



EPSILON
AQUACULTURE LIMITED



The Oyster Hyperbook®



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“Esc” on
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show

PRESS FOR NEXT PAGE

HOW TO USE THIS HYPERBOOK

Navigating around this Hyperbook is easy:

- If you just want to proceed to the next page (or backwards), simply “left click” on the appropriate arrow key at the foot of each page (a pointing finger symbol will appear)



- If you want to use a “hyperlink” to jump to another part of the book, position your cursor over the appropriate button or text (a pointing finger symbol will appear), and left click

- You can practice this here



- Try clicking on this button



- When you are ready, proceed to the Main Menu page (click on this button)



You have completed your first “hyper-jump”

Click on this button to return



Do you want to watch the Seafish Shellfish Video ?

**Single left-click on the icon below – the video will launch in a Windows Media Player window
When you have finished watching it, close that window by clicking on the extreme upper-right x box – you should be returned right here**

TIP – the video looks better in a small window – set Media Player to “view” in “skin mode”



MAIN MENU



THE MAIN SECTIONS OF THE HYPERBOOK

(Press the appropriate action button)



-  Introduction to oyster cultivation
-  The markets
-  The production process
-  The technologies and equipment employed
-  Site selection
-  Legal and administrative issues
-  Suppliers
-  Business planning

NOTE: This is the “Main”
home page - you can return
here from anywhere by
pressing the blue house
symbol



Useful internet links



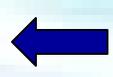
USEFUL INTERNET LINKS PAGE



This Hyperbook contains several “pages” which have links to useful or interesting web-sites. These are mainly located in the LEGISLATIVE and SUPPLIERS sections.

They are easily identified :  (*Example icon only – do not click on this*)

You can access these links as appropriate while you are working with the Hyperbook, provided you are “on line” when you start the Hyperbook session

 Back to Main Menu

INTRODUCTION TO OYSTER CULTIVATION



Native Oysters

Two species of oyster have been cultivated commercially in the UK, namely the native oyster (*Ostrea edulis*) and the Pacific oyster (*Crassostrea gigas*)



Pacific Oysters

This Hyperbook will consider the cultivation of both species



INTRODUCTION TO OYSTER CULTIVATION - Continued



NATIVE OYSTERS

The native oyster (scientific name = *Ostrea edulis*), also known as the European or flat oyster, is a bivalve mollusc that occurs in sheltered coastal inlets and estuaries. It once formed extensive beds all around the UK coast but nowadays natural populations are less abundant. Flat oysters are still fished commercially from natural beds, for example in some of the estuaries of Cornwall, such as the River Fal estuary, from the Solent and from the Thames estuary.



Dredging for flat oysters





NATIVE OYSTERS

Native oysters inhabit the lower inter-tidal area of the foreshore and sub-littoral areas down to 30m. They occur on a range of substrates, from sandy mud to fine gravel.

Management of natural beds will encourage the settlement of juvenile oysters and sustain the fishery. Beds can be raked and tilled on a regular basis to remove silt and ensure that suitable substrates are available for the attachment of the juvenile stages. Adding settlement material, called 'cultch', is also beneficial. The most commonly used 'cultch' is old bivalve shells.

In general, native oysters are not cultivated as commonly as Pacific oysters, since their growth rate is slower, their survival rate is often lower and seed tends to be slightly more expensive. Nevertheless, they do fetch a higher market price.





INTRODUCTION TO OYSTER CULTIVATION - Continued

PACIFIC OYSTERS

The Pacific oyster (scientific name = *Crassostrea gigas*) is a bivalve mollusc native to temperate regions within the Pacific Ocean. Its natural distribution centres around Japan and Korea but it has been introduced to many other countries worldwide for cultivation and is the most commonly produced oyster species. It occurs along the Pacific coast of North America to as far south as California, in Australia and New Zealand, and in Europe. Some cultivation also occurs in South Africa and some South American countries.

Compared to the flat oyster, the Pacific oyster has a wider tolerance to salinity and tidal exposure. It will grow well in fully saline conditions but also in brackish water more typical of our estuaries. It is also more resistant to handling than the flat oyster and can generally tolerate colder temperatures in winter.

This helps to explain why this species is grown so widely around the world.





INTRODUCTION TO OYSTER CULTIVATION - Continued

PACIFIC OYSTERS

The Pacific oyster was first introduced into the UK in 1965 when the former MAFF Shellfish Laboratory at Conwy, North Wales, imported broodstock from Canada. They went on to develop hatchery and cultivation systems suitable for UK waters and assisted the industry to get underway. Since then, farming has developed to the extent that Pacific oysters are, perhaps, the oyster species most commonly encountered by consumers. It can be cultivated around all our coasts, but the main production areas are on the west of Scotland and in southern England.



