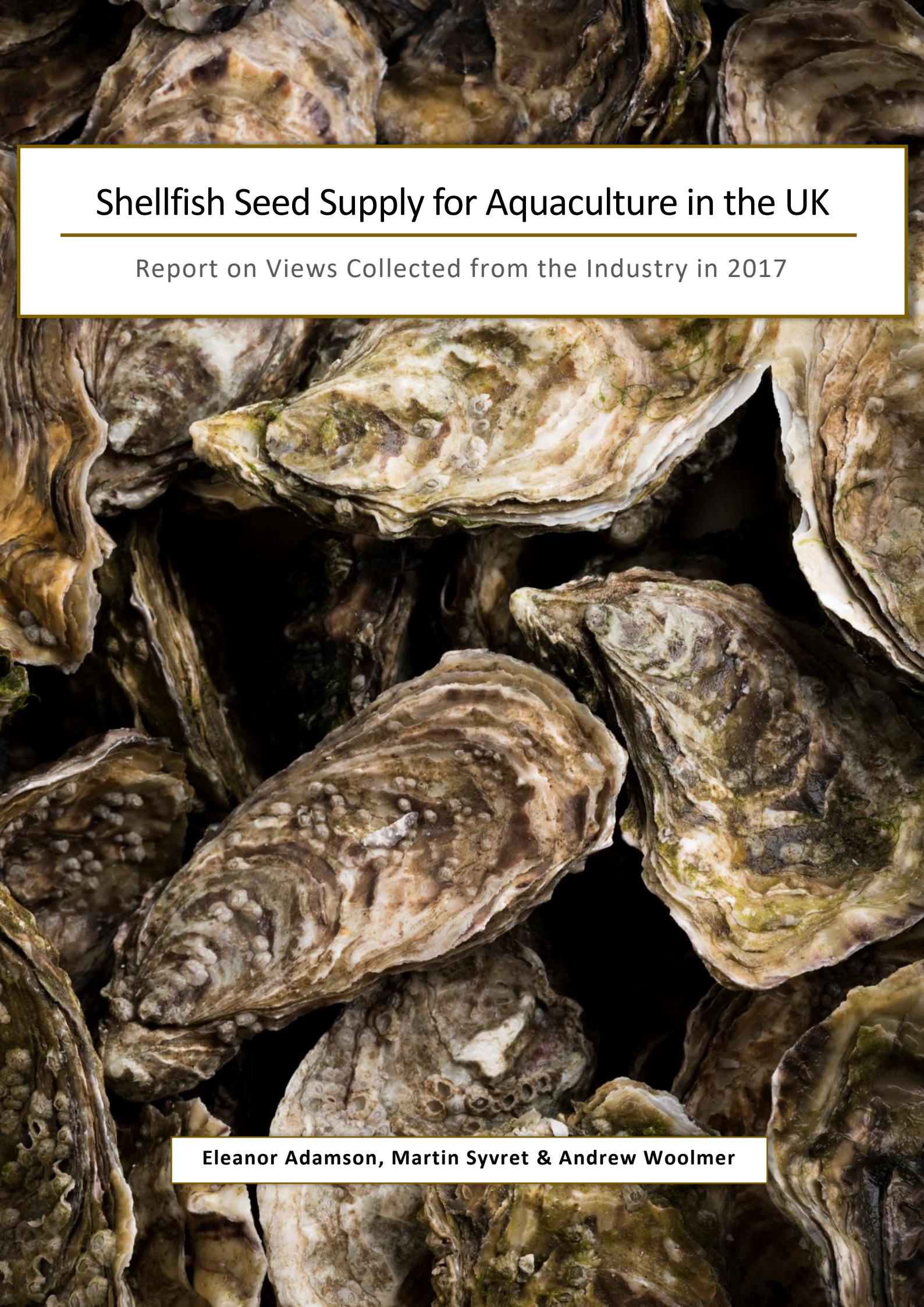

Shellfish Seed Supply for Aquaculture in the UK

Report on Views Collected from the Industry in 2017

Eleanor Adamson, Martin Syvret & Andrew Woolmer

Authors

Eleanor Adamson, The Fishmongers' Company.
Martin Syvret, Aquafish Solutions Ltd.
Andy Woolmer, Mumbles Oyster Company Ltd.

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Preface

This report is prepared for the Fishmongers' Company by Martin Syvret, Andy Woolmer and Eleanor Adamson. It provides a summary of a survey and discussions with industry conducted in 2017 and does not necessarily reflect the view of Aquafish Solutions Ltd, the Mumbles Oyster Company Ltd, or the Fishmongers' Company. The authors cannot be held responsible for any consequences arising from the use of this report.

