Aquafish Solutions Limited
Aquaculture and Fisheries Research, Consultancy & Training

NATIVE OYSTER, OSTREA EDULIS – SUBTIDAL CULTIVATION HANDBOOK

For: The Mumbles Oyster Company Ltd.

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The native oyster, *Ostrea edulis*, or flat oyster as it is also known (see Figure 1), was once the subject of a major commercial fishery, peaking in the mid-1800s after the end of the Napoleonic Wars. Historically, native oysters formed extensive beds, shell banks and may have formed cohesive shell reefs around many of the European coasts including England and Wales.

Figure 1: Wild caught native oyster
(Source: Aquafish Solutions Ltd.)

Indicative, if not wholly reliable, figures for numbers of oysters passing through Billingsgate at the time put the level at about a staggering 500 million per annum. The first official oyster statistics were not produced until 1886 by which time production levels had dropped dramatically to around only 40 million per annum. This reduction in supply saw prices rise dramatically by the late 1880s and it was at this stage that the oyster changed from a food of the poor to a dish more commonly associated with the wealthy.

Today, the stocks of this once abundant species remain at very low levels. Two centuries of over exploitation, TBT (tri-butyl tin) pollution in the 1980s, mortalities due to severe winters in the 1930s and 1940s, competition from exotic pests such as the slipper limpet in conjunction with the parasitic disease Bonamiosis have all meant that current standing stocks are severely depleted.

1.2 Native Oyster Species Action Plan (NOSAP)

The decline in native oyster numbers in the UK led in the late 1990s to the development of a Biodiversity Action Plan (BAP) for this species, the Native Oyster Species Action Plan (NOSAP), for which the lead agency is currently the Shellfish Association of Great Britain.

The main aim of NOSAP is to increase the abundance and geographical range of this threatened species where biologically feasible. The current sources of hatchery or extensively reared seed are limited to diploid oysters, i.e. fertile and capable of reproducing, and therefore any cultivation activities, within appropriate areas, that will increase potential broodstock numbers of this BAP species should be broadly welcomed in terms of their potential to help restore the abundance of this now threatened species.

1.3 Native Oyster Cultivation

Currently there is little cultivation of native oysters (*O. edulis*) practised in the UK due to the perceived difficulties in rearing this species when compared to the Pacific oyster. The 'farming' of *O. edulis* that does take place has barely changed since Roman times and generally involves the management of natural beds through practises such as re-laying oysters in protected high productivity areas. Dredge harvesting at times of seasonal demand is the norm with some suspended culture practiced in areas such as Spain.

In the UK, supply for markets therefore relies predominantly on wild caught oysters which are dredged in areas such as South West England and in Essex. Currently, European production is around 1,500 tonnes p.a. representing a substantial recent decline due mainly to the effect of the *Bonamia ostreae* parasite from the 1970's onwards. This pales into insignificance compared with the historic 1850s fisheries in places such as the Bay of Mont St. Michel and the Firth of Forth. The Jersey fishery alone, in 1855 yielded a grossly unsustainable 34,000 tonnes (worth some £200+ million at current wholesale prices). Farming advances tried in the late 19th century stalled due to a market crash following the highly publicised death of the Dean of Winchester due to eating typhoid infected oysters from Emsworth in Hampshire.

With the moves to *Crassostrea angulata* (1920s) and then *Crassostrea gigas* (1960s) the native European oyster was side-lined to regional production areas such as Belon, Cancale and Whitstable. However, with OsHv1 oyster herpes virus causing a reduction in *C. gigas* production in France from 150,000 tonnes p.a. (2009) to 85,000 tonnes p.a. (2012) and consequential shortfalls and price rises, the markets for native oysters have become re-energised. Successful techniques for culturing native oysters could therefore help to provide a sustainable and economically viable source of native oysters for the market.

For a general review of native oyster aquaculture see the following web-link for the FAO aquaculture guide:

http://www.fao.org/fishery/culturedspecies/Ostrea_edulis/en

1.4 Cultivation Handbook

This Cultivation Handbook is intended to provide a practical guide to establishing and then operating a subtidal native oyster farm within England and Wales. The content is based upon the experience of the authors in setting up and running a subtidal shellfish farm under a Several Order in South Wales and an intertidal native oyster farm in South West England. In addition to this, the handbook draws upon the experiences gained from carrying out the Welsh European Fisheries Fund project entitled "Re-instatement of traditional oyster beds" (2013 to 2015) for which a separate Evaluation Report has been produced.

It is hoped that this handbook will therefore offer practical guidance on the main stages of obtaining a cultivation site, introducing and farming native oysters in a subtidal environment through to eventual harvest and processing for sale. Based as it is on the authors' experiences, the advice given cannot be considered exhaustive and is intended only as guidance. Prior to undertaking any new aquaculture venture it is highly recommended that a thorough and detailed business plan is developed especially with respect to identifying potential markets, market prices and cash flow to first harvest.

SECTION 2 – LICENSING, PERMISSIONS AND CLASSIFICATIONS FOR SHELLFISH AQUACULTURE OPERATIONS

2.1 Introduction

The following section is intended to give an overview of the types of licenses and permissions needed in order to firstly establish a bivalve shellfish farm and then, once authorised, to continue to operate it on a day to day basis. This review of marine licensing is not therefore intended to detail every aspect of the process through which an aquaculture operation can be established and operated.

The degree of consultation etc. in setting up a new farm will vary between sites and in general depends on the species being considered for culture. In particular, the site specific implications of designations under measures of the Habitats Directive, such as Special Conservation Areas (SCAs) and Special Protection Areas (SPAs), would require careful consideration at the very earliest stages of any planned development. It is recommended that a partnership approach be established between the competent authority, statutory advisers and developers which will then enable the early identification of any risks and issues in this respect.

This handbook is primarily intended as a guide for those intending to culture the native oyster, *O. edulis*. The native status of this oyster does have certain advantages when applying for an Aquaculture Production Business (APB) authorisation when compared to the Pacific oyster, *C. gigas*, as, for instance, there are no negative impacts of wild settlement. Indeed, it is likely that the introduction of diploid native oysters will be seen to have a positive environmental impact as they may serve as broodstock to help re-establish wild oyster stocks.

2.2 Licensing of Marine Aquaculture

2.2.1 Crown Estate Leases

Where the seabed is owned by the Crown then The Crown Estate (TCE - see Section 7.1 for contact details) has a statutory duty to obtain a return for the use of land within that ownership and so rental is due for areas of seabed used for commercial purposes, including aquaculture. As such TCE is responsible for granting aquaculture leases for deployment of aquaculture equipment on the seabed (e.g. fixed gear such as in rope mussel cultivation) out to 12nm.

Some limited private ownership of the seabed does occur around the UK where these private property rights prevent public fishing. Permission to operate an aquaculture business within these privately owned areas would therefore be subject to a lease arrangement between the land owner and the aquaculture operator.

Seabed rentals charged by TCE for shellfish are linked to the amount of equipment on site and specified in the lease i.e. these relate to fixed gear aquaculture operations not seabed cultivation. The TCE website states that the majority of shellfish farms pay a relatively small amount which reflects the nature of the industry, being largely comprised of small scale farms.

In England and Wales an application to TCE for a fish or shellfish farming lease can be made at any time. Statutory consent is not required as a prerequisite. If statutory consent has not been obtained, then rather than a full lease, a lease-option will be offered. A lease-option will be important where an applicant does not want to commit to the expenditure of pursuing statutory consent without some assurance that a lease will be granted if consent is obtained.

A lease-option agreement would remain in place until statutory consent is granted but would lapse if the consent is not granted within the period specified in the option agreement. (Source: http://www.thecrownestate.co.uk/coastal/aquaculture/working-with-us/aquaculture-leases/)

2.2.2 Fishery Orders

Licensing to undertake seabed cultivation where some rights of ownership or tenure accrue to the aquaculture operator are normally granted through a type of Fishery Order known as a Several Order under the Sea Fisheries (Shellfish) Act 1967 and these cover areas out to 6nm. Given the need for native oysters to be within the area of primary productivity if reasonable growth rates are to be achieved, then 6nm should cover most areas considered for offshore seabed cultivation of native oysters. The granting of a Several Order is for a fixed time period and in effect removes the public common law right of fishing.

The underlying rationale for the granting of a Several Order is that the productivity of the fishery must be enhanced and the applicant for a Several Order must therefore supply a management plan stating how this will be achieved. Where native oysters are to be grown this might involve the laying of shell cultch material (see Section 3.3.3) to encourage spat settlement or the re-laying of seed or part grown (half-ware) oysters for on-growing to full market size.

In England, Several Orders are granted by the Department for Environment, Food and Rural Affairs (DEFRA) whereas in Wales this power rests with Welsh Government. The process of obtaining a Several Order can be a time consuming and possibly costly process especially if there are public objections to the application necessitating a public enquiry. In England the option does exist for Several Orders to be granted to the local Inshore Fisheries and Conservation Authority (IFCA) which may then lease the rights under the order.

In Wales “Welsh Ministers may by order make any provision in relation to Wales which the authority for an IFC district may make for that district by a byelaw made under section 155” under Sec. 189 of the Marine and Coastal Access Act 2009, Power of Welsh Ministers in relation to fisheries in Wales. This covers the area out to 12nm as it relates to “Wales” under the same meaning as in Government of Wales Act 2006 (Colin Charman, Natural Resources Wales, pers. comm.). Sec. 155 covers the IFC district duties under Sec.s 153 and 154. Sec. 153 seeks to ensure that “the exploitation of sea fisheries resources is carried out in a sustainable way” where sea fisheries resources and exploitation include shellfish aquaculture activities. It may be possible therefore that Welsh Ministers might have the power to issue Fishery Orders out to 12nm under the Marine and Coastal Access Act 2009 but this would need to be confirmed and the extent or limitations of any such powers identified.

For further information regarding Fishery Orders please see the following web-link:

https://www.gov.uk/shellfisheries-several-orders-and-regulating-orders

2.2.3 Marine Licences

Under the Marine and Coastal Access Act 2009 (MCAA) The Marine Management Organisation (MMO) is responsible for marine licensing of certain activities in English inshore and offshore waters and for Welsh and Northern Ireland offshore waters. In Wales, Natural Resources Wales (NRW) is responsible for inshore waters whereas in Northern Ireland this responsibility rests with the Department of Environment Northern Ireland. Marine Scotland is responsible for Scottish inshore and offshore waters.

In general shellfish aquaculture activities are exempt from the requirement for a marine license. The Marine Licensing (Exempted Activities) Order 2011, as amended by the 2013 Order, exempts “the deposit of any shellfish, trestle, raft, cage, pole or line in the course of the propagation or cultivation of shellfish”. The MMO state that this is provided that the deposit is unlikely to cause obstruction or danger to navigation and that the deposit is not made for the purposes of disposal. The likelihood of impacting shipping should always be ascertained through discussions with the appropriate competent organisation e.g. local harbour authority. In Wales The Marine Licensing (Exempted Activities)(Wales) Order 2011 applies.

It should be noted however that whilst most shellfish aquaculture activities are exempt from marine licensing by the MMO or NRW an exemption notification must be obtained before any activities can be carried out. Further information about marine licensing is available on the MMO and NRW websites (see Section 7.1 for contact details).

2.3 Aquaculture Production Business Authorisation

2.3.1 Obtaining an APB Authorisation

Under the Aquatic Animal Health (England and Wales) Regulations 2009 all aquaculture production businesses (APB's) must be authorised by the competent authority. For England and Wales the competent authority is the Fish Health Inspectorate (FHI) at the Centre for Environment, Fisheries and Aquaculture Science (CEFAS – see Section 7.1 for contact details).