Hatchery produced Pacific oyster seed





INTRODUCTION TO OYSTER CULTIVATION - Continued

Like other bivalve molluscs, oysters are filter feeders removing natural phytoplankton (microscopic algae or plant cells) and organic particles from sea water as it passes over the gills. The gills have the dual function of respiration and feeding. They act like fine, intricate nets that trap food particles from the water. The quantity of water filtered by an oyster (filtration rate) depends on a number of factors including animal size, water temperature and the concentration of suspended particles. In good conditions, an adult oyster can filter up to 10 litres of water per hour.

In general, the cultivation of bivalve molluscs is considered to be indicative of a healthy environment since the animals need good conditions in which to grow. In general, shellfish cultivation tends to have a 'green' image since the animals feed on natural food in the water. Good site selection will ensure that any detrimental effects of cultivation are kept to a minimum.

The integration of oyster cultivation into the general use and management of the coastal zone is of high importance.

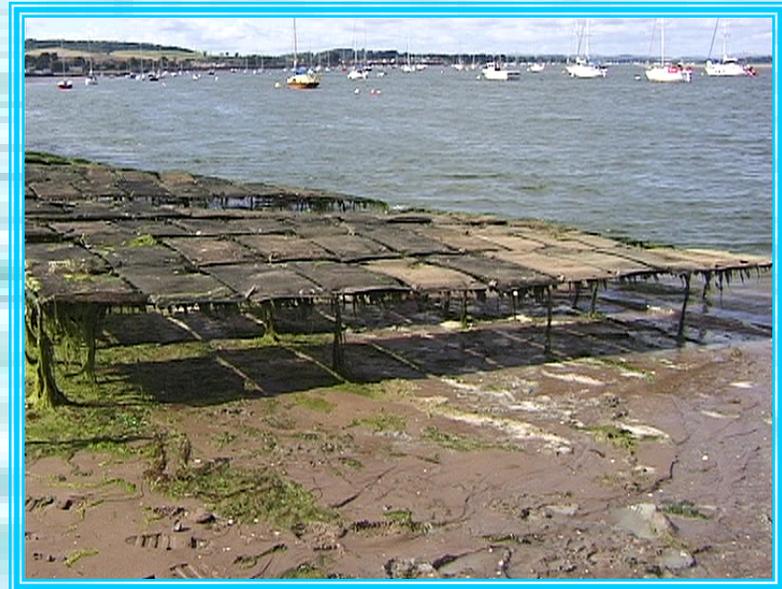




INTRODUCTION TO OYSTER CULTIVATION - Continued

Oysters are one of the predominant molluscan groups in the world, are an important protein source in many regions, and may become even more so in the future. Total world production of oysters has been increasing steadily since 1970 and increased dramatically between 1987 and 1994 with the production of approximately 3 million mt in 1996. The top oyster producers are the People's Republic of China, Japan, Korea and France.

Culture practices and on-growing methods for oysters vary. However, it must be concluded that semi-intensive culture from hatchery and nursery phases to on-growing and harvest is a well-established practice in most locations around the world.



Cultivating Pacific oysters on the foreshore





INTRODUCTION TO OYSTER CULTIVATION - Continued

The FAO reported on the major aquaculture species groups which were cultured in Europe in 1995 - Fin fish (779,000 mt) and molluscs (626,000 mt), with only a very limited production of aquatic plants (5,000 mt) and crustaceans (2,000 mt)

In marked contrast to finfish production, the production of molluscs has remained relatively static, growing at an average annual rate of only 0.3% by weight since 1984 (5.7% by value) and production decreasing by 4.2% since 1994 (although value increased by 7.2% over this period). The main mollusc species cultivated within the region are mussels (61.2% of the total, with the main species being the blue mussel (*Mytilus edulis*) and Mediterranean mussel (*M. galloprovincialis*)), oysters (25.5%; main species being the Pacific cupped oyster (*Crassostrea gigas*)) and clams (13.1%; main species being carpet shells, *Tapes* spp.). The main mollusc-producing countries within the region in 1995 were France (34.3% total molluscs), Italy (25.7%), Spain (17.1%), and the Netherlands (12.9%). The total value of mollusc production in 1995 was US\$907 million or 24.0% of total aquaculture production within the region.



INTRODUCTION TO OYSTER CULTIVATION - Continued



A recent study by McAllister Elliott and Partners suggested that the prospects for oyster cultivation in Europe was not too favourable. Even with costs of production reduced annually by 2%, future demand was likely to be static. The French output was considered to be stagnant with only the small producer nations showing capacity for growth. However, the profitability of such operations was called into question.



An example of bag and trestle oyster cultivation





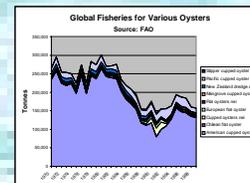
THE MARKETS FOR OYSTERS

The global and regional “market” for oysters is presently defined by the availability of *supply* from the wild fishery plus the cultivation sector.