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The FISHMONGERS' Company

Fishmongers' Hall | London Bridge | London | EC4R 9EL

Shellfish Seed Supply for Aquaculture in the UK

Report on Views Collected from the Industry in 2017

Contents

Executive Summary

Anecdotal accounts and some industry reports in recent years have suggested, that due to emerging biosecurity and production issues, there is a structural constraint in secure seed supply for the UK shellfish industry. Growing interest in native oyster restoration and cultivation has highlighted the need for seed supply. These factors have raised interest in the development of new shellfish hatchery capacity. Here, we summarise the results of a small survey conducted in November 2017 that aimed to gauge opinions from industry on current and future demand for shellfish seed, to investigate the case for a "new multi-species hatchery".

The survey interviewed UK shellfish growers and hatchery producers, and results were presented for general discussion at a small gathering at Fishmonger's Hall that included hatchery producers and industry experts. Much of what is summarised here will not necessarily be new information to those with good working knowledge of the industry, however, we feel it worth summarising and making publicly available for those with a general interest.

Results of the survey reveal that Pacific oyster growers are by far the largest market for hatchery produced shellfish seed for on-growing in UK waters. Among growers, there are generally no concerns about the availability of Pacific oyster seed at levels necessary to maintain current production volumes. In addition, current growers, due to a combination of legislative and water quality issues constraining the development of new farms, have only limited plans to increase current levels of Pacific oyster cultivation, and so do not anticipate that there will be an increased demand for shellfish seed in the UK in the short to medium-term. Most current shellfish growers have little or no interest in diversifying away from Pacific oysters to produce other species that would require hatchery sourced seed. There is however interest in some quarters in developing farms for other bivalve species such as clams.

There are two British hatcheries that currently produce Pacific Oyster seed. Both are situated in waters free from the shellfish diseases Oyster Herpes virus and *Bonamia*. In combination, the two hatcheries supply all Pacific oyster seed to UK growers in disease free areas, and at full capacity, the two hatcheries can produce more seed than they can sell in the UK. Historically, when supply at one hatchery has been interrupted, the other has had capacity to supply volumes of seed more than adequate to meet the entire UK market demand for disease free Pacific oyster seed. This raises serious questions about the business case for increasing the current level of commercially produced oyster seed.

However, for reasons not fully understood, British hatcheries are independently having to work harder to produce the same volumes of shellfish seed. There could well be a strategic case to support current hatchery businesses to ensure the UK retains existing hatchery capacity in disease free areas. If conditions at either or both disease-free hatcheries should change to affect their long-term ability to produce disease free Pacific oyster spat, then it is unclear where UK growers could source disease free seed, and they may look to a body such as CEFAS to help provide answers.

Shellfish seed for UK aquaculture

Annual UK shellfish aquaculture production is valued in excess of £35 million (Seafish, 2016). Cultivation generally involves rearing juvenile bivalve molluscs ("seed" or "spat") on the sea bed, on ropes, or in bags or cages suspended on trestles. The UK shellfish aquaculture industry is dominated by native blue mussel production (*Mytilus edulis*), and to a lesser extent, cultivation of Pacific oysters, a non-native species. Pacific oysters, also sometimes known as Rock oysters, have had a recent change in scientific name to *Magallana gigas*, although the previous scientific name of *Crassostrea gigas* is still commonly used.

Around most of the UK coastline, blue mussel growers rely on natural settlement of wild mussel spat as a source of seed, and thus have no need to purchase hatchery produced seed for on-growing. In Scotland, however, concerns about variation in wild spat fall have led to the establishment of a pilot-scale blue mussel hatchery in the Shetland Islands that aims to produce seeded ropes, hopefully buffering the Scottish industry's reliance on wild resources. Mussel growers in the south of the UK generally experience high rates of wild mussel settlement and therefore do not share concerns about alternatives to wild sourcing.

In contrast, Pacific oyster cultivation, which is mostly undertaken by relatively small-scale operations, is reliant on oyster spat produced by commercial hatcheries. In 2017, there were three commercial shellfish hatcheries in the UK: in Morecambe Bay, at Whitstable, and on the Channel Island of Guernsey, and both the Morecambe Bay and Guernsey hatcheries currently supply Pacific oyster seed. As of May 2018, we understand that the operator of the Whitstable hatchery, who is of retirement age, has decided to wind-up production at that site.

In addition to supplying Pacific oyster seed, in 2017 UK hatcheries were offering to supply clam and cockle seed (from Whitstable) and native oyster spat (*Ostrea edulis*) (from Morecambe Bay), although there is only a small market demand for these species at present. Native oyster spat is now also just starting to be produced in spatting ponds at other locations (Tony Legg, pers. comm.), with plans already underway to expand production significantly using this method in coming years. Currently, UK hatcheries have no capacity to produce scallop seed (*Pecten* and *Aequipecten* sp.), and the very limited demand for king scallop seed is met by an overseas hatchery. Hence, for economic reasons, production of Pacific oyster seed is currently the main focus of UK hatcheries.