Applications to establish a new APB, change ownership of an APB or to change use and species at an existing APB can be made by submission to the FHI of a completed Form AW1. This form can also be used to request permission to introduce alien and locally absent species under The Alien and Locally Absent Species in Aquaculture (England and Wales) Regulations 2011, although this shouldn't generally apply to areas being considered for native oyster cultivation.

The information requested by the Form AW1 includes details about the applicant and owner/operator; proposed changes to an existing APB; details of the site to be developed; species to be cultivated; facilities to be utilised; details of entitlement to operate e.g. lease contract. The form can be supplemented with additional information about the proposed aquaculture operation which could include mitigation approaches for any known impacts on that site. The latter is especially relevant where the APB may be located within or near an inshore or offshore European Marine Site (EMS) such as a Special Area of Conservation (SAC), Special Protection Area (SPA), Site of Special Scientific Interest (SSSI) or Marine Conservation Zone (MCZ).

Amendments to Regulation 100 contained within the Conservation of Habitats and Species (Amendment) Regulations 2011 mean that "marine works" (shellfish farm in this case) now includes authorisations for APBs. Therefore, where a proposed shellfish farm will take place within an EMS, the APB authorisation is now subject to the Habitats Regulations Assessment for plans or projects. As such any shellfish farm application in an EMS is now required under Regulation 61 to undergo a Test of Likely Significant Effect (LSE) on the designated features. Therefore, if no other consents are needed, then the FHI as the competent authority must determine whether an appropriate assessment is required, based on information reasonably provided by the applicant, during which they must take into consideration any advice from Natural England and published guidance available from the European Commission. The application can only be consented to if it does not adversely affect the integrity of the EMS, based on the site's conservation objectives.
The general consultation process for APB authorisation is the same for both England and Wales but with different consultees (Mike Gubbins, FHI, pers. comm.). Consultees are granted up to 90 days in which to reply to the consultation process. The consultees used for shellfish sites will include, but are not limited to, the following:

- Food Standards Agency / CEFAS Classification and Sanitary Survey teams
- Natural England
- Natural Resources Wales

- The IFCAs
- The Crown Estate
- The Local Authority

Any objections, comments or queries by the consultees will require investigation as part of the APB application process. Before any authorisation of an APB can take place an assessment visit by an FHI Inspector will normally take place. This site visit allows the Inspector an opportunity to follow up on comments by the consultees and the Inspector will normally take this opportunity to discuss with the applicant the detailed conditions of authorisation that the site would be subject to whilst operating as an APB (see also Section 2.3.2).

2.3.2 Biosecurity Measures Plan

As an integral part of the authorisation process for an APB, the applicant will be required to draw up and have approved a Biosecurity Measures Plan (BMP). This BMP should help to identify disease risks associated with the proposed farm through shellfish movements, site procedures etc. and should then offer risk limitation or mitigation measures in this respect. It would be considered best practice within the BMP, bearing in mind the fact that introductions of non-native species would be illegal, to also consider any non-native or invasive species implications associated with the operation of the shellfish farm e.g. non-native introductions with seed movements.

Guidance and a template for the BMP is available on www.defra.gov.uk/aahm. It is recommended that the draft BMP is submitted to the FHI before the site assessment visit by the FHI Inspector. This will then allow the Inspector time to review the BMP and then to offer informed advice to the applicant on finalising the BMP following the site assessment visit.

Following a Form AW1 application, and once a BMP has been approved by the FHI, no LSE has been confirmed (where applicable), a site inspection has been carried out and the consultation process has been finalised then an APB authorisation can be issued.

2.3.3 Surveillance Scheme

Authorised APBs will be assessed for risk in terms of disease prevention and control and will then undergo site visits by Inspectors at predefined intervals. These inspections are designed to help ensure that the APB is operating within its authorisation conditions and as stipulated within the BMP.

Information on designated areas of notifiable diseases is available through CEFAS on www.defra.gov.uk/aahm in the section 'Disease Designations'. It is recommended that this website is reviewed periodically in order to keep up to date with disease occurrences, especially where a shellfish farm may be involved in bringing shellfish in from other areas.

2.3.4 Record Keeping

The authorisation conditions for an APB will state the minimum level of record keeping required in operating a shellfish farm. This will include the following:

- **Movement records;** CEFAS will provide a Movement Book, completion of which is considered the minimum level of record keeping in this respect. This Movement Book, or an equivalent electronic format, must be available for inspection at any time. The movements recorded must include all shipments of molluscan shellfish into and out of the mollusc farming area including movements to processing.

- **Mortality records;** The BMP template available from CEFAS contains a 'Biosecurity log book' template. This minimum level of information should be kept for any stock mortalities and must detail how dead shellfish were disposed of. As with the movement records, these mortality records must be available for immediate inspection and in a format that can be copied for later analysis. It should be noted that any unusual or high mortality levels within farmed shellfish should be reported immediately to the FHI.

- **Annual production and economic data;** Data detailing annual production of shellfish must be submitted annually and is normally either collected during the first site visit of the year or via a postal request, the shellfish producer may also be asked to provide additional economic data related to the business.

2.4 Harvesting Classification and Sanitary Surveys

It is a requirement under EU legislation (EC Regulation 854/2004 Annex II) for all beds from which bivalve shellfish are harvested to have a Classification according to a microbiological standard based on the presence of the bacteria *Escherichia coli.*

E. coli is used as an indicator organism for the presence of faecal contamination and shellfish are tested to obtain the number of colony forming units (CFUs) in 100g of flesh and intra-valvular liquid. *E. coli* occur naturally in the digestive tract of animals and humans and are generally considered harmless although there are strains, such as 0157:H7, which can cause illness in humans (see Section 5.3.1). The importance of Shellfish Classifications in terms of consumer food hygiene is discussed further in Section 5.1.

2.4.1 Classification Process

An application to have a shellfish bed classified can be made by contacting the Food Standards Agency (FSA). Section 7.1 has contact details for the FSA and information about how to request a Classification. Once an application for Classification has been made, sampling of representative shellfish is normally undertaken on behalf of the FSA by the Local Authority EHOs. The EHOs send the shellfish samples to an accredited testing laboratory in order to assess the levels of *E. coli* CFUs in 100g of flesh and intra-valvular fluid. A provisional Classification can normally be issued after sampling fortnightly for 3 to 4 months with full Classification being achieved after a full year's results have been obtained, normally based on monthly sampling intervals.

There is also scope under a Memorandum of Understanding between the Food Business Operator (FBO) and the FSA for the FBO to submit additional samples for inclusion in the microbiological data set for a production area. This is known as the Harvesters Own Sample Protocol. The advantage of doing this is considered to be that a larger data set helps to identify contamination trends and may add to the stability of the Classification based on the 90% compliance.

The intention is that FBO sample results are considered alongside the FSA's official control microbiological results dataset for the classification, closure or opening of the relevant production area. An increase in microbiological data from a shellfish production area would increase the knowledge of the microbial contamination trends within the area and may benefit the stability of the area's classification.

Classifications issued for shellfish harvesting beds are based on the following criteria in terms of how many CFUs are present:

Class A: A harvesting area where test results are shown to be consistently less than 230 CFUs of *E. coli* per 100g of flesh and intra-valvular liquid.

Class B: A harvesting area where 90% of samples have less than 4,600 CFUs of *E. coli* per 100g of flesh and intra-valvular liquid. The remaining 10% of samples must not exceed 46,000 *E.coli* per 100g.

Class C: A harvesting area where test results are shown to be less than a maximum limit of 46,000 CFUs of *E. coli* per 100g of flesh and intra-valvular liquid.

Prohibited Area: A harvesting area where test results are shown to be higher than 46,000 CFUs of *E. coli* per 100g of flesh and intra-valvular liquid.

Current Classifications for England and Wales can be found via the following web-link:

https://www.food.gov.uk/enforcement/monitoring/shellfish/shellharvestareas

2.4.2 Sanitary Surveys

Under EC legislation EU/854/2004, Section 6, of Annex II, if the competent authority (FSA) decides in principle to classify a new production area or re-laying area then a Sanitary Survey must be carried out. These surveys provide an inventory of the sources of pollution of human or animal origin likely to be a source of contamination for the shellfish harvesting or production area. Information included in the surveys is as follows:

- An examination of the quantities of organic pollutants which are released during the different periods of the year, according to the seasonal variations of both human and animal populations in the catchment area, rainfall readings, waste-water treatment etc.;
- Determination of the characteristics of the circulation of pollutants by virtue of current patterns, bathymetry and the tidal cycle in the production area;
- Establishment of a sampling programme of bivalve molluscs in the production area which is based on the examination of established data, and with a number of samples, a geographical distribution of the sampling points and a sampling frequency which must ensure that the results of the analysis are as representative as possible for the area considered.

Where harvesting or production beds are already classified for other shellfish species then these Sanitary Surveys are a good reference source for establishing likely points of microbial contamination. Sanitary surveys are now in the public domain and can be accessed via:

http://www.cefas.defra.gov.uk/our-science/animal-health-and-food-safety/food-safety/sanitary-surveys.aspx

2.4.3 Long Term Classifications and Local Action Groups

Long Term Classifications: Where Class B harvesting or production beds have a compliance level for Classification purposes of over 5 years data then the bed is categorised as having a Long Term Classification (LTC). The benefit to industry of a shellfish bed having an LTC is that it demonstrates greater stability in an area which may then potentially increase saleability of the product. As the LTC is based on compliance over 5 years then it has a 'smoothing' effect on poor results.

Local Action Groups: These groups (LAGs) are set up to assist Local Enforcement Authorities (LEA) in the investigation of high *E. coli* and positive biotoxin results. Membership of a LAG normally includes the LEA, FSA, CEFAS, Environment Agency, water companies, IFCA and sometimes local FBOs.

The primary functions of a LAG are to act as a conduit for effective communication exchange, to contribute relevant data to investigations, and to help inform decision making on appropriate health protection measures. LAGs are responsible for developing a Local Action Plan that should include the exceedance levels for *E. coli* and biotoxins and describe the process for investigations to be carried out.

For a comprehensive guide to Classifications in England and Wales see the following:

http://www.cefas.defra.gov.uk/media/748045/20140703%20classification%20protocol%20revised%20version%209.pdf

In the UK the majority of commercially viable shellfish beds for the supply of live bivalve shellfish to market are Class B. Whilst it is possible under the legislation to supply shellfish direct to market from Class A beds it is considered best practise by many operators to hold these shellfish in a depuration unit before supply to the food chain as a matter of 'due diligence' (see Section 5.3.2).

SECTION 3 – NATIVE OYSTER CULTIVATION

3.1 Site Selection and Offshore Cultivation

Native oysters are widely distributed around the British Isles but are less common on the east and north-east coasts of Britain and Ireland. The main stocks are now in the west coast of Scotland, the South East of England and Thames estuary, the River Fal and Lough Foyle.

Wild populations of *O. edulis* are associated with highly productive estuarine and shallow coastal water habitats on firm or hard substrates of mud, rocks, muddy sand, muddy gravel with shells and hard silt. In terms of cultivation, any mobile sediments should be avoided as these will result in the potential smothering of the oysters. In exploited areas, suitable habitat for spat settlement has been and is created through the deposition of what is termed 'cultch' material such as broken shells and other hard substrata (Source: http://www.marlin.ac.uk/speciesfullreview.php?speciesID=3997).

In terms of environmental conditions for aquaculture, seawater temperatures above 8 to 9 ^{o}C for much of the year are preferable for fastest growth and exposure to low air temperatures should be avoided as this can kill oysters. Minimum temperatures for survival are between 3 to 4 ^{o}C. Salinity of seawater should be above 25‰ and ideally closer to full salinity i.e. above 30‰ and up to 35‰.