WILD SUPPLY - GLOBAL

The world total wild-caught supply of one species or other of oysters was 157,000 tonnes in 1999. Note the declining supply

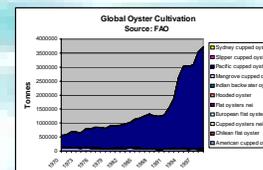
Click on the thumbnail to see the total global wild supply data



CULTIVATED SUPPLY - GLOBAL

By contrast to the wild supply situation, cultivated oyster production has been steadily increasing over recent years.

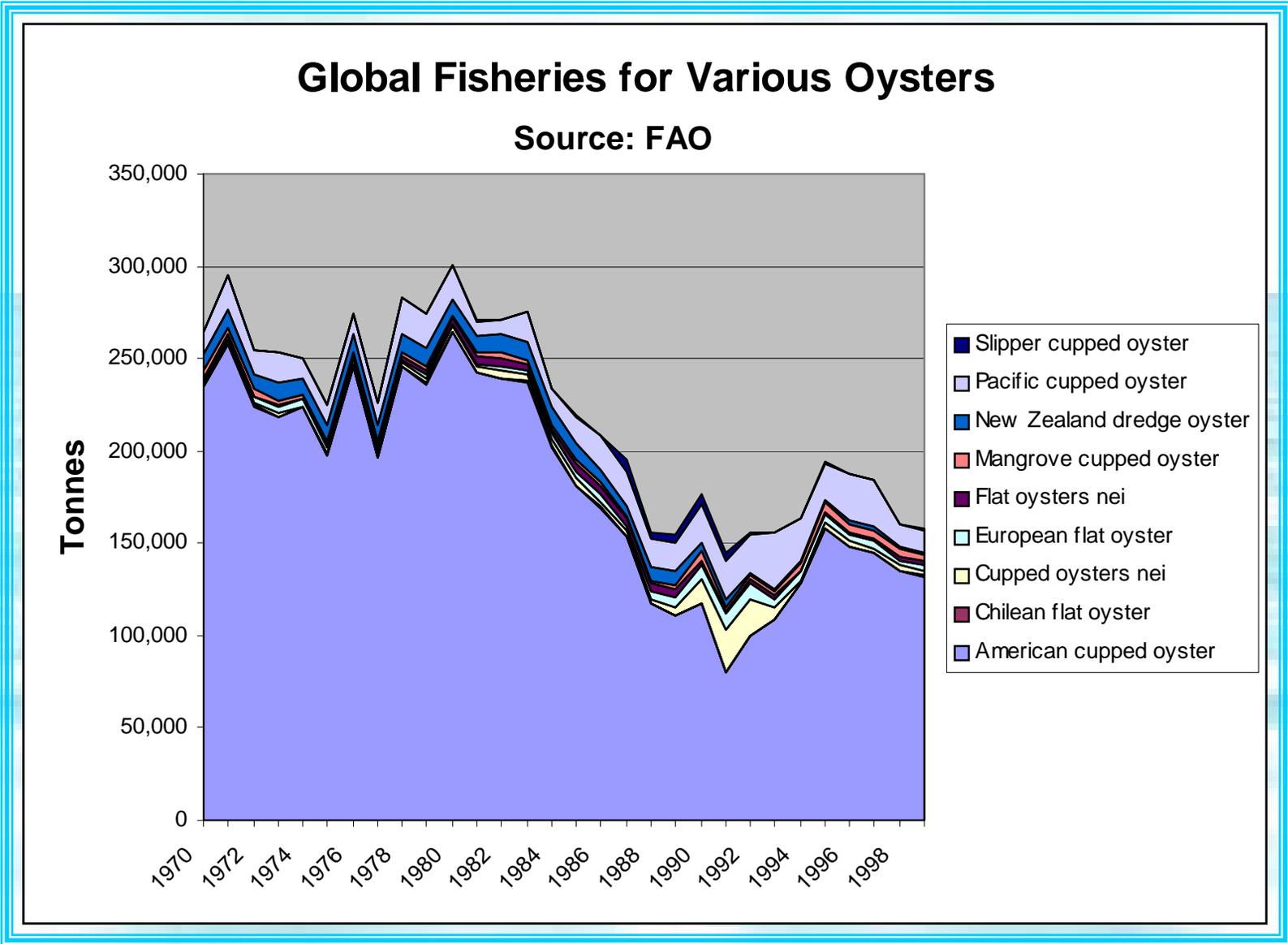
Click on the thumbnail to see the total global cultivated supply data