The "new hatchery" idea

The idea for a new multi-species shellfish hatchery seems to have floated around the UK shellfish culture scene for a number of years, probably largely driven by the idea that seed availability is one key factor that limits both current production volumes and industry growth (e.g., Seafish, 2016). Concerns about the need to access triploid seed to compete with French growers and to enable growers to operate in areas where growing diploid stock is prohibited, combined with policy statements supporting increases in shellfish aquaculture production, may on the surface present a solid case for expanding the UK's hatchery capacity.

As long ago as 1984, a Shellfish Association of Great Britain discussion paper identified the need for large supplies of shellfish seed and government funded R&D to support commercial hatcheries (Edwards, 1984). In more recent history, a review of Scotland's shellfish industry recommended development of a multi-species hatchery (Kaspar, 2014), and to some extent this has been realised by the NAFC Marine Centre "stepping-stone project" blue mussel hatchery in the Shetland Islands, which put its first seeded ropes in the sea in 2017.

A wide-ranging report on domestic Aquaculture in England, Wales and Northern Ireland commissioned by Seafish in 2016 clearly identifies the need for a 'National Shellfish Seed Strategy' that would fulfil the "immediate need to address the seed demand supply conundrum" (Hambrey & Evans, 2016). In Wales, a feasibility study examined the potential for a local oyster hatchery to support native oyster restoration (Syvret, 2015) and plans for an energy generating tidal lagoon in Swansea allow for incorporation of a shellfish hatchery (Syvret & Woolmer, 2017) although current indications are that the proposed lagoon will not now be developed. In England, a shellfish hatchery was even briefly considered among ways to re-purpose the old AstraZeneca Laboratory site in Brixham (Goodwin *et al.*, 2017).

Certainly, the UK lacks a direct equivalent to the Cawthron Institute, which undertakes shellfish aquaculture research and service provision and is often referred to in the context of its contribution to New Zealand's successful shellfish sector. Likewise, the UK sector hasn't received the same level of centralised support as neighbouring French growers, where hatcheries were until recently supplied with tetraploid broodstock from the state-owned Ifremer. Both New Zealand and France have thriving shellfish aquaculture sectors, so would not a larger investment in UK hatchery capacity address current aspirations to expand shellfish production and upscale sustainable protein production from coastal waters?

The "seed demand-supply conundrum"

The "conundrum", often spoken of in terms of "chicken and egg", refers to the seed demand-supply dynamic as a limiting factor in non-mussel shellfish industry expansion. The UK aspires to significantly increase non-mussel shellfish production from aquaculture. This means more seed supply from hatcheries on one side, and more farms engaged in on-growing on the other, with investment and activity on each side being dependent on investment and activity in the other.

The assumption is that greater supply of shellfish seed would stimulate the establishment of new farms, but that the economics of seed production limits production without a ready market already established. This is true as far as seed production goes, as hatcheries generally produce seed in response to orders from growers rather than keeping stock on hand for unanticipated sales. However, establishment of new shellfish farms is limited on several fronts, including the complexity surrounding the licencing and permitting requirements that must be satisfied in order to set up new farms, or indeed to expand production in existing operations. This complexity contributes to a general lack of certainly that discourages investment across the shellfish aquaculture sector, a state that has existed for over 30 years (Edwards, 1984).

The benefit and complication of disease free shellfish waters

There are two main diseases of cause for concern in oyster cultivation: variants of the Oyster Herpes Virus (OsHV-1) that cause high mortality in Pacific oysters, and the parasite *Bonamia ostreae* which impacts populations of the native oyster. Both have caused massive mortality events in European waters (Pernet et al., 2016), and regulations are in place that prohibit the transfer of diseased shellfish into disease free areas.

Unlike other European waters, the majority of UK waters available for oyster cultivation have disease free status, and therefore most growers around the UK coastline can only source seed from hatcheries in disease free areas. The hatcheries that supply Pacific oyster spat, i.e., Morecambe Bay and Guernsey, both operate in disease free waters and take every precaution to keep their locations disease free.

Disease free status is generally (although not always) considered a good thing, as farmers suffer much lower rates of shellfish mortality than, for example, across much of neighbouring Europe where oyster diseases are prevalent. However, large European hatcheries in the disease positive areas are able to produce spat much more cheaply, and this economy of scale means that European growers can still make a profit while sustaining higher levels of

mortality especially once they learn how to mitigate against the worst impacts of diseases such as Oyster Herpes Virus. UK growers in diseased areas, at present, are free to import seed obtained from European hatcheries and can therefore benefit from the cheaper prices of seed, however this option is only available to a small number of UK farms in disease positive zones.