A tidal flow of 1 to 2 knots (50 to 100 cm second^{-1}) is optimal as this will ensure a good supply of food, although less (around 0.5 knots) is acceptable. The longer the period of immersion the better the growth rate and some growers have commented that any exposure should be avoided as it may result in mortalities. Limited exposure before harvest may have some benefits in that it can help to promote shell hardness and extend shelf life. Maximum exposure, i.e. percentage of time at which growth stops, is considered to be approximately 25 to 35% but this is site and environment dependent.

Areas where the waters carry a very high silt burden should be avoided as this can cause smothering. Also, areas where poor water exchange exists should be avoided as this may result in oxygen depletion, particularly during warm weather, which can weaken or kill the stock. In order to achieve good growth rates the native oyster must be grown within the primary productivity zone where phytoplankton levels are highest.

With any new site being considered for aquaculture it is advisable to carry out monitoring of the area in terms of its environmental, physical and biological characteristics. Trials would then need to be undertaken to properly assess growth and mortality rates of the shellfish as well as performance of any cultivation equipment. If these initial trials prove successful then pilot trials at commercial-scale production levels could be instigated. Only then should actual commercial-scale cultivation be considered.

3.2 Cultivation Overview

3.2.1 Production Levels

Production figures indicate that in 2012 approximately 111 tonnes of native oysters were cultivated in England and Scotland with no Welsh production. Of this 111 tonnes, the English production is stated to be ~86 tonnes produced 'On bottom' whilst Scottish production is 25 tonnes produced 'Off bottom' (Source: CEFAS, January 2015).

3.2.2 Current Cultivation Techniques and Offshore Cultivation

Current farmed production of native oysters is predominantly based on the dredging of wild seed which is then re-laid into subtidal sheltered high productivity growing areas where it then grows to market size.

Previous trials placing native oysters intertidally in the traditional French *poche* oyster bags have not been successful. More recently however, on-growing of hatchery reared native oyster seed to market size has been successfully undertaken in Jersey using the ORTAC system which is a rigid more three dimensional system than the relatively flat two dimensional *poche* bags.

Whilst offshore production levels of oysters, either suspended or on the seabed, are very limited in the UK at present, both the Pacific and native oyster are considered to be good candidates in this respect. Previous trials have shown that both oyster species can grow and survive well both in the nearshore and higher energy offshore environments.

It seems likely that as experience is gained in working offshore that this area of aquaculture will attract more interest. This is primarily due to the greater availability of space, lending itself to larger more economically viable farm sizes, plus the likely improvements in terms of microbial water quality that will be found as production is moved away from more traditional growing areas, such as estuaries, which can be subject to intermittent water quality issues.

3.3 Seed Availability

3.3.1 Hatchery Production

It is likely, that at least initially, any major expansion in subtidal or offshore cultivation of native oysters will be subject to seed supply shortages not only in terms of total numbers, but also in terms of obtaining seed that is large enough to cope with and remain within a high energy environment. Up until recently Seasalter (Walney) Ltd. was the only hatchery in the UK producing any commercial quantities of *O. edulis* spat for the industry. However, more recently seed has also become available from the Ardtoe Hatchery in Scotland run by Viking Fish Farms Ltd.

Seasalter (Walney) Ltd. is a commercial shellfish hatchery based outside of Barrow in Furness in the North West of England. Whilst the main species produced by Seasalter Walney is the Pacific oyster, they also currently produce to order several million native oyster seed per annum. Minimum orders for native oysters are around 2 million seed and this would be produced during gaps in the hatchery’s normal Pacific oyster production activities. Native oysters hatched during the early summer are normally collected by the customer in the autumn of the same year as they cannot be overwintered in the nursery area.

Although size is often variable, native oyster seed (see Figure 2) are usually around 10mm (6mm sieve size) in length by August/September of the year of hatching. Excess seed can sometimes become available if survival rates are above average.

Production at the Ardtoe hatchery is targeted mainly at servicing the needs of existing customers and is constrained by their ability to produce sufficient levels of live microalgae at that latitude. This means that there is a greater reliance on intensive hatchery production of phytoplankton. Therefore Ardtoe prefer to sell seed oysters at the relatively small size of 2 to 4mm although they can sometimes produce limited numbers of 6 to 8mm seed.

Figure 2: Hatchery produced native oyster seed (centre) shown alongside Pacific oyster seed (bottom)
(Source: Aquafish Solutions Ltd.)

Small seed of 2 to 4mm would require some form of intermediate on-growing stage post hatchery either intertidally or through the use of Floating Upweller Systems (FLUPSY). Seed oysters for seabed cultivation will require on-growing within some form of containment until they are large enough to be placed out at sea.

Whilst the size at which they can be placed out will vary between sites, even 6 to 10mm seed are likely to require a further full growing season within containment prior to re-laying at sea i.e. seed size of 15g+.

In terms of seed costs, Seasalter Walney now has a standard price covering both native and Pacific oysters. As an example, the price quoted by Seasalter Walney per 1,000 oysters for ~10mm shell length (6mm sieve size) is €10.75 which roughly equates to £9. This equates to a cost per million seed of approximately £9,000 or a minimum order price of around £20,000.

By way of a comparison, the cost of oyster seed from the Ardtoe Hatchery varies between Pacific and native oysters with Pacific oysters being 20% less expensive than native oysters. The cost per 1,000 4mm shell length native oysters is quoted as £10.08 or £10,080 per million plus carriage. No minimum order is specified.

3.3.2 Pond Production of Seed

Extensive pond production of native oyster seed has been investigated in the past as a potential means of helping with restocking and regeneration of wild fisheries. In theory this approach offers the opportunity to produce large numbers of low cost native oyster seed and so might be one way to produce the number of seed oysters that would be required for large-scale offshore culture.

Figure 3 shows the spatting ponds used by Rossmore Oysters to produce native oyster spat for re-laying. Production in a good year is reported as being the equivalent of 100 tonnes of adult stock. Larvae are produced by the broodstock within the ponds (~100 million larvae in total) and these are then settled on to mussel shell. Once the spat reach about 1 to 5mm in size they are then re-laid within sheltered beds.

Figure 3: Rossmore Oysters' native oyster spatting ponds, Cork, Ireland (Source Image: Tristan Hugh-Jones)

Figure 4 shows the settled spat being collected from the ponds once they have reached the size at which they can be re-laid.

Figure 4: Spat collection from Rossmore Oysters' ponds (Source Image: Tristan Hugh-Jones)

In the UK a research project was carried out at Seasalter Shellfish (Whitstable) Ltd. under FIFG funding that sought to describe and document this pond production approach to rearing native oysters for later re-laying (see Section 7.2 – Native Oyster Restoration). Figure 5 shows the larval settlement ponds and nursery system that were constructed as part of these trials.

Figure 5: Spat settlement pond and nursery system at Seasalter Shellfish (Whitstable) Ltd. (Source Image: Aquafish Solutions Ltd. and John Bayes)

With further development work and a suitable location it seems reasonable to assume that this method could be refined to the point where it could be successfully used to rear large numbers of native oyster seed within the UK.

3.3.3 Wild Seed Collection

The production of seed oysters using either hatchery or pond production techniques requires a significant capital investment and on-going operational resources. The collection of wild seed could therefore be seen as a very cost effective way of obtaining new stock for on-growing. Indeed a significant portion of French Pacific oyster farming still relies on wild settled seed. The drawback with the use of wild settled seed is considered to be a lack of control over production traits such as growth rates or disease resistance.

The term ‘cultch’ refers to any material placed on the oyster grounds that can then act as a settlement substrate for spat. The most commonly used material is old clean (free of flesh) shell. Oyster shell is said to have the best attractant properties although cockle, scallop, mussel and slipper limpet shell are also considered to be effective cultch materials (see Figure 6).

Figure 6: Fast growing 1 year old native oysters attached to shell cultch (Source: Tony Legg, Jersey Sea Farms)

The laying and management of cultch is normally carried out using the same fishing vessels employed in the oyster fishery. Distribution methods for cultch include simply tipping shell material over the side of the vessel or washing the material off the deck using deck hoses.

Actively managed *O. edulis* dredge fisheries have traditionally employed a variety of management measures to ensure the provision of clean cultch material for settlement. The primary objective of cultch management is to 'clean' the cultch material through the removal of silt or mud thus leaving it available for the spat to settle on. Harrowing is a traditional method of cleaning cultch. This involves repeatedly towing tooth and chain harrows over the oyster beds thus re-suspending the fine silt and mud which is then washed away by tidal action. In order to provide maximum benefit in terms of creating a suitable settlement substrate, harrowing is normally carried out in early to mid-summer just prior to the normal spawning season for the native oyster.

Suspended systems utilising commercially available settlement substrates, such as the French coupelles or Chinese hats constructed of PVC, can also be deployed in order to collect seed at times of natural availability. The settlement substrates used are normally dipped in a lime wash prior to deployment so as to give them similar settlement characteristics as natural shell. There are many 'recipes' for these lime washes but one example is given as follows:

Mix 2 parts sand with 4 parts lime and 6 parts cement using fresh water. Mix to a creamy consistency and then dip the settlement material into the mix. Allow the material to dry naturally before use. Figure 7 shows a suspended spat collection system using the French coupelles placed on plastic sticks. In this image some of the lime wash has broken off to reveal the coupelles.

Figure 7: Native oyster spat collection rig
(Source: Lawrence Eagling)

If settlement is successful using this type of rig then the seed oysters can be stripped off once they are a manageable size and then either re-laid or placed in containment for on-growing. Mechanised methods are available for stripping the sticks and coupelles.

3.4 Seabed Cultivation

3.4.1 Density and Depth Considerations

When distributing oysters for on-growing on the seabed a variety of methods can be employed. These can include washing from the deck (see Figure 9) through to more labour intensive methods such as shovelling from the boat deck or emptying bags over the side of a boat. The method favoured for distribution by Rossmore Oysters for their pond produced spat (see Section 3.3.2) is shovelling from the deck into beds that are marked at the corners using buoys (see Figure 8). For relatively shallow and sheltered sites then sticks can be used for marking the beds.

Figure 8: Native oyster spat distribution by Rossmore Oysters
(Source Image: Tristan Hugh-Jones)

Density control in shallower waters was considered by Rossmore Oysters to be good but will be less easy to control in deeper more exposed sites. In these more fully offshore sites densities achieved will be dependent on the rate of introduction of oysters, depth of water, current velocities or state of tide, drift of the boat etc.

Oyster density on the seabed should be at least a minimum of 10 oysters per m^2. Upper density limits will depend largely on the productivity of the site and any density dependent disease affects but with a likely maximum of 20 to 30 oysters per m^2. The use of GPS type systems for recording where oysters are re-laid is essential.

The maximum water depth to which seabed cultivation of native oysters can be carried out will primarily be dictated by the availability of their phytoplankton food source. If the oysters are placed too deep, where phytoplankton levels are low, then a consequent reduction in growth rates will occur.

Offshore, where wave action may be greater, the need to provide food for the oysters must be matched against the potential effects of wave action which may cause movement of the shellfish, or possibly smothering, should sediments become mobile under these conditions. A balance must therefore be achieved between providing the oysters with enough food to promote reasonable growth rates whilst avoiding the possible negative effects of a high energy marine environment.

3.4.2 Subtidal Harvest Using Eco-harvesters

For relatively shallow and sheltered waters it may be possible to use an ‘eco-harvester’ which is an aquaculture barge fitted with a ‘pump-scoop’ harvesting system and elevator (see Figure 9).