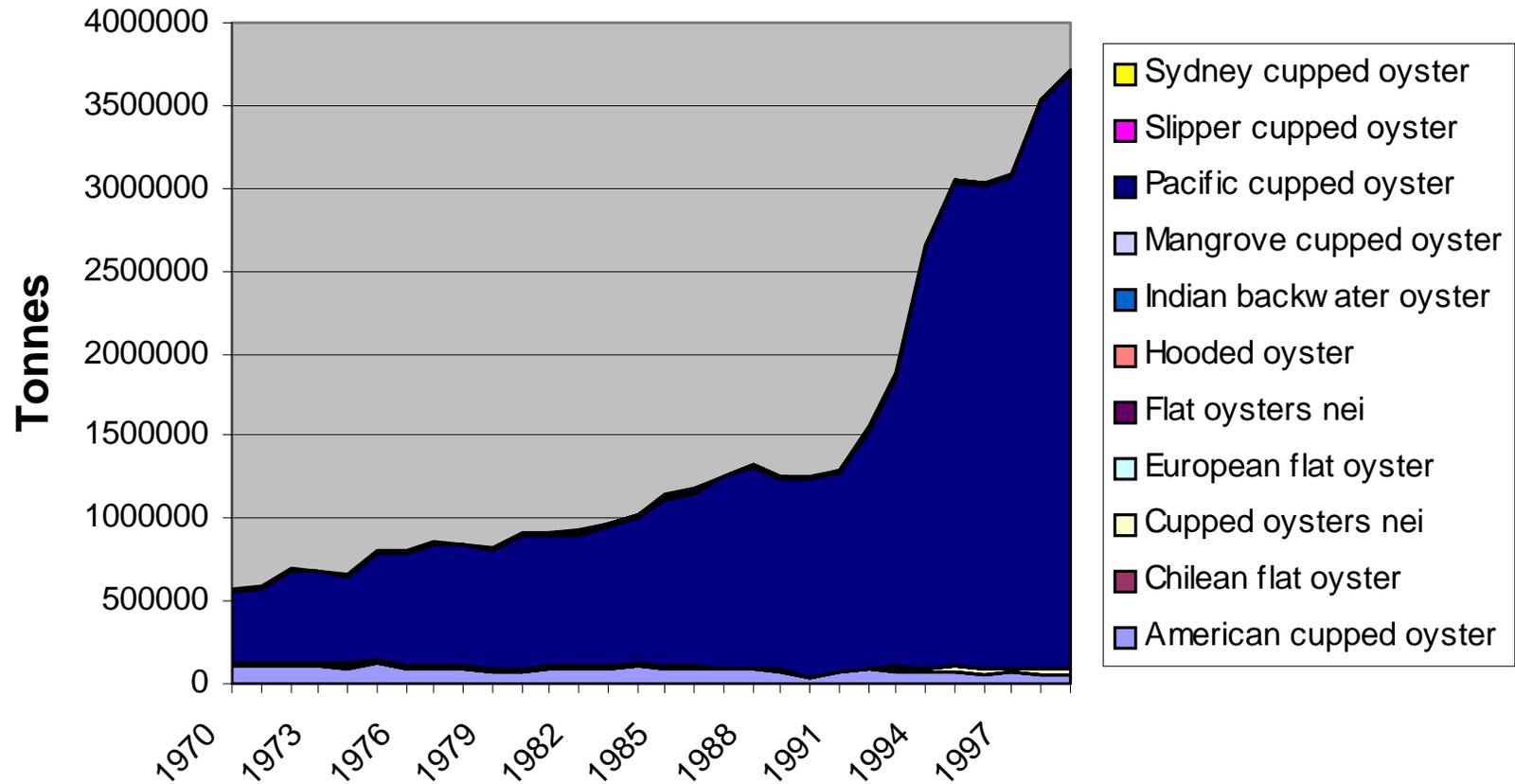
Global Fisheries for Various Oysters

Source: FAO





Global Oyster Cultivation Source: FAO

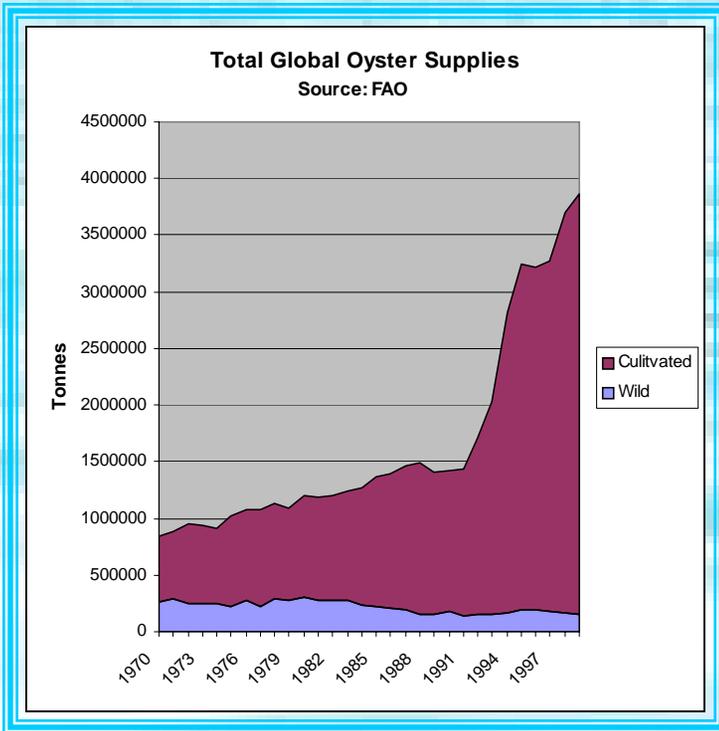




THE MARKETS FOR OYSTERS - Continued

COMBINED SUPPLY - GLOBAL

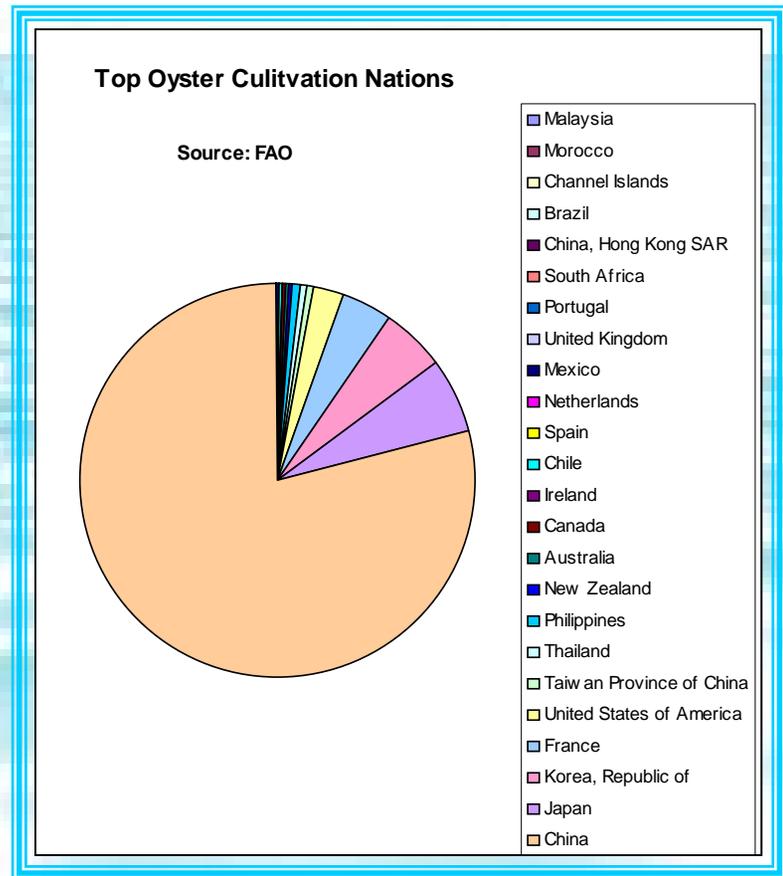