Potential game-changers

Changes in disease status in UK Waters

The likelihood of disease spread is hard to quantify. The presence of Oyster Herpes Virus is associated with warmer water temperatures, and as there is a trend towards warmer waters around the UK coastline, there is a perceived risk that major shellfish diseases will become more prevalent. Regardless, shellfish diseases have spread throughout much of the NW European coastline and may do similarly around the UK coastline given that Oyster Herpes Virus, for instance, is now found in areas of south west, south and the south east of England.

If shellfish diseases do expand their range in UK waters, then there will be no requirement or reason for UK growers to continue to source disease-free seed. In this case, depending on prevailing trade regulations, it's likely that UK hatcheries will be unable to remain competitive against their low-priced European neighbours which have greater economies of scale.

Changes in disease status in UK Hatcheries

If either of the two UK Pacific oyster hatcheries change their disease status, they would no longer be able to supply to growers in disease-free waters. This would place the full burden of disease-free supply onto one hatchery. To date, when one hatchery has experienced periods of low productivity, the other hatchery has managed to supply the entire UK market with Pacific oyster seed, but strategically, reliance on a single hatchery is risky, because any interruption in supply (due to any unforeseen failure or disease outbreak) would then halt the industry entirely in the disease-free waters.

Supplying to meet increased demand

At the moment, despite 'blue growth' policy aspirations, there is little evidence to suggest that demand for shellfish seed will increase. However, if the industry's uncertainty around licencing and permits for new and existing operations can be overcome, then the UK bivalve aquaculture industry would likely see investment and higher production volumes. If this happens, then growers will need to access larger volumes of Pacific oyster seed, more seed of larger size classes ready for grow-out, and they'll be looking for seed of known quality with respect to growth and survival. The capacity to meet this demand in a reasonable timeframe and guarantee good quality seed stock will be essential to enable cultivators to upscale production, if the regulatory goal posts shift to facilitate industry expansion.

Diversifying the offering – triploids, alternative species

Pacific oysters are naturally diploid organisms, meaning they have two copies of every chromosome. Triploids, that have three copies of each chromosome, are considered infertile. At present, UK hatcheries can produce both diploid and triploid Pacific oyster seed. Triploid oysters are considered desirable because, as they do not reproduce, all their energy goes towards growth, and hence they do not experience the "milkiness" that diploids take on during the summer spawning period. This means triploids can be sold all year round, and much of the French market is now dominated by triploid oysters.

Perhaps even more significantly, in regions of the UK where wild or naturalised Pacific oyster populations exist, consents for new farms may well be contingent on the use of triploid stock in order to mitigate the "escape" risk and wild recruitment of larvae. The development of new farms in these areas will depend on a secure supply of triploid seed.

There is interest in the native oyster (*O. edulis*) across Europe for both commercial production and restoration of the native oyster reefs that were once present around the coastlines. Significant work is being undertaken Europe-wide to increase production of native oyster spat in commercial quantities, and if the UK could establish itself as a reliable source of high-quality native oyster seed, then a substantial market may exist in supplying seed for restoration projects. Europe wide, most native oyster spat is collected from sites with high wild spat fall, with some also produced in specially constructed spatting ponds. The UK hatchery in Morecambe Bay can produce native oyster spat, but it's not clear, even after 100 years of interest in flat oyster production, that the species can be reliably produced at commercial scale (John Bayes, pers. comm).

Survey of current growers and seed producers – Aquafish Solutions Ltd.

Overview

In late 2017, Aquafish Solutions Ltd. were engaged to carry out a small review of British bivalve shellfish hatchery production and capacity, with a view to informing the Fishmongers' Company on the viability of current arguments for expansion of hatchery capacity and production of new species. The remit also included the identification of issues affecting the ability of the hatcheries to produce seed for on-growers at the levels necessary to support current or future production requirements. The review gathered evidence through two surveys:

(1) Industry Survey – this took the form of in-depth phone interviews with nine on-growers, and incorporated email comments from two other industry representatives. The interviews were structured under the following main sections:

- Current shellfish production levels, including location and type of on-growing systems
- Type and source of seed e.g. hatchery, wild seed
- Current seed requirements for each farmed species
- Identification of any issues with, or arising from, sourcing seed (e.g. interruptions in supply, mortality events) and what level of threat or constraint this is to the business
- Identification of other possible seed suppliers should current seed supply be interrupted
- Comment on need for improvements in broodstock lines, tetraploid development of Pacific oysters, lines for disease resistance etc.
- Estimation of likely future production levels, whether this would involve any diversification in species types and whether it was felt that there was sufficient current hatchery capacity to support this

(2) Hatchery Survey – detailed discussions were undertaken with the three UK commercial hatchery operators operating at that time, and results incorporate evidence gathered from discussions with two other people involved in the hatchery industry. The discussions covered:

- Current seed production levels by species and seed type (diploid or triploid)
- Ability of the hatchery to produce seed of other species other than those currently under production
- Where applicable, method of inducing triploidy in Pacific oysters
- Scope for increase in current seed production levels by species and seed type
- Identification of any issues that had occurred in the past with supplying industry with differing species or seed types (diploid or triploid)
- Likely future shellfish seed production levels by species and type
- Whether centralised tetraploid broodstock production of Pacific oysters would be of benefit to the hatchery
- Comments on the impact of Oyster Herpes Virus both on on-growers and the hatcheries.

