urchins per day per fisherman with a minimum test size of 50mm. Harvesting is not allowed on Mondays and each fisherman must maintain a personal log book for daily fishing records. In other Italian regions, there are similar rules e.g. in Sicily and Puglia (Addis, 2017). The sea urchin is commonly harvested by SCUBA diving. A minimum size of 40mm test diameter is used.

The first study to assess economics of the sea urchin market in the Mediterranean was conducted in 2016 (Furesi et al., 2016), assessing profitability, distribution costs, and fishing systems. Annual harvest levels in Sardinia were 114,000 specimens per vessel and this equates to 1,700 sea urchins/ day. Due to the increasing demand for sea urchin in the region, the economics versus the conservation efforts are being considered. Market understanding of quality and traceability will also help in increasing profitability and improving sustainability. The sea urchin fishery is putting immense pressure on wild stocks of *P. lividus*, and it is estimated that natural stocks are depleted and more than 50% of harvested individuals were below minimum size last year (Addis, 2017).

Importantly, FAO (2016) reports no landings for sea urchins or other echinoderms in Italy or Sardinia during the period 1950-2014. This shows that major discrepancies exist in the sea urchin fisheries data collected in Europe.

Markets and routes to market

During the summer months, there is a lack of sea urchins, particularly to service the influx of tourists. In addition to fresh roe, there is an increase in other forms of sea urchin sales, including frozen and

vacuum packed roe. The consumption of roe due to these processing methods now allows for expansion of serving options in restaurants and as a flavouring in pasta and pizza (Furesi et al., 2014). Italian fish and seafood products imports have experienced a 5.8% growth annually and opportunities for high value products include sea urchins. In 2015, Global Trade Atlas reported that Canadian imports of sea urchins to Italy have increased by 294% (Anonymous, 2016b). This shows what kind of opportunities there may be for NPA urchins in unexpected European markets. Unprocessed, processed, and frozen seafood products are well accepted by Italians and are considered staples. Frozen seafood is considered convenient and affordable. Seafood products that contain natural sustainable products, offered in small pack sizes are key to being successful in the retail market (USDA Foreign Agricultural Service, 2015).

Cedimar s.r. is a company in Sardinia that sells processed urchin harvest from the wild (Figure 23) and they have a large domestic market for their product.



Figure 23. Ricci di Mare- Sea urchin roe caught in Sardinia, Freschi & Pronti brand offered by Cedimar.s.r., Italy (Cedimar s.r., 2017).

Products, processed sea urchins and value added products

“Sea urchin pulp” is a product used for “creative” starters and for seasoning of pasta. Many companies, including Nieddittas (Sardinia, Italy), retail this product and it is sold in Europe. The company retails the product in glass jars (Figure 24) (Melbury & Appleton, 2016).



Figure 24. *Polpa Di Riccio* Sea urchin pulp by Nieddittas® (Melbury & Appleton, 2016).

3.2.3. Spain

In Costa Brava, Spain sea urchin roe is used as an addition to soups and stews or as side dishes with truffle and cooked egg. The purple sea urchins, “gariones” are locally harvested from November 1st to April 1st (Eckhardt, 2016).

Fishery background

The landings of echinoderms have been fluctuating from 435-730 tonnes in the period 2004-2014. In 2014, FAO reported landings of 520 tonnes (FAO, 2016). Most of this catch comes from the northern Atlantic regions of Galicia and Asturias, where *P. lividus* is harvested. There is also harvest on the Mediterranean coast of Spain in northern Catalonia ranging from 0.5 tonnes/year to 9 tonnes/per year. However, these figures are likely underestimations as a large portion of the catch is sold directly to retailers or otherwise processed; it is estimated that the catch ranged between 30 and 40 tonnes in 1998 (Andrew et al., 2002) (Ballesteros & García-Rubies, 1987) .

Markets and routes to market

In areas of Spain as well as the Canary Islands, sea urchins are underexploited and are not commonly consumed. Due to the overpopulation of the sea urchin *Diadema antillarum*, there has been investigations into the sea urchin market in Spain. It has been found that there could be opportunities for selling locally; however, marketing through locals, chefs, and friends will be required to grow this market (Grisolía et al., 2012).

Products, processed sea urchins and value added products

Figure 25 shows a product produced by Eris-Mar®. The raw product originates from Costa Brava. The sea urchins generally are smaller in maturity, with limited supply (Eris-Mar, 2016).



Figure 25. a) Sea Urchin Roe, a “raw” product with a 12-month shelf life, maintaining flavour and original texture b) Sea Urchin Conserve, a sterilized, canned product with 3 year shelf life (Eris-Mar, 2016).

3.2.4. Portugal

P. lividus has been harvested from Portugal, for many centuries but there is little published information on the current status of these fisheries (Andrew et al., 2002). FAO reports landings of sea urchin of 7 tonnes in 2014 (FAO, 2016).