The combined total of wild and cultivated oysters has increased dramatically - almost 4 million tonnes in 1999



CULTIVATED SUPPLY

The world's cultivated production is dominated by China, Japan, Korea and France - together having 94% of the total

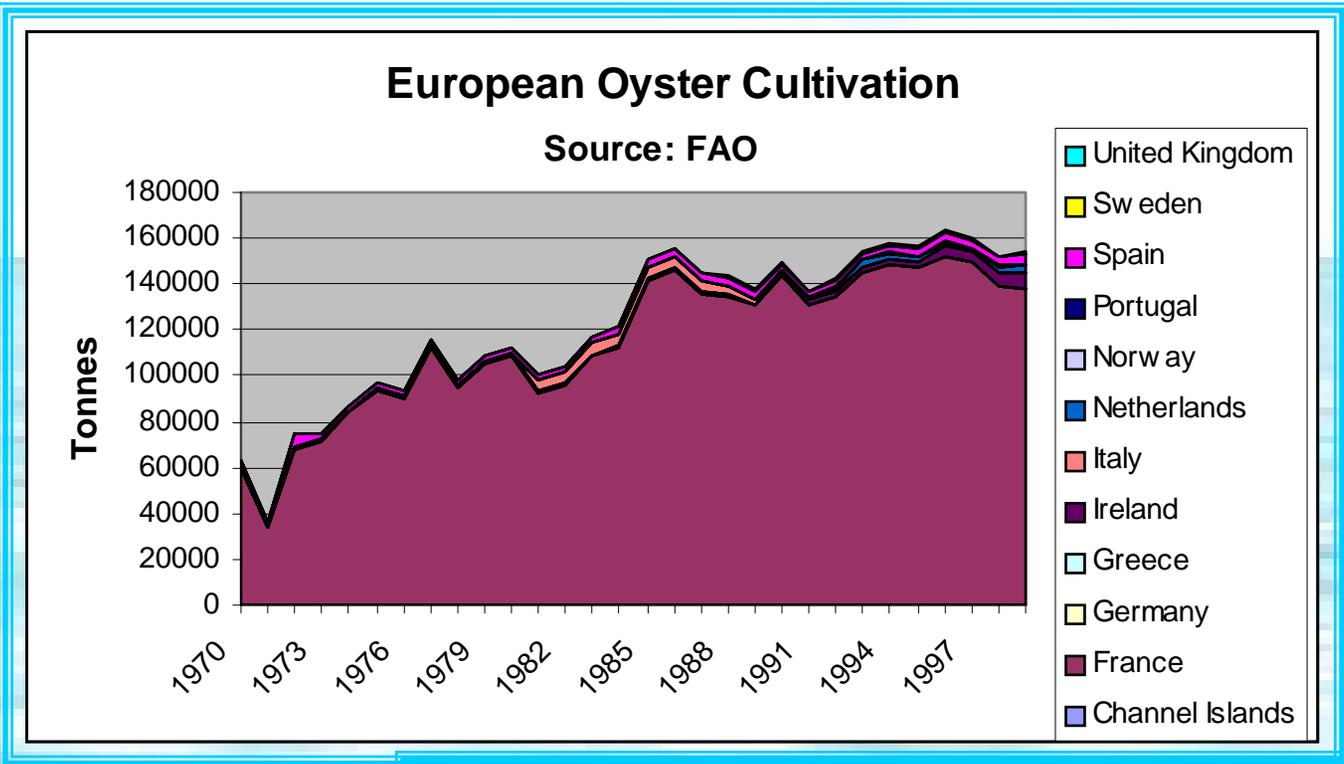
(Data is average for 1997-1999)