Main Findings – Industry Survey

Current bivalve shellfish production levels in the UK

Pacific oysters

- UK and British oyster production is currently based around the Pacific oyster (*Crassostrea gigas*).
- Most intertidal growers in England and Wales produce <50-tonnes per annum using bags and trestles with a small number of growers producing up to 100-tonnes per annum.
- One UK grower, based in Poole Harbour, produces in excess of 100-tonnes per annum through sea bed cultivation using an eco-harvester. The largest British producer of Pacific oysters is based in Jersey, producing several hundred tonnes per annum using bags and trestles.

Native oysters

- Whilst only small-scale at present, there is increasing interest in native oyster (*Ostrea edulis*) cultivation using new systems e.g. Ortac4 cylinder and Microreef.

King scallop

- Sub-tidal cultivation of king scallops (*Pecten maximus*) only appears to be carried out by 1 to 2 growers in the UK although significant investment is being put into developing one SW of England farm site.

Type, source and seed requirements

Pacific oysters

- UK oyster farms in an Oyster Herpes Virus (OsHV-1) negative area can currently obtain diploid seed from Seasalter Walney and both diploid and triploid seed from Guernsey Sea Farms.
- UK seed requirements for Pacific oysters in OsHV-1 free areas are highly variable ranging from tens to hundreds of thousands for smaller growers (~<£5-k p.a.) through to millions for larger producers (~£25-£50-k p.a.).
- Those oyster farms in OsHV-1 positive areas can generally import French seed, often triploid, at typically one-third of the cost of that supplied by British hatcheries.
- In the past, where one hatchery has been unable to supply seed, the other has normally been able to cover grower requirements. This situation might change however if either, or both, hatcheries we ever to become OsHV-1 positive or were to cease production for any reason.
- It is thought unlikely that there will be any hatchery development in Scotland in the next 5 years being in a position to supply growers with known performance seed.

Native oysters

- Seasalter Whitstable, Seasalter Walney and the Ardtoe Laboratory (now FAI Farms) have previously produced diploid seed, and Seasalter Walney still currently produces native seed. Spatting ponds are already used in Ireland to produce seed and there are plans for further pond developments in Ireland, Scotland, Wales and Denmark for 2018 onwards.

- Jersey Sea Farms (JSF) report that they have a requirement for 10 million+ spat of a size from 2mm+. The estimated value of this seed is £150-300-k.
- The European Aquaculture Society have stated that a lack of seed is the limiting factor for expansion of native oyster cultivation.

King scallop

- All current seed production for king scallop cultivation in the UK is undertaken by the Scalpro hatchery in Norway using UK broodstock. They have stated that they wish to increase the number of 'satellite' hatcheries able to produce this species.
- The SW of England grower is currently purchasing a minimum of 4 million seed a year at a cost in excess of £100,000 although this cultivation operation is still in a start-up phase of production

Breeding Programmes

Pacific oysters

- Several growers mentioned the need for increased disease resistance.

Native oysters

- JSF have been selecting native oyster broodstock over the last 3 oyster generations and working with researchers at Xelect in St. Andrews.
- Loch Ryan Oyster Co. Fishery Ltd. believe that their Irish oysters are *Bonamia* tolerant/resistant and so may be of value for breeding programmes. This would however require further investigation to assess the level or degree of tolerance to disease.
- The Roslin Institute and Cefas are developing a research project investigating improving aquaculture species lines, this includes native oyster and *Bonamia* resistance. There is some question however over the cost to the animal of developing such resistance, e.g. reproduction and growth.

King scallop

- The SW of England grower is currently working with Scalpro to investigate broodstock health in order to try and eliminate poor years of seed production

Future shellfish production levels and current hatchery capacity

Pacific oysters

- English and Welsh growers stated that future production would either stay the same or possibly increase slightly. Uncertainties over the regulatory status of Pacific oysters was given as one reason for a reluctance to expand significantly.
- If both British disease-free hatcheries remain in operation, then it would appear that there is sufficient hatchery capacity at present to service English and Welsh needs for seed.
- Scottish aquaculture has a stated aim to double oyster production by 2030, seed for which will need to come from the two OsHV-1 free hatcheries. An increase in nursery production capacity may be needed to service this potential need.

Native oyster;

- JSF estimate that, if production goes to plan, then there may be a requirement for 50 million seed at a minimum of 2mm.

- JSF are currently gearing up towards this through pond and hatchery initiatives and are at about 20% of that at present.