Figure 9. Eco-harvester operating on a south coast site
Left-hand image: Pacific oyster seed being spread over an on-growing site.
Right-hand image: Harvesting of oysters using an elevator dredge.
(Source: Aquafish Solutions Ltd.)

Whilst this system is very effective in shallow waters with relatively constant depth it is not designed for operations in deeper water where more traditional dredge designs would be required.

3.4.3 Subtidal Harvest Using Dredges

Hand-hauled Dredges: Light weight hand-hauled dredges such as those still employed in the Fal oyster fishery (see Figure 10) of Cornwall were used in South Wales for at least 500 hundred years until the early 20th Century when the advent of powered vessels enabled the use of larger dredges.

Figure 10: Traditional hand-hauled native oyster dredge from the River Fal
(Source: Salacia-Marine)

Light dredges used today still follow the same basic design with a mild-steel A-frame to which is attached a 'chain belly' made up of steel rings which combined with an upper netting section form the 'bag' where the catch is collected. The 'scythe' or blade at the front of the dredge can take various forms but is usually a rubber blade or a simple round wooden bar akin to a broom handle. Light dredges vary in size between 0.75 to 1.0m with their size dictated by the ability of the fishermen to recover the combined weight of the gear, retained oysters and associated by-catch. Hand-hauled dredges are generally deployed from small open fishing vessels <8m in length by a variety of methods:

- **Anchor dredging:** This involves anchoring the vessel then paying out the anchor warp (usually around 100m) then shooting the dredge and pulling the vessel and dredge using the anchor winch back to the anchor. This approach is used by the 'haul–tow' boats in the Fal oyster fishery where the anchor capstan is manually operated.

- **Sail dredging:** Also undertaken in the Fal oyster fishery where traditional oyster smacks are employed to drag small dredges which are recovered by hand. When the tidal currents are sufficiently strong the vessels drift with the current during hauls and then sail back up stream.

- **Powered tows:** Small dredges such as these can be deployed either singly or in pairs from powered vessels for short periods before being recovered by hand. Discussions with fishermen familiar with this gear suggest that it is essential to keep the vessel speed as slow as possible. It is very common that the tide is used to pull the dredge with the engine being used to slow the vessel and provide steerage.

Heavy Dredges: Heavy dredges employed by larger fishing vessels are of a similar design to hand-hauled dredges but scaled up accordingly (see Figure 11). The basic design remains the same with an A-frame forming the basis of the dredge with a belly of steel rings, however the upper net bag is often replaced with a continuation of the belly rings. The main differences are the addition of strengthening bars to the A-frame and often a rectangular or curved frame to the mouth of the bag to keep it open.

Scythe design varies according to the nature of the seabed being worked. A recent innovation employed in areas of the UK with *Crepidula fornicata* infestation is the addition of a 'ladder' across the mouth of the bag intended to reduce bycatch of *C. fornicata* chains. The dredge size is dictated by the size and power of the fishing vessel, but is generally around 1.5m across.

This type of dredge is usually deployed either singly or in pairs from fishing vessels equipped with a hydraulic trawl winch and aft A-frame for lifting onto the deck. The dredge is deployed over the stern of the vessel and towed at a ~2 knots for short periods of around 2 minutes (Fen Duke, skipper of FV Emily Rose, pers. comm.). Under 12m trawlers are the most commonly employed type of vessels in UK oyster dredge fisheries, usually switching from other fisheries in the winter months.

Figure 11: Oyster dredges used in the Chichester Harbour and Solent oyster fisheries (Source: Sussex SFC).

Oyster Tongs: A common oyster fishing method employed in the eastern USA, but not currently used in UK fisheries for *O. edulis*, is the use of oyster tongs (see Figure 12). These tongs are a form of long-handled basket normally deployed in shallow waters where they manually remove oysters from the seabed using a scissor-like action. Vessel sizes employing the use of tongs generally range from small skiffs up to 10m+ vessels. In deeper water a modified version colloquially named Patent Tongs are used. These Patent Tongs have been shown to be very efficient at harvesting oysters when compared to dredges.

Figure 12: Oyster tongs
Left-hand image: Typical oyster tongs used in Crassostrea virginica fisheries in the USA
Right-hand image: Patent tongs being recovered (Source: Maryland Watermen's Association)

In general these oyster tongs are used on flat substrates, free of rocks or stones, where there is a relatively high stocking density. These conditions may well mirror suitable benthic subtidal areas for native oyster cultivation in the UK and as such may be worth consideration in future trials.

3.5 Fixed Gear Cultivation

3.5.1 Site Selection and Location of Fixed Gear Cultivation

Site selection will be based on a number of factors including water temperature (max/min and average), water quality, phytoplankton levels, seed availability, substrate type, water depth, current velocity, other marine uses etc.

There have already been some moves ‘offshore’ in terms of other shellfish such as rope mussel culture. Up until recently in the South West of England these rope mussel farms have been limited to nearshore sites where they still receive a degree of protection from the prevailing weather conditions (see Figure 13). However trials are currently underway off the south coast of England to test the performance of true offshore farms operating in exposed conditions.

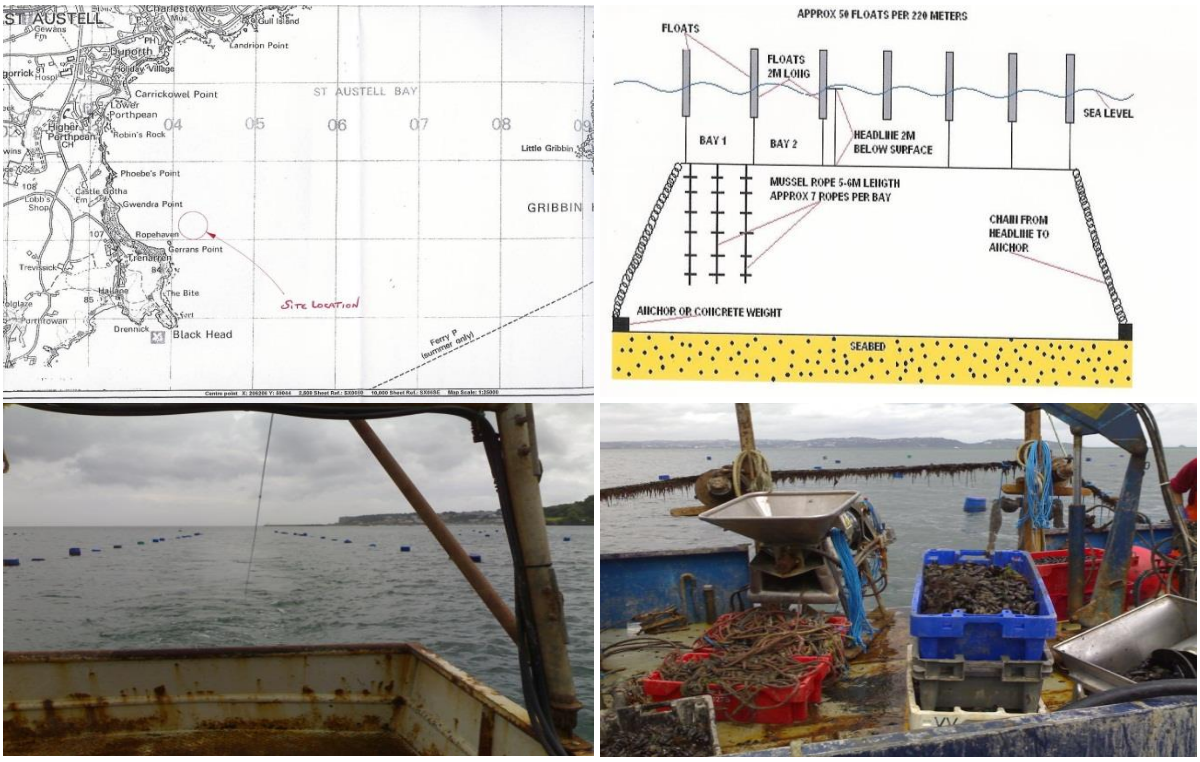

Figure 13: South West England-based nearshore rope-mussel cultivation operations
Images: Top Left = St. Austell Bay, Cornwall; Top Right = Generalised longline system design used in the SW; Bottom Left = View across Torbay from harvesting vessel; Bottom Right = Processing equipment aboard Devon-based mussel harvesting-vessel
(Source: Aquafish Solutions Ltd.)

In general the techniques used in these nearshore sites do not vary much from those used in the sheltered estuarine or sea loch environments where much of UK rope-grown mussel production takes place. This technique is however proving successful where it has been tried in South West England and the lessons learned could equally be applied to small to medium scale suspended cultivation of native oysters in nearshore waters.

It seems likely that the move to more truly offshore, higher energy environments, will be based on the development of large-scale shellfish farms. These farms will require significant capital inputs in terms of a high number of specialised and innovative longline systems designed to operate under extreme environmental conditions. Longlines employed are likely to be serviced by purpose built vessels.

The larger spaces available offshore means that farms can be of a low density design which would therefore have a low environmental impact from farm operations. Large-scale production will mean lower unit production costs and an increased potential for mechanisation. The high capital outlay for these systems means that high output levels will be required if farms are to be economically viable. This type of farm operation will therefore be a departure from the nearshore type of operation shown in Figure 13.

3.5.2 Design Considerations for Suspended Shellfish Cultivation

The majority of development work to date in terms of offshore suspended shellfish cultivation has been on mussels as they show rapid growth to market size and attach naturally to substrates through means of byssus production. The ability to self-attach to a cultivation substrate means that they do not require the use of containment structures in the same way as oysters.

Figure 14 shows a design being considered for offshore mussel cultivation off the Californian coast using continuous looped droppers attached to a buoyed headline submerged at 10m. There are also plans with this farm to cultivate oysters in containment alongside the mussels.

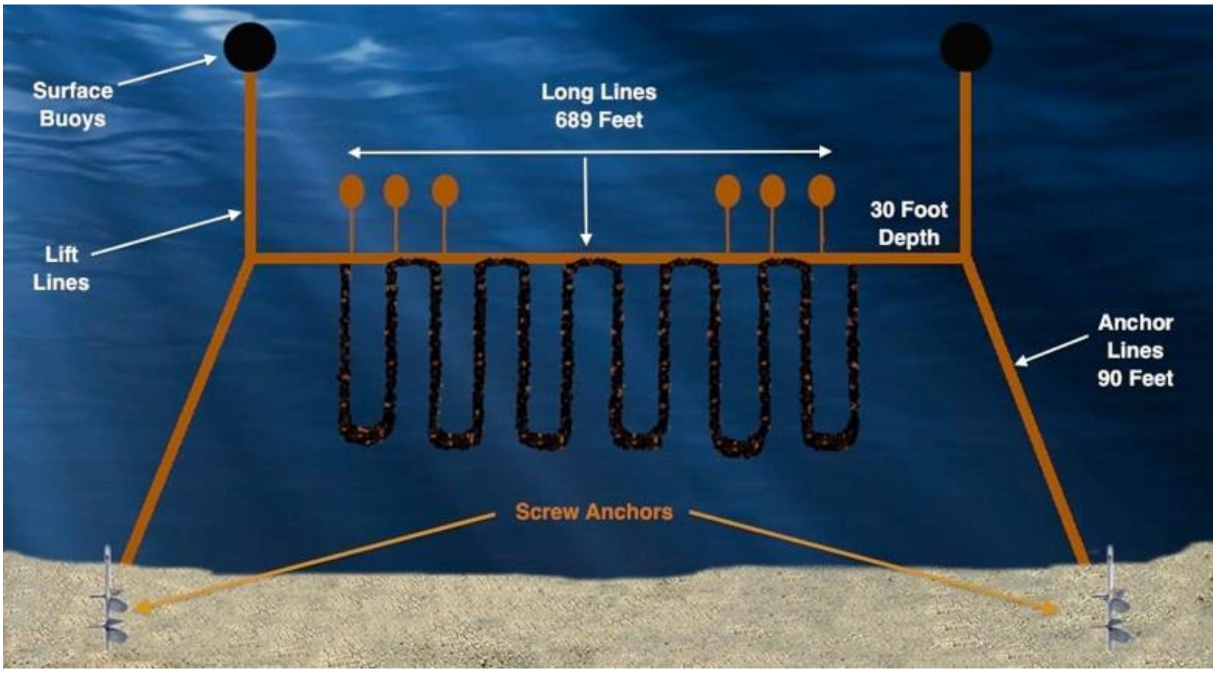

Figure 14: Individual longline system from the Catalina Sea Ranch proposal (Source: http://www.catalinasearanch.com/)

The main headline shown in Figure 14 will be around 200m long and the whole longline will be secured with screw anchors. This is generally in keeping with the main design parameters of other offshore mussel farms.