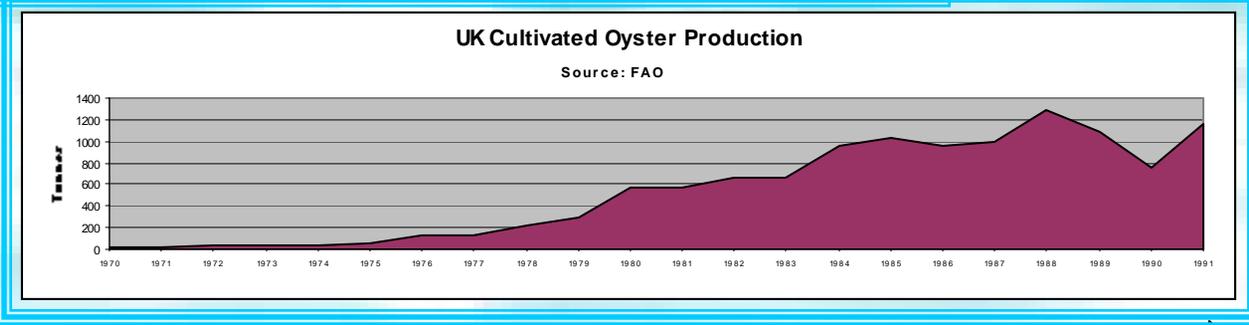


THE MARKETS FOR OYSTER - Continued

Production of oysters in Europe is dominated by France



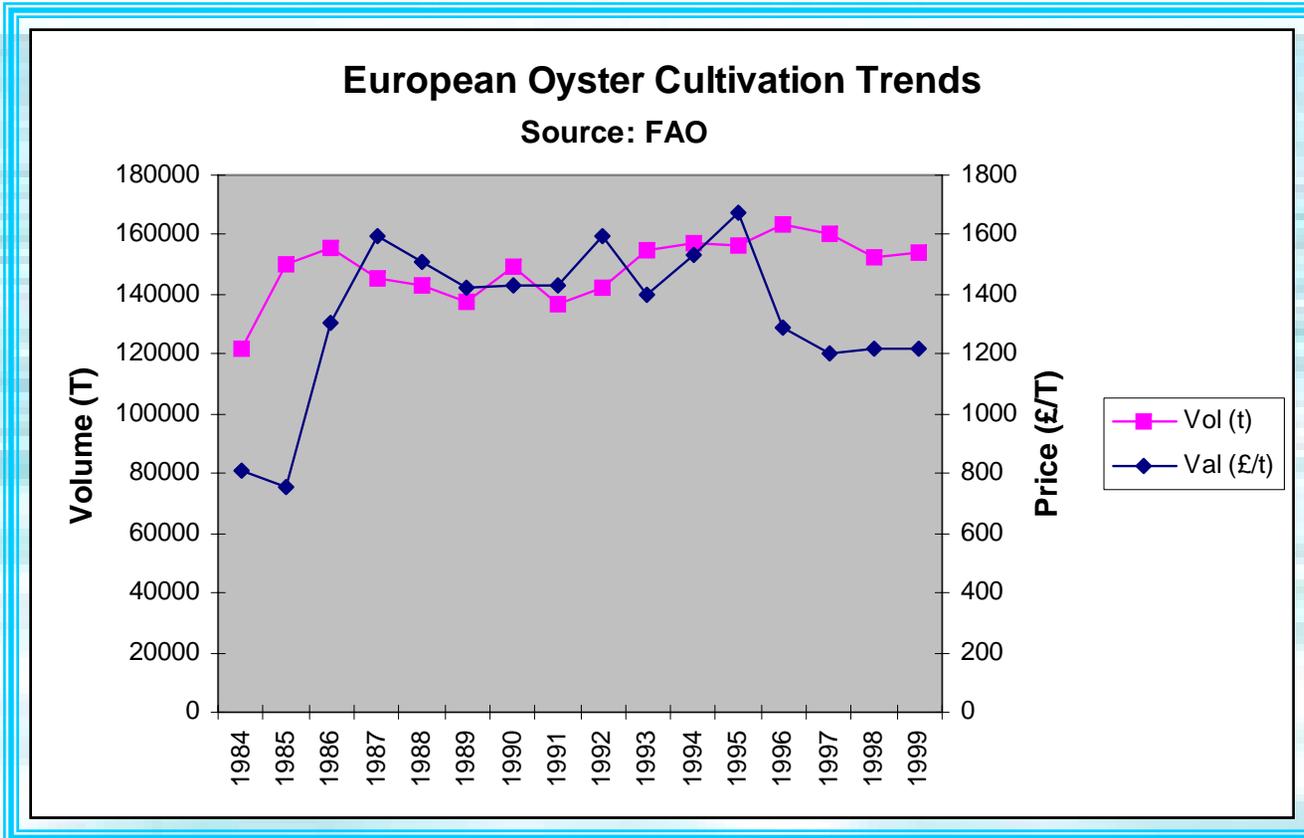
UK production has increased





THE MARKETS FOR OYSTERS - Continued

Oyster production in European countries has been rising only slowly in comparison with the global total. First sale value reached a reasonable plateau level between the mid 1980's and mid 1990's, but has since reduced to a lower level.





THE MARKETS FOR OYSTERS - Continued

The market for oysters in the UK and several other European countries was extensively studied by Seafish in 2001

You can find this report as a Word document “Shellfish Market Report” inside the main Hyperbook folder. Click “exit” to leave this show, if you want to see the report now

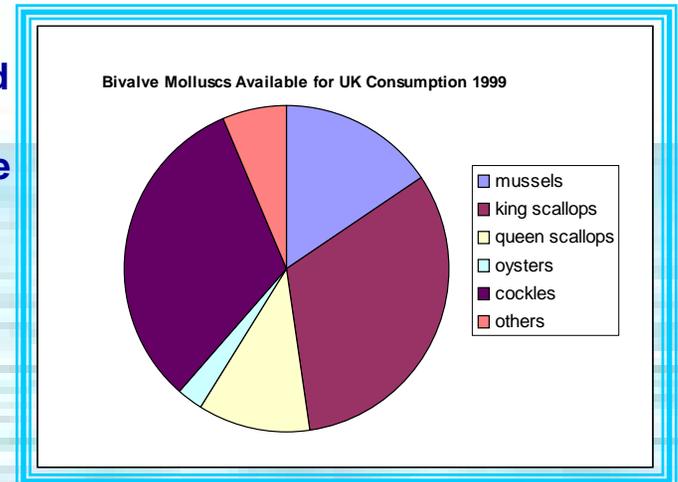
Oysters were seen as being relatively static in terms of the market, and increasing competition from low-priced imports is possibly eroding the prospects for UK primary producers. Convenient, appealing, added-value product development was seen as one prospect for increasing consumption of oysters.