King scallop

- The SW England grower has a 4-5 year plan to increase long-lines from 24 to 60. Scalpro estimate that they could produce up to 10 million seed a year.

Main Findings – Hatchery Survey

Seed production levels by species and seed type

- Seasalter (Walney) Ltd. and Guernsey Sea Farms Ltd. are considered disease-free whilst Seasalter Shellfish (Whitstable) Ltd. is in an Oyster Herpes Virus and *Bonamia* positive area.
- British shellfish hatchery production is mainly centred around the production of diploid and triploid Pacific oysters at present. Whilst they can produce many other bivalve species, in practical terms it is probably difficult/inconvenient for them to change over to producing other species, especially without firm orders or a strong market demand.
- British Pacific oyster production areas that are already affected by Oyster Herpes Virus are generally able to buy and import French seed at one-third to one-quarter of the costs of that produced by the disease-free British hatcheries.
- Seasalter Whitstable produce Manila clam seed which goes for export to the EU. There is also reported to be a limited demand for the native clam, *Ruditapes decussatus*.
- There is one grower in the SW of England cultivating king scallops. Currently however no British hatcheries are producing this species with seed supply coming from the Norwegian hatchery, Scalpro. There is a report that Scalpro are now in the process of setting up production facilities in the UK (John Bayes, pers. comm.).

Scope for increase in current seed production levels by species and seed type

- Guernsey Sea Farms cite a lack of nursey capacity as a limiting factor in increasing Pacific oyster seed sales. The use by growers of solar powered Floating Upweller Systems (FLUPSYs) may be one method of overcoming a lack of nursery capacity within the hatchery.
- Guernsey Sea Farms also reported that demand for disease-free Pacific oyster seed hadn't changed significantly for the last 10 years. They questioned where extra UK Pacific oyster production would be sold as a saturation of the UK market was a possibility. Seasalter Walney stated that new producers are needed to grow the market for seed. New shellfish producers might well be French operations looking for new sites.
- If the Pacific oyster tetraploid technique can be acquired, then Seasalter Walney would look to supply diploids and triploids at a 50:50 ratio starting next season.
- Seasalter Whitstable state that when operational they could have produced much larger quantities of Manila clam seed if there was a market for it. There are currently emerging markets outside the EU for this species.

Identification of any issues that had occurred in the past with supplying industry with differing species or seed types

- Guernsey Sea Farms report that they have never had to turn away a customer for Pacific oyster seed although they do struggle to supply the larger seed types due to constraints on nursery capacity.
- Seasalter Walney has just experienced its worst two years of production. Production of diploid Pacific oysters has now restarted using a new operational protocol. However, they are having to work harder to produce as much seed as they did in the past, something that was reported by all three British hatcheries.

Triploidy in Pacific oysters and centralised tetraploid broodstock

- Seasalter Walney is only producing diploid Pacific oysters at present but wants to acquire the technique and equipment to develop tetraploid broodstock. The centralised production of tetraploid broodstock, or assistance in this respect, would therefore definitely be of help to Seasalter Walney, although they recognise that this may impact on Guernsey Sea Farms who already have triploid production capability.
- Guernsey Sea Farms already has the capacity to produce triploids by an undisclosed method and currently sells triploids to both the UK and overseas markets. Currently one-third of all production is triploids. They would therefore look less favourably on a joint industry project to develop tetraploids.
- Seasalter Whitstable stated that without disease resistant females there would be no point in centralised tetraploid production.

Comments on the impact of Oyster Herpes Virus both on on-growers and the hatcheries

- Guernsey Sea Farms work very hard to ensure they remain free of Oyster Herpes Virus. They recognise that should they become OsHV-1 positive, then due to the economies of scale enjoyed by French hatcheries, it is unlikely that they would be able to remain competitive when selling to growers in disease affected areas.
- Seasalter Walney stated that should the hatchery ever become OsHV-1 positive, then they would most likely cease seed production and instead buy in French seed for on-growing on their cultivation sites.
- Seasalter Whitstable are in an OsHV-1 positive area. This has had recent implications for their ability to move native oyster seed to OsHV-1 negative areas due to advice from CEFAS that no shellfish should be moved from a disease positive to a disease negative area.

Survey Summary and Conclusions

British shellfish production - current and future

In general, the English and Welsh Pacific oyster growers who responded to the survey expressed an opinion that future production would either stay the same or possibly increase slightly. There did not appear to be plans for any significant increase in production or species diversification, other than possibly to mussel cultivation. Reasons given for a likely lack of significant growth in production included uncertainties over the regulatory status and treatment of Pacific oysters as a currently non-native species and a reluctance amongst some growers to have to use triploid seed. Barriers in the site consenting process are also recognised to be a constraint in the development of new farms. As such, it must be concluded that were both British disease-free hatcheries to remain in operation, then it would appear that there is sufficient hatchery capacity at present to service at least English and Welsh needs for disease-free Pacific oyster seed.