The advantage of the submerged system is that the shellfish are located away from the most extreme impacts of wave action which occur at the sea surface. In deep water, the water particles are moved in a circular orbital motion when a wave passes. The radius of the circle of motion for any given water molecule decreases exponentially with increasing depth (see Figure 15). The wave base, which is the depth of influence of a water wave, is about half the wavelength. At depths greater than half the wavelength, the water motion is less than 4% of its value at the water surface (Source: http://en.wikipedia.org/wiki/Wave_base).

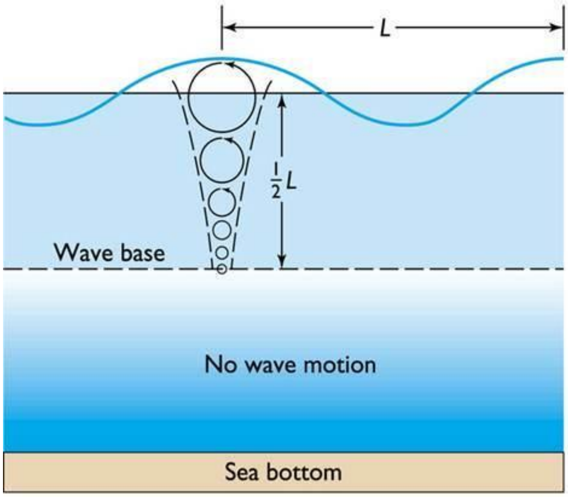

Figure 15: Decay of wave energy with depth
(Source: www.tulane.edu/~bianchi/Courses/Oceanography/Chap7.ppt)

Therefore by placing the shellfish below the surface the chance of losses through wave action are reduced. The use of pencil floats (see Figure 13) at the surface as opposed to circular buoys is recommended as their profile creates less resistance to vertical water movement. This means that pencil floats help to reduce the rise and fall of the longline with sea swell. Reduced motion of the longline is preferable as this will decrease stress levels on the shellfish and therefore promote faster growth. As with seabed cultivation however the shellfish must not be placed so deep that there is insufficient food to allow reasonable growth rates.

The amount of access and working time on any given offshore site will be governed by the prevailing weather and sea conditions versus the stability and windage of the aquaculture vessel. In general, larger boats (see Figure 16) are better able to work in rough conditions although they are also likely to have more windage than smaller vessels meaning that careful consideration must be given to the design of vessels for any particular site.

Figure 16: Examples of New Zealand mussel harvesting vessels
Left-hand image shows harvesting in a nearshore site; Right-hand image shows offshore harvesting with recreational sea angling boats in the background
(Source: Offshore Shellfish Ltd.)

3.5.3 Suspended Cultivation Techniques for Oysters

There are several purpose designed shellfish cultivation systems currently being produced worldwide that would be suitable for fixed gear or suspended cultivation of native oysters. An example of the Australian AquaTray system produced by TTP Plastics (Tooltech) is shown in the Figure 17. With this system the trays can be separated by risers (as shown) or placed flat together where smaller oysters are being on-grown or where sea conditions are rougher and the systems may be subject to more movement.

Figure 17: Australian AquaTray system being used in offshore suspended culture of Pacific oysters
Top left image: Purpose built aquaculture vessel for use with AquaTray system
Top right image: AquaTrays being deployed offshore (marker buoy in background)
Bottom image: AquaTrays after recovery from subtidal culture (Source: Peter Hoare)

A Californian five-tiered lantern net system currently being used by the Santa Barbara Mariculture Co. to farm Pacific oysters is shown in Figure 18. This farm is 28 hectares (70 acres) in size and located about 1.2km (0.75 miles) off the Santa Barbara coast. The farm uses twelve 137m longlines submerged to a depth of 6m and running parallel to the shore in between 24 to 27m depth of water. The area receives 0.5 to 1m per second wind chop on a regular basis and 3m swell occasionally.

Extreme sea conditions are rare but may reach 6m swells and 60-knot winds. The farm is serviced where possible on 2 to 4 days every week, year round. Testing is carried out each week for algal toxins (PSP and ASP) and the water is also tested for faecal coliform levels on a monthly basis and after heavy rainfall events. Survival of the hatchery reared oyster seed is reported to be excellent under these offshore conditions.

Figure 18: Five-tiered lantern net used for open water oyster culture.
Note: The main longline is shown with the hydraulically driven retrieval block.
(Source: Cheney et al., 2010 – see Section 7.2 – Offshore Bivalve Cultivation)

The 137m longlines are constructed of 25mm diameter rope with no metal connections. The longlines are kept in place using concrete anchors designed to grip the ocean floor. Longlines are reported to have an operational life of up to 7 years. Each longline can hold up to 6.8 tonnes of shellfish. As shellfish grow then more floats are added to maintain the 6m depth.

At harvest a mechanical line hauler retrieves the head-line and the lantern nets containing the Pacific oysters are swung on-board. The lantern net system doesn't however lend itself to mechanical handling and so servicing of these systems (e.g. cleaning of biofouling) is a labour intensive process. Productivity and condition indices are both reported as being high with Pacific oysters grown from 6mm seed to a market size of 100mm in 10 months.

SECTION 4 – DISEASE, PEST SPECIES AND BIOSECURITY

4.1 Shellfish Diseases and Parasites

Bonamiosis is a disease of the native oyster, *Ostrea edulis*, affecting both wild and cultivated stocks, and is caused by infestation with the protozoan parasite, *Bonamia ostreae*. It was first recorded in Europe in the 1970's following the investigation of oyster mortalities in French shellfish farms.

The first recorded incidence of Bonamiosis in the British Isles occurred in 1982 in the River Fal. Although the disease can produce mortality rates as high as 80% in affected oysters, within the UK the prevalence of *Bonamia* in farmed oyster stock can be kept relatively low by following good management practices, and typically reaches 10 to 20% with relatively low levels of mortality (up to ~20%) (Source: http://www.defra.gov.uk/aahm/files/Guide-Bonamiosis.pdf).

Transmission of *B. ostreae* between individuals is thought to be density dependent requiring the close proximity of oysters for infection to take place. Whilst mortality levels in low density wild stocks may therefore be relatively low, culture of native oysters in high densities does run a risk in *B. ostreae* positive areas that high mortality levels in stock may occur. The UK operates restriction zones (Confirmed Designations) where *Bonamia* has been isolated, preventing the movement of susceptible stock from a controlled zone into a clear area.

Bonamia exitiosa is known to cause high mortality levels in affected stocks of native oysters and whilst considered to be an exotic disease to the European Union, it was found in *O. edulis* in north western Spain in 2007 and then subsequently in southern Spain (linked with imported oysters from Italy), the Adriatic coast of Italy and then in France in 2007/08. Unlike with *B. ostreae*, Pacific oysters are thought to be a transmission vector for *B. exitiosa*. This new form of *Bonamia*, *B. exitiosa*, was identified in the UK after investigative work on the River Fal native oyster stocks. However after repeated testing it has now been confirmed that this area, and therefore the UK, is considered free of *B. exitiosa*.

Macro-parasites can also be an issue for native oysters in terms of either their impact on general oyster growth performance and condition or in terms of the visual appearance of what is considered to be a premium oyster product. An example of a macro-parasite of native oysters is *Polydora ciliata* which is a bristleworm that burrows into calcareous substrates, including oyster shells (see Figure 19).

Whilst *P. ciliata* doesn't attack the actual oyster tissue within the shell it does cause damage and weakening of the shell structure that can then leave the oysters more open to predation. Where this bristleworm reaches and damages the inner lining of the shell, the oyster will normally lay down a nacreous layer to seal the perforation (Source: Marlin). The resulting 'blister' will often contain anoxic black mud which if perforated during oyster opening can release hydrogen sulphide (rotten egg) gas.

Heavy infestation has also been shown to reduce the condition and therefore flesh content of oysters and as such *P. ciliata* can have a significant detrimental impact on market acceptability of an oyster product.

Figure 19: Native oyster (top middle) showing indications of Polydora infestation (Source: Aquafish Solutions Ltd.)

Previous work looking at suspended native oyster cultivation in offshore waters has shown reduced levels of macro-parasitic infestation. Therefore it seems that where parasitic infections are an issue that suspended culture in the offshore environment may be one method of avoiding reductions in product quality.

4.2 Pest Species

A variety of pest species, both native and non-native can affect native oyster cultivation operations. These pest species include the native green crab (*Carcinus maenas*) and starfish (*Asterias rubens*) as well as the invasive non-native slipper limpet (*Crepidula fornicata*) and the American whelk tingle *Urosalpinx cinerea* and may in the future include the carpet sea squirt *Didemnum vexillum*.

Whilst green crab and starfish predate upon native oysters, slipper limpets compete with the native oyster for both space and food and have no natural predator in the UK which means that this highly successful invasive species can occur in very high densities at some sites. In high densities *C. fornicata* is able to modify the underlying habitat by rapid deposition of pseudofaeces which forms a cohesive mud that inhibits *O. edulis* larval settlement and smothers the living oysters. *C. fornicata* is present in Milford Haven and Swansea Bay. *Urosalpinx cinerea* is not recorded in Wales.

In addition to predation and impacts on the native oyster's habitat, pest species can also pose an operational issue in terms of fouling that must then be removed before the product can be placed on the market. Examples of fouling organisms include the slipper limpet as well as calcareous tube worms and sponges (see Figure 20).

 

Figure 20: Fouling organisms of native oysters
Left-hand image: Light tube-worm fouling on a wild caught native oyster.
(Source: Aquafish Solutions Ltd.)
Right-hand image: Sponge encrusting the whole upper shell of a native oyster.
(Source: Salacia-Marine).

Where pest species already exist then eradication is likely to be difficult to achieve. Management techniques, i.e. keeping pest species numbers within operational tolerances, include the following:

- **Green crabs:** Baited pots can be used to control crab numbers.
- **Starfish:** Techniques generally involve physically removing starfish from the oyster bed and include starfish 'mops'; roller dredges; diver collection.
- **Slipper limpets:** Dredging to limit population numbers; smothering with other shellfish e.g. mussel seed as was undertaken in the eradication of an accidental introduction into the Menai Straits; regular chain harrowing.
- **Carpet sea squirt:** Possible control of introduction of the species by washing stock and equipment with freshwater.

For a comprehensive review of possible pest management methods please see CCW Contract Science Report No. 960 (Section 7.2 – Native Oyster Restoration). General information about invasive non-native species in Great Britain can be found at the website of the GB Non-Native Species Secretariat as follows:

http://www.nonnativespecies.org/home/index.cfm

4.3 Biosecurity

Given the risks posed to native oysters and other native marine species and habitats through potential disease or invasive non-native species introductions it is obviously vital to ensure biosecurity is prioritised at all levels of farm operations. Indeed, as described in Section 2.3, it is a requirement for the issue of an APB license that a Biosecurity Measures Plan has been produced and approved by CEFAS and that all shellfish movements are recorded.