Southern Portugal refers to the sea urchin as "Ourico do Mar". The Portuguese prize the sea urchin as a delicacy. In Alentejo, a traditional way of preparing sea urchin is by placing the whole sea urchin in-between pine needles. The pine needles are burned and the sea urchin cooks (Deutsch & Murakhver, 2012).

3.2.5. Other European Countries

In the United Kingdom, sea urchin roe is a compliment to pasta or hollandaise sauce or serves as a topping for baked potatoes and biscuits. Polpa di Riccio di Mare is offered as an Italian and Spanish product that is available in the United Kingdom. There is a market for the product, but it is likely very small and significant information was not easily found.

Although sea urchins are not traditionally consumed in Germany there is a very small niche market in high end restaurants in Germany for good quality sea urchin roe. There may be limited options to supply sea urchins and roe into this luxury restaurant sector as it is expected that the demand for seafood will increase significantly in Germany compared to other European countries. It is predicted that products with the greatest potential in the food processing sector are fish and seafood of which roe and urchin are included (Food Export Association, 2016).

4. Conclusion

The supply of sea urchins has fluctuated considerably in the last few years; fisheries have declined rapidly in many countries due to overfishing. From the peak landings of about 120 thousand tonnes in 1995 to the current levels of about 75 thousand tonnes, traditional harvesters such as Japan, Chile, US and to a lesser level, Canada, have all experienced reduced catches. Russia and Peru are supplying larger quantities to the global market than they did in 1995, but no new major entrants have emerged in the last few years.

The market for sea urchins remains mostly traditional with Japan, consuming about 80-90% of the current global supply (50,000-60,000 tonnes). Obtaining reliable information on market demand in individual countries, excluding Japan, proved difficult as little information is published; additionally, some of the harvest may be illegally obtained and traded with little or no paper trail. There is a domestic market in many sea urchin harvesting countries, especially in Chile, New Zealand and the Philippines, likely to be about 4,000-5,000 tonnes annually. In Europe, the market is also traditional; mainly in continental Europe and the Mediterranean countries, Italy, France and Spain. The overall market in Europe is probably not large, likely to be about 3,000-3,500 tonnes estimated as whole sea urchins. No new emerging markets outside the traditional markets were observed in this study; however, sea urchins seem to be novel and trendy and due to growing interest, small niche markets may exist in various countries throughout Europe. Also, there may be an emerging niche market for sea urchin or roe in high end restaurants in various European countries including Scandinavia.

There is likely an unmet demand in the Asian market for good quality sea urchin products at suitable prices, particularly in view of reduced supply to the market. This provides options for a new entrant (e.g. from the Northern Periphery and Arctic area), assuming that a logistic route from harvest to market can be economically established. The green urchin supply is under-utilised in countries such as Norway and Greenland and assuming that roe enhancement is a viable option, also in Iceland. It must be stressed however, that the Asian market, especially Japan, cannot be entered without cooperation with companies already established in the market. The highest value in Japan is reserved for top quality

sea urchin roe, from a processor with a very good reputation and from a local Japanese sea urchin species, caught within Japan. Imported sea urchins and sea urchin products will demand considerably less value and getting an accurate price for a product is crucial in order to make economic predictions.

For the NPA countries such as Iceland, Greenland and Norway, supplying to markets such as France is the obvious choice; fisheries in France are low compared to the relatively high landings in the 1970s and 1980s and supply from other countries such as Ireland and Spain appears small. There is an established traditional market in France, especially within the HoReCa sector for mainly whole sea urchins. Iceland has in the past years successfully exported green sea urchin to the French market and is currently the main supplier to the French market. The overall French market appears however to be small, or around 350-450 tonnes as whole sea urchins based on harvest and import figures. There may be an unmet demand on the market, assuming a right selling price, as there are indications that the supply to the market has been about 1,000 tonnes in the recent past. A recommendation could be that the supply be increased gradually in order to avoid “boom and bust” price cycles.

There may also be options to supply other traditionally consuming countries with sea urchins such as Italy and Spain. However, care must be taken in exporting to Italy, as a large part of the current supply may be from illegal or unlicensed fisheries. The harvests in Spain have been relatively constant during the period 2010-2014 at about 500-750 tonnes but as they also export, e.g. to France, therefore it is possible that they are self-sufficient when it comes to sea urchins. Overall on the European market, there may be opportunities not only in supplying whole sea urchins, but also in supplying processed roe e.g. from animals with low gonad yields or damaged urchins, for the variety of traditional dishes consumed, as well as for garnishes, dips, sauces, and pâtés.

There may also be options to supply the apparent emerging high end restaurant niche market in various European countries such as in Scandinavia, Germany and England, but although this market may be lucrative it is at the same time quite unpredictable when it comes to regular supply during harvesting.

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