Those Pacific oyster growers already in an Oyster Herpes Virus positive area, which includes most of the largest British producers, are generally able to import Pacific oyster seed, often triploid, from French hatcheries at around one-third to one-quarter of the cost of that supplied by British hatcheries. One grower commented that Defra "should not protect the industry to death over Oyster Herpes Virus" and gave the opinion that if a disease-free grower wanted to import French seed then they should be allowed to otherwise the potential economics of French production might eventually put them all out of business anyway (Gary Wordsworth, pers. comm.). However, discussions with growers in disease-free areas did not seem to indicate a desire at present to import cheaper seed at the expensive of losing their disease-free status.

The ASSG stated that the aim in Scotland is to double Pacific oyster production by 2030 and this increased production would be reliant on the two disease-free British hatcheries. It was felt by the ASSG that it is unlikely that in the next 5 years that there would be any hatchery development within Scotland being in a position to supply seed with known performance (Nick Lake, pers. comm.). It seems possible therefore that if the existing hatcheries are to meet such an increased Scottish demand, then extra nursery capacity will need to be developed either at the hatcheries themselves or as part of the on-growing cycle e.g. solar powered FLUPSYs as previously successfully tested in Cornwall.

Guernsey Sea Farms questioned where any large increases in UK Pacific oyster production would be marketed. The factors requiring consideration are (1) French seed is cheaper than that produced by British hatcheries although disease related mortalities will be higher (2) Prices into France for Pacific oysters are half that obtained in the UK markets and so producers using British seed may be at a competitive disadvantage (3) Would any large increase in UK production flood the UK market? If so, increased UK production might have to involve sales to the French market where prices received are much lower. An alternative, might be exports outside the EU e.g., Asia.

For the native oyster, production levels through cultivation activities are currently low but there is significant interest in increasing production of this premium oyster product. A

recent EAS conference in Croatia highlighted that a lack of seed is the single most important factor limiting the expansion of cultivation of this species. A series of working groups have now been set up through the EAS to look at research and development needs. Jersey Sea Farms (JSF) have been active in trying to increase seed production through technical support to UK hatcheries and the development of pond production projects in a number of European countries. They state that they have 8 million seed under cultivation for 2019 onwards and currently require around 10 million+ seed oysters per annum from 2mm+. They have estimated that eventually there may be a need for up to 50 million native oyster seed at a minimum of 2mm of which they are currently at ~20% production. JSF also stated that they felt that any new hatchery developments may destabilise the hatcheries currently working with this species.

There is some interest in South West England in the suspended cultivation of king scallops using lantern nets. This is a relatively new venture and is yet to actively market product. This grower is entirely dependent at present on seed production from Scalpro, a Norwegian hatchery although there is a report that Scalpro is developing UK hatchery facilities for scallops (John Bayes, pers. comm.). There are plans by the SW grower to increase production from 24 to 60 long-lines over the next 4-5 years. Current seed requirements are about 4 million per annum with a cost in excess of £100,000. Future seed requirements may be as much as 10 million per annum.

British hatcheries – limitations and threats

Were both disease-free British hatcheries to remain in operation then there appears to be sufficient hatchery capacity at present for English and Welsh growers to maintain Pacific oyster production at its current level. Increased Scottish production may however require additional nursery capacity which would need to be addressed as there appears to be insufficient nursery capacity at present. Discussions with Seasalter Walney and Guernsey Sea Farms indicate that they both feel well placed to meet current Pacific oyster seed demands. However, were these hatcheries to become unable to supply disease-free seed, then there are no obvious alternative supplies of Pacific oyster seed available to the UK growers not currently affected by Oyster Herpes Virus. A cessation in production of both British disease-free hatcheries may be unlikely, but there have been incidents in the past where one hatchery has been unable to supply seed and so growers were reliant on the other hatchery. Were one of the hatcheries ever to become Oyster Herpes Virus positive then the UK growers requiring disease-free seed would find themselves wholly reliant on just one hatchery. Guernsey Sea Farms stressed how important biosecurity was to them. They have even taken a decision not import broodstock of other species in order to minimise biosecurity threats. During the course of the industry surveys, one grower asked for advice, possibly from CEFAS, about what other Pacific oyster seed sources might be available were the two disease-free British hatcheries to become unable to supply seed. There might perhaps be a need for a contingency plan in this respect or at least consideration of other possibilities for the supply of disease-free Pacific oyster seed to UK growers.

In discussions with the British hatcheries, all reported that they were having to work harder to produce the same level of seed as they did previously. All of the hatcheries have had an, as yet, undefined issue with water quality. The issues may not be exactly the same at each hatchery but in discussions between themselves they have identified similar trends or symptoms such as seed mortalities at certain sizes. There may therefore be a need for research into what the water quality issues really are, but the hatcheries all acknowledged that this will not be easy to solve.