It appears that the UK is probably a net exporter of oysters:

- 1100 tonnes per year cultivated + c. 600 tonnes from the wild
- Exports of 900 tonnes
- Imports of 250 tonnes

So total consumption around 1100 tonnes per annum

(Data from Seafish & UK Customs & Excise)



On the next two pages we will look at the overall seafood market in the UK





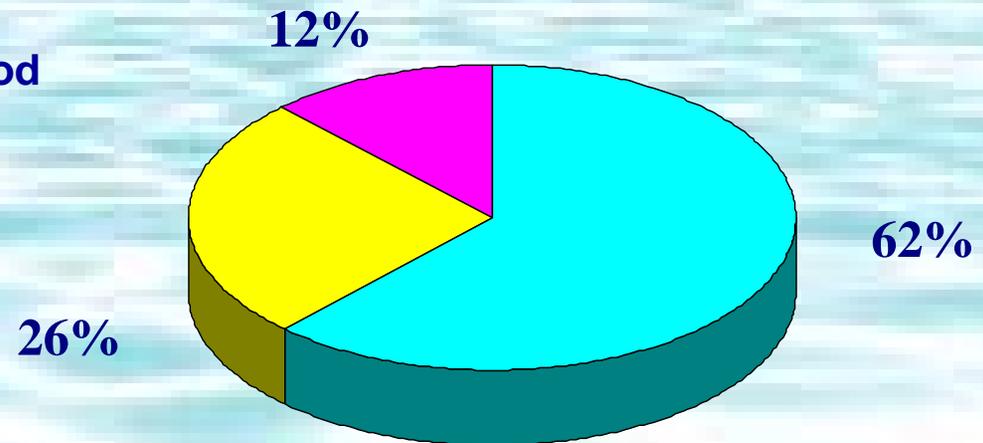
THE MARKETS FOR OYSTERS - Continued

Seafood is purchased in two broad categories by consumers:

- *Retail* - where it has to be prepared for eating at home
- *Foodservice* - where it is purchased in a ready-to-eat form

There are overlaps where shops and petrol stations sell ready-prepared meals, and sub-categories such as take-away foodservice. The main distinction between the two broad categories is that the consumer pays more per unit piece of protein in foodservice than he/she does in retail.