Awareness of the diseases that can affect the shellfish being farmed is essential. As described in Section 4.1 the most significant disease affecting native oysters in the UK is *B. ostreae*, a serious parasitic disease of native oysters for which restrictions on movements are in place. Movements of *O. edulis* in the context of *B. ostreae* can be reasonably undertaken in terms of biosecurity as long as the oysters originate from areas which have an equal (or higher) health status as the receiving area. Movements of shellfish from restricted areas, known as Confirmed Designations, within England and Wales will require the permission of the Fish Health Inspectorate (FHI) based at the CEFAS Weymouth Laboratory. Confirmed Designations are listed on the website as follows:

https://www.gov.uk/prevent-fish-or-shellfish-diseases#control-areas-for-notifiable-disease-outbreaks

As well as the potential for transfer of disease, movements of shellfish species for re-laying have in the past been associated with accidental introductions of non-native species. One example within Wales was the movement of *C. fornicata* into the Menai Straits in North Wales following a movement of mussel seed. The role that these types of shellfish movements might play in the spread of non-native species is only now being recognised and there have been calls for tighter controls in this respect such as the introduction of movement controls similar to those used for notifiable diseases such as *B. ostreae*.

4.4 Aquatic Animal Health Certification

Recognising that movements of live shellfish for farming can pose a risk of disease transfer, imports of shellfish from other EU Members States are subject to controls, and all movements of live shellfish between European countries for farming require some form of animal health notification. At a minimum this will be an electronic TRACES notification, whilst many movements will require inspection and health certification. It is important to understand that the animal health certification described here is different from the movement documents required under food safety regulations for shellfish harvested for human consumption.

In England and Wales, if a site wishes to import native oysters for farming, it must first be authorised by the FHI as an importer then each import must be accompanied by a valid health certificate signed by the competent Veterinary Authority in the Member State of origin. The importer is responsible for ensuring that any native oyster imports are made in accordance with the rules, and the FHI must be notified at least 24 hours in advance of any import taking place using form AAH1, available online here:

https://www.gov.uk/government/collections/aquatic-animal-health-and-movements-forms

Exports of shellfish for farming from England and Wales to the EU must be notified to the FHI at least 5 working days in advance, since they may require a health certificate in which case a physical inspection at the site of origin is required.

Imports from third countries (those outside the EU) are only permissible from parts of the USA, and advice should be sought from the FHI at an early stage. Exports to third countries will have to comply with the requirements of the country to which they are being sent, and guidance should be taken from the receiving competent authority. For further information from the FHI on movements of shellfish please see the following web-link:

https://www.gov.uk/government/collections/aquatic-animal-health-and-movements-guides

SECTION 5 – SHELLFISH AND FOOD HYGIENE

5.1 Classifications and Hygiene - Overview

In common with all oysters, the native oyster is a filter feeding bivalve mollusc and so has the potential to bioaccumulate microbial contaminants and algal toxins that can cause illness in humans. Of particular risk to human health are shellfish that are either eaten raw or lightly cooked, such as the oyster. Shellfish Classification (see Section 2.4), originally drawn up under the Shellfish Hygiene Directive (SHD), provided public health protection from the consumption of shellfish which are accepted as being a potentially high risk food.

The use of *E. coli* levels in bivalve molluscs as an indicator for Classification of harvesting waters is readily justifiable on scientific grounds as the presence of *E. coli* is evidence of recent contamination by human sewage or animal faecal matter. If high levels of *E. coli* are recorded then this can have very serious economic impacts on shellfish growers as they are then required to either re-lay by moving stock to cleaner water or heat treat the shellfish. In terms of the Classification system, where 'downgrades' in Classifications from B to C take place then ultimately this may put the shellfish farmer out of business as the extra work involved in re-laying, or the lower price received for heat treated shellfish, will often make the farm financially uneconomic to operate. Whilst many European countries have a high percentage of Class A waters where growers can sell direct to the market, in England and Wales these form only ~1% of beds placing businesses at a disadvantage compared to foreign imports as many major retail chains will only buy product from Class A waters. Shellfish from Class B waters require purification which involves both capital outlay for equipment and then an on-going operational cost.

Despite significant investment in infrastructure and technology to remove faecal contamination from public waste water discharges in recent years it has become apparent that Classification status is decreasing and that agricultural inputs or 'diffuse pollution' remain significant in many catchments and may dominate in some catchments at certain times of the year. Moving offshore therefore provides an opportunity for shellfish producers to avoid the potential impacts of diffuse pollution on Harvesting Classifications. There is also the potential that a greater number of A Grade Classifications could result from a move offshore. Stable Classifications would certainly encourage confidence in this sector and would be likely to lead to greater levels of investment in the shellfish aquaculture industry.

5.2 Classifications and Treatment of Shellfish

The setting of the Classification for a bivalve shellfish harvest area dictates what, if any, post-harvest treatment is required before the shellfish can be placed on the market. The differing treatment levels for each Classification category are described as follows:

Class A: Shellfish can be harvested for direct supply to the market and then human consumption, providing all other End Product Standards are met (see Section 5.4.1).

Class B: Shellfish can go to market after depuration in an approved centre or after re-laying in an approved Class A re-laying area. Alternatively the shellfish can be subject to an EC approved heat treatment process.

Class C: Shellfish can go to market only after re-laying for at least 8 weeks in an approved re-laying area, i.e. higher quality water Classification, and then depurated where necessary in an approved centre. Alternatively the shellfish can be subject to an EC approved heat treatment process.

Prohibited Area: Shellfish must not be harvested or offered for human consumption.

5.3 Shellfish Hygiene

5.3.1 Bacterial Contamination of Shellfish

Improvements in public health over the last century together with more effective hygiene controls on shellfish production areas have meant that diseases such as typhoid, paratyphoid fever and other gastroenteritis caused by the *Salmonella* spp. bacteria found in sewage are now not so widespread. Non-sewage related bacterial illnesses include the pathogenic *Vibrio* spp., especially *Vibrio parahaemolyticus* and *Vibrio vulnificus*.

5.3.2 Depuration of Bivalve Shellfish

The development of purification or depuration (controlled purification) as a method of eliminating bacterial contamination from shellfish dates back to the beginning of the last century when outbreaks of typhoid fever associated with the consumption of sewage contaminated shellfish occurred both in the US and Europe. The earliest purification technique simply involved the re-laying of shellfish in clean seawater.

The chemical sterilisation of seawater was developed ~1915 at the shellfish research station at Conwy in North Wales and in the 1920's the use of ozone for water sterilisation was introduced in France, a technique that is still widely used in many parts of Europe.

It was not until the 1950s that the use of ultraviolet sterilisation of seawater was introduced which proved popular as it did not leave residues or by-products in the seawater. Today we normally refer to depuration as a managed or controlled process that takes place within an approved premises. As re-laying of shellfish in cleaner water is not a controlled process then it is no longer considered to be depuration.

Operated correctly within approved premises, modern depuration systems (see Figure 21) based on UV sterilisation, ozonation or combinations of water sterilising technology ('hybrid' systems) have proved to be extremely effective in reducing bacterial contamination levels within shellfish and thus providing a safe food product in this respect.

For examples and technical information regarding different depuration systems, including information on the Sea Fish Industry Authority (Seafish) standard design purification systems, please refer to the publication section of the Seafish website http://www.seafish.org/publications-search.

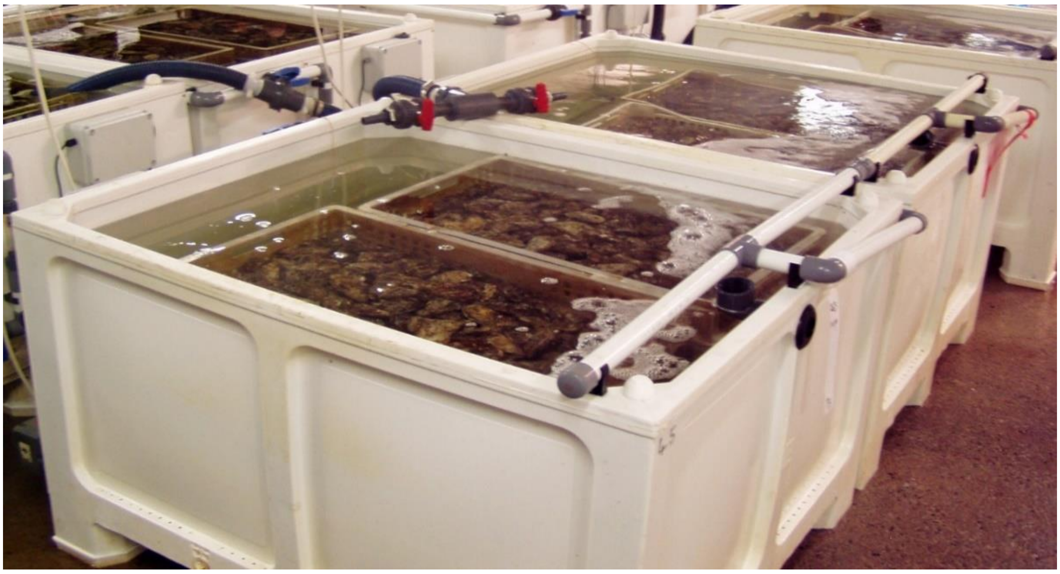

Figure 21: Small scale shallow tank depuration system (Source: Aquafish Solutions Ltd.)

Under EC Regulation EC 853/2004 the approval for shellfish purification plants to operate must be given by the Local Enforcement Authority. Conditions of Approval will be issued following a technical inspection and microbiological challenge test. For further information on the inspection, challenge testing and approval process see the CEFAS website as follows:

http://www.cefas.defra.gov.uk/our-science/animal-health-and-food-safety/food-safety/purification-plants.aspx

Training in the correct use and operation of bivalve purification systems is available to industry through the Seafish and Royal Environmental Health Institute of Scotland (REHIS) accredited courses which are delivered in England and Wales by the Southern Shellfish Training Centre (see Section 7.1 for contact details).

For a comprehensive overview of the depuration of bivalve shellfish please refer to the FAO Fisheries Technical Paper (No. 511) available via the following web-link:

http://www.fao.org/docrep/011/i0201e/i0201e00.htm

5.3.3 Viral Contamination of Bivalve Shellfish

In recent years it has been recognised that in Europe that viral contamination of shellfish now forms the major part of shellfish related illnesses with norovirus being the most common cause of illness. Businesses are increasingly turning to self-monitoring to protect product reputation and to limit product recalls. Unfortunately, whilst depurating shellfish is generally effective for the removal of bacterial contamination it is not effective in removing pathogenic viruses such as norovirus which are only eliminated slowly from shellfish.

Avoiding viral contamination of shellfish during production is therefore seen as key to minimising public health issues in this respect. Whilst norovirus can survive in seawater for long periods it would however seem logical that the further offshore that shellfish are cultivated the less will be the likelihood of the problems posed by norovirus contamination of shellfish. It would seem therefore that offshore cultivation of native oysters could offer the chance to avoid the problems associated with viral contamination of shellfish, giving the offshore shellfish producer a major advantage over many of the inter-tidal producers of oysters. An alternative way of looking at this may be that oysters grown inter-tidally could be 'finished' offshore i.e. held in norovirus free offshore waters until norovirus levels are considered to be at a level whereby there is no threat to the consumer.