Another issue identified by Seasalter Whitstable is a lack of trained or qualified staff able to work in hatcheries. They highlighted that what is needed is practical tuition for people who wish to enter the industry, something along the lines of the Lycée Professionnel Maritime et Aquacole. They felt that a training centre and suitable funding should be available to help bridge this skills gap in the UK hatchery sector (John Bayes, pers. comm.).

Triploid Pacific oysters – current status & future opportunities

One British hatchery is only producing diploid Pacific oysters at present but wants to acquire the technique and equipment to develop tetraploid broodstock. The other disease-free British hatchery already has the capacity to produce triploids by an undisclosed method and currently sells triploid seed to both the UK and overseas markets. They would therefore look less favourably on a joint industry project to develop tetraploids. French hatcheries used to be centrally supplied by Ifremer with tetraploid broodstock. However, once the patent expired, French hatcheries started to produce their own tetraploid broodstock. There are now concerns in France that these newer tetraploids may not be of the 'same quality' as those produced previously with increasing levels of reversion to the diploid state observed; increased gametogenesis/spawning; decreased resistance to mortality in young oysters.

Availability of cost effective triploid seed would be of benefit to developers of new and existing farms in areas where there are no currently naturalised Pacific oysters. Regulatory uncertainty over the status of Pacific oysters restrict new growers to the use of triploid stock in order to mitigate concerns about wild recruitment. Existing growers are being forced to adopt triploid stock in sites where there is a risk of spawning (John King, pers. comm.). This is certainly the case where water temperatures are sufficient for spawning and settlement.

The French market for Pacific oysters is now mainly triploids as they can be sold year-round (without milkiness in summer) as they don't suffer the same loss of condition as diploid oysters which can render diploids unsaleable for extended periods over the summer months. Some of these French triploids are now being sold in London and they are likely to prove popular as they can be consumed throughout the summer. From a hatchery perspective, producing triploids might open up seed sales to the 'Irish' producers who are now almost entirely French owned/controlled i.e. producing product for the French market. Warming sea temperatures may lead to a greater requirement for triploid use in Scotland in the future and warnings have already been issued about the future of some gadoid species in this region due to rising sea temperatures.

The business case for a new commercial shellfish hatchery in the UK to supply species other than mussels is, in early 2018, unconvincing, as current hatchery capacity is more than adequate to supply the entire UK market. The UK shellfish sector is somewhat precariously positioned on a number of fronts, including licensing and secure tenure, disease transmission and water quality, and cultivation of native versus non-native species. If any of these factors change significantly to encourage investment in non-mussel shellfish cultivation, then, following projections of increased demand for seed, there may be a cause for staged investment in a commercially scalable hatchery venture, however in the medium term, it would seem much more practical to channel any strategic support into securing the future of the hatcheries that already supply the entirety of the growers in disease-free UK waters.

Working with existing hatcheries

Support for existing UK shellfish hatcheries appears to be the strongest strategic position for securing the UK's shellfish seed supply, given the current position of the UK shellfish aquaculture industry and the potential risks it faces. Discussions with the three UK hatcheries operational in 2017 revealed that they were all having to work harder to produce seed, and all struggle with unexplained mortality events, for example in certain size classes. This phenomenon is not unique to UK hatcheries, as North American hatchery producers also face unexplained issues with seasonal production (Kramer, 2018). Specific causes aren't clear and are likely to be hatchery specific, but no doubt general water quality and chemistry are involved. Finding the root causes of hatchery mortality will require collaborations between hatcheries and research establishments, possibly with staff hosted at the hatchery.

New technologies

Discussions with UK hatchery operators highlighted an interest in modernisation of systems. Developing biosecurity "firewalls" between the marine environment and the hatchery system would reduce the biosecurity risks currently faced by existing hatcheries. Technologies employed in finfish Recirculating Aquaculture Systems (RAS), such as the environmental control and automated systems, may offer some viable approaches but R&D is necessary – shellfish hatcheries are very different operations to finfish RAS farms.

Supporting dissemination of research on disease transmission and resistance

Ongoing research in the UK and internationally aims to better understand, limit and alleviate the impacts shellfish disease. We understand that current initiatives include genomic investigations into resistance, understanding the trade-off between resistance and other desirable traits such as growth and fertility, and understanding risk of virus transmission among oyster species in shared containment facilities, among many other initiatives, including the EU VIVALDI project (www.vivaldi-project.eu) and the Aquaculture Research Collaborative Hub (https://www.aquaculturehub-uk.com). At present, despite efforts to bring industry and researchers together, there could be a perceived lack of dissemination and information sharing, and there could be a role for facilitated knowledge transfer among different shellfish stakeholder groups.

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