5.3.4 Emerging Shellfish Hygiene Issues

There are new emerging microbial threats which have implications to both waters and bivalve shellfish of all species and which could become problematic in the future. *V. parahaemolyticus and V. vulcanus*, marine strains of *Vibrio* bacteria, are warm water estuarine species whose increased incidence has been linked with climate change. These strains are becoming widely spread in the marine environment and are particularly associated with sediments. They can cause periodic problems such as following summer storm events when conditions are optimal for growth with high temperatures and reduced salinity. Some *Vibrio* species have also recently been implicated in producing toxins such as Tetrodotoxin (TTX) normally associated with puffer fish.

Antibiotic resistant *E. coli* are an increasing cause for concern and can be associated with waste water treatment works or with agricultural practices. As with norovirus, offshore production would be likely to remove bivalve shellfish from likely contamination sources in this respect.

5.3.5 Toxic Algal Blooms

Phytoplankton or microalgae are simple marine plants that form the primary food source for many marine bivalve molluscs. However, of the 5,000+ species of phytoplankton that exist worldwide about 2% are known to be harmful or toxic (Source: Wikipedia). Where these toxin producing algae occur in large numbers then they are often referred to as harmful algal blooms or HABs. Certain species of phytoplankton are associated with producing biotoxins that can be the cause of shellfish poisonings in consumers (see Figure 22). Biotoxins implicated in shellfish poisonings include the following:

- **Okadaic Acid:** Produced by the dinoflagellate *Dinophysis*, this biotoxin is responsible for causing Diarrhetic Shellfish Poisoning (DSP).

- **Saxitoxin:** Produced by the dinoflagellate *Alexandrium*, this biotoxin is responsible for causing Paralytic Shellfish Poisoning (PSP).

- **Domoic Acid:** Produced by the pennate diatom *Pseudo-nitzschia*, this biotoxin is responsible for causing Amnesic Shellfish Poisoning (ASP).

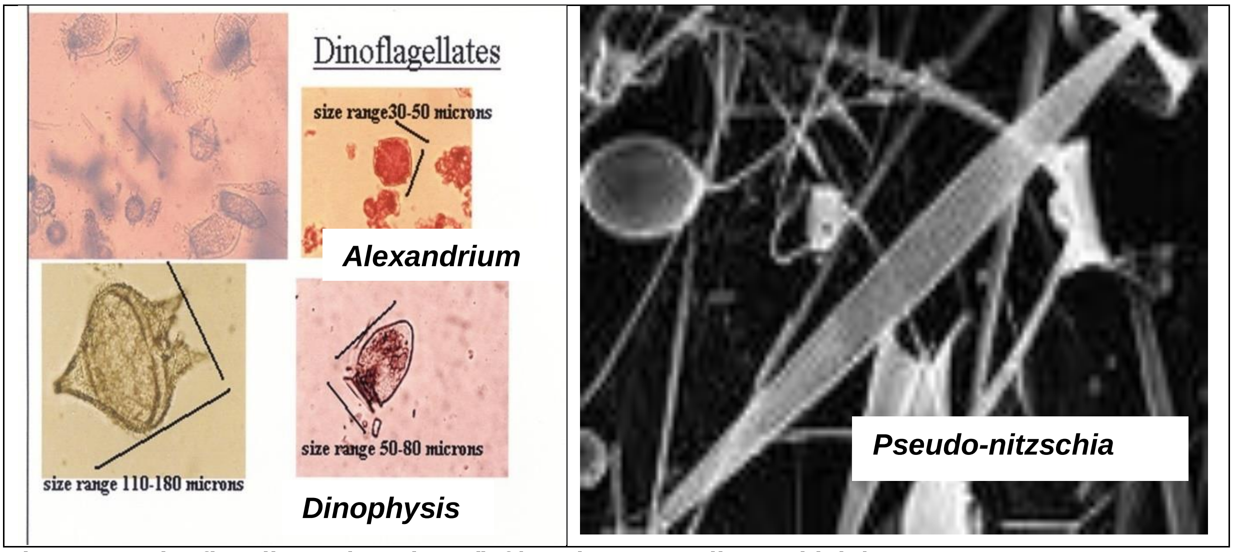

Figure 22: Dinoflagellate microalgae (left) and pennate diatom (right)
Notes: Top right dinoflagellate is Alexandrium which causes PSP; bottom right is Dinophysis which causes DSP. Pennate diatom is Pseudo-nitzschia which causes ASP.
(Source: Southern Shellfish Training Centre)

Due to the potentially serious health impacts that some of these toxin producing phytoplankton can have there is a monitoring programme carried out around England and Wales by CEFAS on behalf of the FSA. This monitoring programme consists of a weekly analysis of seawater samples for the presence of these phytoplankton.

Where an alert level is recorded in a shellfish production area for these biotoxin producing phytoplankton then a Temporary Closure Notice and/or Warning Notices will be issued by the Local Enforcement Authority. These will remain in place until the waters and shellfish are found to be free of both the phytoplankton and associated biotoxins.

It should be noted that the FSA state that, whilst an official monitoring programme exists, it is the responsibility of Food Business Operators (FBOs) to ensure that the shellfish placed on the market do not contain biotoxins above permitted levels (see Section 5.4). In practical terms, for a shellfish farm there is little that can be done whilst a HAB is present other than avoiding harvesting until the harvesting water and shellfish are given the all clear.

In terms of testing, simple test kits are now available to industry which can detect the main biotoxins associated with these types of shellfish poisoning incidents. Over time FBOs involved with shellfish production will gain experience of their production areas and will build an understanding of the times of highest risk when HABs are likely to occur. With this knowledge FBOs can then increase testing at times of highest risk as part of their due diligence and in order to protect consumers.

For further information on the official monitoring programme see the following web-link:

https://www.food.gov.uk/enforcement/monitoring/shellfish/ewbiotoxin

5.4 Risk Management

5.4.1 End Product Standards and Testing

It is the responsibility of the FBO placing a food product on the market to ensure that it is fit for consumption and meets End Product Standards (EPS). Current EPS for live bivalve shellfish are as follows:

1. Less than 230 CFUs of *Escherichia coli* in 100g of flesh and intra-valvular liquid.
2. Must not contain *Salmonella* bacteria in 25g of flesh.
3. Be alive, fresh and in good condition.
4. Normal amounts of intra-valvular liquid at sale and adequate response of shellfish to percussive tap.
5. Must taste fresh, no off-flavours and be free of detritus.
6. Must not contain marine biotoxins in excess of permitted levels.

It is up to the FBO to decide how often End Product Testing (EPT) is carried out based on their own assessment of risk. The regulator may indicate the minimum number of animals required to produce enough flesh to make a microbiological or algal biotoxin test valid but will not specify how often the FBO should carry out the test. The reason for this is that the FBO should know their product better than anyone else and so are best placed to make an informed risk assessment of threats to human health.

FBOs can either hold the shellfish and release them only after testing, i.e. a system of positive release, or alternatively the FBO can decide on a frequency of EPT that gives them the confidence that they can observe trends and allows them to cease harvesting before critical levels of microbial or biotoxin contamination are reached. Collaboration with other harvesters in an area on sharing results may give a better picture of the overall potential microbial or biotoxin loading to be expected.

5.4.2 HACCP

There are many different routes by which bivalve shellfish intended for human consumption may become unfit for human consumption through microbial, chemical or physical contamination. Pre-harvest contamination routes include waste water flow or spills and diffuse pollution which may result in biomagnification. Post-harvest recontamination routes could include cross-contamination with undepurated stock, contamination by handlers or through poor storage.

Section 5.3.2 describes how depuration can be used to reduce low level bacterial contamination in bivalve shellfish but it is clear from the pre and post-harvest contamination routes that this is only one aspect of ensuring food safety and minimisation of risk to consumers. Therefore in terms of overall food safety, depuration should be viewed as part of a wider more all-encompassing system based around a Hazard Analysis Critical Control Points (HACCP) approach from production to dispatch.

The main principle behind the HACCP approach is that it focusses on identifying the 'critical control points' (CCP) in a food production process where food safety issues may occur, i.e. hazards, and then puts in place measures to monitor these points in order to prevent things going wrong. HACCP also provides corrective actions where a problem occurs.

The role of HACCP in helping to ensure a standardised approach to food safety is widely recognised and is indeed a legal requirement for depuration and/or dispatch centres. Seafish have developed a generic HACCP depuration template to help businesses comply with HACCP requirements but it is important that each FBO carries out a 'walk through' for their own business in order to identify the unique characteristics of their operational procedures that may be considered to be CCPs.

An overview of food hygiene legislation both national and European with particular emphasis on HACCP implementation can be found on the Seafish website as follows:

http://www.seafish.org/industry-support/legislation/hygiene

There is also an online tool developed by the FSA to help small business develop HACCP. This tool is available via the following web-link:

http://www.food.gov.uk/business-industry/manufacturers/myhaccp/#.U1owq7FwaM8

Specific training courses are available through Seafish in HACCP for live bivalve production as well as many other seafood industry based training courses and apprenticeships. Details about this training and apprenticeships are available via The Seafood Training Academy as follows:

http://www.seafoodacademy.org/home.html

5.4.3 Active Management

Over time shellfish producers will build up experience and an understanding of the characteristics of their particular production and harvesting beds and wider catchment. This 'local knowledge' should allow them to make informed decisions about their operational practises as weather conditions or other environmental parameters change. This proactive response to changing conditions based on dynamic risk assessments by the shellfish producers is termed 'active management'. For example, if there had been a recent CSO spill following heavy rainfall within or near a shellfish production area then a decision might be taken to voluntarily suspend harvesting until conditions had changed. There may then be scope to modify regulatory Classification sampling to match only the times when the production beds were being harvested thus avoiding unnecessary Classification downgrades for the producer whilst still ensuring public health protection (see Section 2.4.1 – Harvesters Own Sample Protocol).

Ideally, a mix of historical Classifications, active management and EPT should be employed to protect both the consumer and the producer. With this approach, the Classification system gives an overview of the historic hygiene status of the beds, active management is practised by the shellfish producer to provide proactive consumer safety and EPT is used as part of the due diligence thus maximising public health protection while protecting the reputation and livelihood of the shellfish producer.

In mainland Europe there is a more pragmatic and flexible approach to Classifying production beds and in setting minimum depuration times. Added to this, greater use of active management together with EPT means that the approach of shellfish producers in mainland Europe is closer to a HACCP-based risk management system.

Section 7.2 (Food Hygiene) contains a recommendation for further reading regarding good practise in microbiological monitoring of bivalve mollusc harvesting areas.

5.4.4 Good Manufacturing Practise Guidelines

The Sea Fish Industry Authority *Good Manufacturing Practise Guidelines* (GMPG – June 2007) provides an excellent step-by-step guide on how to adhere to best practise when preparing live bivalve shellfish for the market including signposts to relevant legislation.

The GMPG is available for download from the publications section of the Seafish website as follows:

http://www.seafish.org/publications-search

SECTION 6 – AQUACULTURE ECONOMICS AND MARKETS

6.1 Economics

There appears to be very little literature available concerning the economics, either actual or predicted, of subtidal or offshore native oyster cultivation. In many ways this is to be expected given the current low level of actual subtidal production that takes place. There has however been work carried out to assess the economic viability and minimum stocking densities of wild caught native oysters using different harvest methods namely hand-hauled dredging, power dredging and collection by commercial divers, although this economic assessment doesn't however reflect the cost of seed, mortality losses etc. associated with aquaculture operations. For further information please refer to CCW Contract Science Report No: 960 (see Section 7.2 – Native Oyster Restoration).

The Sea Fish Industry Authority Hyperbook series does include an Economic Modelling Tool for approximate calculations of economic performance of differing culture scenarios (e.g. seabed and suspended) for a range of shellfish species. This tool can be used to model various performance indicators from cash-flow through to Net Present Value (NPV) or Internal Rates of Return (IRR) calculations. These Economic Models do allow the user to assign costs to various production scenarios and they also have the capacity to build in user-defined costs. Whilst not designed for offshore aquaculture operations they could offer a rough guide to help define likely performance of differing aquaculture approaches to offshore culture and would provide a starting point for developing full business plans.

In order to give some insight into possible production values that might be associated with subtidal seabed cultivation of native oysters, at a low to medium density of 20 oysters per m^2, this would give a total number of oysters per hectare of 200,000. Using a recent market value of €6.50 per kg (~65 cents/oyster) for undepurated stock being sold into France, this would give a total value per hectare of cultivated seabed of €130,000 or £95,000. By comparison, prices for depurated native oysters sold direct to top-end restaurants in the UK are likely to be in the region of £8.00 to £10.00 per kg (when allowing £100/tonne for depuration costs). Using the scenario described above this would give a value of £160,000 to £200,000 per hectare excluding packaging costs and transport to market (packaging costs would be about £6 per 25kg polystyrene box, £1 per 13kg wooden French basket and £0.70 per 5kg small wooden basket).

6.2 Markets

The market for the native oyster is predominantly based around being sold live in-shell. Typically, for smaller orders, oysters are supplied chilled in waxed, waterproof cardboard boxes or in wooden punnets. Potential options for selling oysters include direct sales to the public either at the 'farm-gate' or through mail order, with web-based ordering now popular for the supply of small quantities of oysters. Other local markets might include fishmongers, farmers markets or restaurants, potentially with delivery direct to the customer. Larger quantities of oysters might be supplied to wholesalers either depurated or undepurated with a consequent price differential. Bulk sales of British oysters do take place into the European market with France stated as a primary market in this respect.

Age at harvest with seabed cultivation is likely to be around 30 to 36 months with a harvest size of between 60 to 100g per oyster. The native oyster is often regarded to be a 'premium' product when compared to the more widely available Pacific oyster and this is reflected in prices charged at the table with, for example, London restaurant prices quoted as £24 to £28 per half dozen for native oysters versus £14 to £18 per half dozen for 'Rocks'. The FAO aquaculture guide states that in Europe the wholesale average price is commonly 3 to 5 times greater for native oysters compared to Pacific oysters.

One drawback with the native oyster is that during its reproductive phase developing young oysters are retained within the oyster's mantle cavity for a period of time. The practical consequence of this is that native oysters can only be consumed from September to April (months with an 'r' in them) when they are not brooding these young oysters. This is not the case with Pacific oysters which do not retain the developing larvae, although they will also be subject to a loss of condition following spawning that may render them unmarketable for a period of time.

Production figures indicate that in 2012 approximately 111 tonnes of native oysters were cultivated in England and Scotland with no Welsh production. Of this 111 tonnes, the English production is stated to be ~86 tonnes produced 'On bottom' whilst Scottish production is 25 tonnes produced 'Off bottom'. An estimated price per tonne of £7,600 gives a value of ~£843-k (Source: CEFAS, January 2015). This is a small production level when compared to France and Spain which produced 2,683 tonnes in 2010 (Source: Eurostat). The dramatic reduction in French Pacific oyster production in recent years due to Oyster Herpes Virus means that there are market opportunities at present for oyster exports to the Continent.

6.3 Grants

Grant funding for capital purchases of aquaculture equipment has previously been made available through the European Fisheries Fund (EFF) managed by the MMO whilst EU Axis 4 funding was distributed through a network of Fisheries Local Action Groups (FLAGs). It is beyond the scope of this handbook to detail other current sources of grant funding. However, it is worth noting that the new European Maritime and Fisheries Fund (EMFF) is due to come on-stream in 2015. The MMO state that details regarding EMFF will be published in the summer of 2015 with the scheme set to open for applications in autumn 2015. Funding will again be made available for aquaculture, fishing ports, fish processors, and FLAGs.

For further updates on EMFF please see the following web-link:

https://www.gov.uk/commercial-fishing-fisheries/funding

6.4 Insurance

Insurance policies are now available for aquaculture operations although this is considered a specialist market. Policies can be set up through reputable insurance brokers, agents or direct with the insurers themselves. Whilst many types of farming operations can be insured it is possible that seabed native oyster cultivation operations may be difficult to insure due to the fact that the stock may not be placed within containment and as such stock control will be harder to calculate and prove. A good starting point for investigations into obtaining insurance for aquaculture operations would be to review the information contained on the following website:

http://www.aquacultureinsurance.com/About-Aquaculture-Insurance/Buying-Cover

SECTION 7 – CONTACT DETAILS AND FURTHER INFORMATION

7.1 Contact Details

- **The Crown Estate Leases**

For more specific questions regarding aquaculture leases through **The Crown Estate** contact:

Alex Adrian or Charlene McPake
The Crown Estate
6 Bell's Brae
Edinburgh EH4 3BJ

Tel: 0131 260 6076 / 0131 260 6078

E-mail: enquiries@thecrownestate.co.uk

- **Marine Licensing in England and Wales**

For information regarding marine licensing and exemptions see the following:

England; https://www.gov.uk/make-a-marine-licence-application

Wales; http://naturalresources.wales/apply-and-buy/marine-licensing/?lang=en

For more specific questions regarding English marine licenses and exemptions contact:

Marine Management Organisation - Marine Licensing Team

Tel: 0300 123 1032

E-mail: marine.consents@marinemanagement.org.uk

For more specific questions regarding Welsh marine licenses and exemptions contact:

Natural Resources Wales - The Marine Licensing Team

Tel: 0300 065 3000

E-mail: marinelicensing@naturalresourceswales.gov.uk

➢ Aquaculture Production Business (APB) Authorisation

The Centre for Environment, Fisheries & Aquaculture Science (CEFAS) are the competent authority responsible for issuing APB authorisations. For APB applications see the following:

https://www.gov.uk/fish-shellfish-or-crustacean-farm-authorisation

Applications for an APB can be made using a Form AW1 available as follows:

https://www.gov.uk/government/publications/application-to-authorise-a-fish-or-shellfish-farm-form-aw1

For more specific questions regarding APBs contact the **Fish Health Inspectorate**:

Fish Health Inspectorate
Cefas laboratory
Barrack Road
Weymouth
Dorset
DT4 8UB

Tel: 01305 206 700

E-mail: fhi@cefas.co.uk

➢ Shellfish Harvest Classifications

The Food Standards Agency now have an email mailbox set up solely for requests for new harvesting applications and queries relating to classification. The address is as follows:

shellfishharvesting@foodstandards.gsi.gov.uk

For more specific questions regarding shellfish Harvesting Classifications contact:

Food Standards Agency
Hygiene Delivery Branch - Primary Production
Enforcement & Local Authority Delivery Division
Aviation House, 125 Kingsway, London, WC2B 6NH

Tel: 0207 276 8180

Website: https://www.food.gov.uk/enforcement/monitoring/shellfish/shellharvestareas

➢ Trade Association

For general industry support and advice contact:

Shellfish Association of Great Britain
Fishmongers' Hall
London Bridge
London EC4R 9EL

Tel: 020 7283 8305

➢ Purification/Depuration Training

For information about Seafish/REHIS accredited courses in bivalve purification please contact the **Southern Shellfish Training Centre**, a Seafish Approved Training Provider:

Martin Syvret - Southern Shellfish Training Centre –
C/o 62 Harrington Lane, EX4 8NS Devon, UK

Office Tel: +44 (0) 1392 462129
Mob: +44 (0) 7966 461810

E-mail: training@aquafishsolutions.com
Web-page: http://www.aquafishsolutions.com/?page_id=14

7.2 Further Reading

➢ Bivalve Shellfish Cultivation

- For a general review of native oyster aquaculture see the following web-link for the FAO aquaculture guide:
  http://www.fao.org/fishery/culturedspecies/Ostrea_edulis/en

- Brief overviews of several different aquaculture shellfish species farmed in the UK can be found in the Seafish Information Leaflets. See Resources page of Sea Fish Industry Authority website.
  http://www.seafish.org/publications-search

- Detailed information on UK aquaculture shellfish species and an economic modelling tool can be found in the Sea Fish Industry Authority Hyperbooks:

  Sea Fish Industry Authority, 2002. In: *The Oyster HYPERBOOK*. Sea Fish Industry Authority and Epsilon Aquaculture Limited, CD-ROM.

- Walne, P.R., 1979. In: *Culture of Bivalve Molluscs – 50 years' experience at Conwy.* Fishing News Books Ltd., Farnham, Surrey, England, 189p.

➢ Site Selection

- Brenner, M., Ramdohr, S., Effkemann, S. and Stede, M., 2009. Key parameters for the consumption suitability of offshore cultivated blue mussels (*Mytilus edulis* L.) in the German Bight. *European Food Research and Technology*, Vol. 230, pp. 255-267.
  http://www.jacobs-university.de/phd/files/1267709857.pdf

- For general information on selecting a site for bivalve cultivation in the UK see the following CEFAS Technical Report No. 136:
  www.cefas.defra.gov.uk/publications/techrep/techrep136.pdf

➢ Food Hygiene

- An overview of depuration in bivalve molluscs can be found in the FAO Fisheries Technical Paper No. 511 which is available via the following web-link:
  http://www.fao.org/docrep/011/i0201e/i0201e00.htm

- Microbiological Monitoring of Bivalve Mollusc Harvesting Areas - Good Practise Guide:
  https://www.cefas.co.uk/nrl/information-centre/eu-good-practice-guide

Offshore Bivalve Cultivation

- Alfred Wegener Institute – Offshore Maritime Technologies

http://www.awi.de/de/forschung/neue_technologien/marine_aquaculture_maritime_technologies_and_iczm/research_themes/maritime_technologies/

- Cheney, D., Langan, R., Heasman, K., Friedman, B. and Davis, J., 2010. Shellfish Culture in the Open Ocean: Lessons Learned for Offshore Expansion (Ed. John S. Corbin). *Marine Technology Society Journal*, Vol. 44, Number 3, May/June 2010, pp. 55-67.

http://www.ljhs.sandi.net/faculty/DJames/NOSB/Study%20Guides/Aquaculture%20MTS%2044.3.pdf

- Syvret, M., FitzGerald, A., Gray, M., Wilson, J., Ashley, M. and Ellis Jones, C., 2013. *Aquaculture in Welsh Offshore Wind Farms: A feasibility study into potential cultivation in offshore wind farm sites*. Report for the Shellfish Association of Great Britain, 250p.
  http://www.aquafishsolutions.com/?page_id=83

Native Oyster Restoration

- Laing, I., Walker, P. & Areal, F., 2005. *A feasibility study of native oyster (Ostrea edulis) stock regeneration in the United Kingdom*. CARD Project FC1016, Native Oyster Stock Regeneration – A Review of Biological, Technical and Economic Feasibility, CEFAS Lowestoft, 95p.
  http://www.seafish.org.uk/media/Publications/Oyster20Feasibility20Study.pdf

- Syvret, M., Bayes, J. & Utting, S., 2008. FIFG Project No: 06/Eng/46/05 - *Sustainable Production of Native Oyster Spat for On-growing*, 71p.

http://www.seafish.org/media/Publications/Sustainable_Production_of_Native_Oyster_Spat_Final.pdf

- Woolmer, A.P., Syvret, M. & FitzGerald A., 2011. *Restoration of Native Oyster, Ostrea edulis, in South Wales: Options and Approaches.* CCW Contract Science Report No: 960, 93 pp.
  http://goo.gl/YO6NX0