The balance between seafood retail and foodservice



Source: SFIA, Foodservice Intelligence & Superpanel

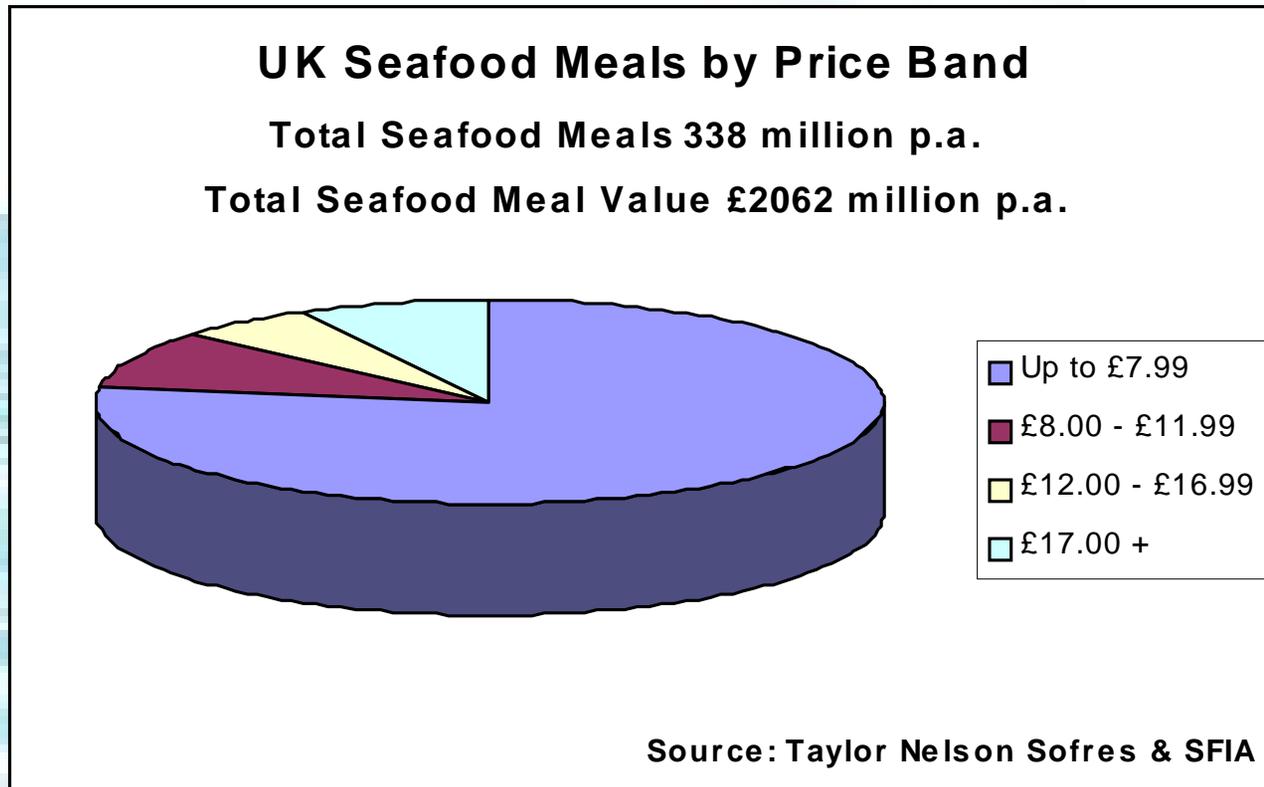
■ Retail ■ Catering ■ Fish and chip shops





THE MARKETS FOR OYSTERS - Continued

UK seafood consumption in foodservice - in terms of number of meals and their values - is interesting:



- 338 Million seafood meals per annum
- 25% of them costing more than £8 per meal





THE MARKETS FOR OYSTERS - Continued

The “Farm to Fork” concept is a way of understanding how aquaculture products are valued by consumers - and how the value of the product works backwards through the supply chain to the aquaculturist at the edge of his farm. In the absence of any firm data for OYSTERS in the UK, we must use MUSSELS to illustrate the concept:

THE MUSSEL “MEAL VALUE TRANSFER” EXAMPLE

One example might be a typical moule mariniere-type dish, which as a main course would probably have at least 500g of whole mussels, and which might sell to the consumer for around £8.00. In foodservice we can follow a well-researched “chain” of value through the catering outlet:

Price of the meal		£8.00
Less VAT @ 17.5%	(£1.19)	£6.81
Less restaurants “margin” of 66%		£2.27
Less cost of other ingredients	(c.£0.50)	£1.77

In effect we are suggesting that a restaurateur offering such a dish would not be able to pay any more than £3.54 per kg for whole mussels “delivered to his back door”.

This still appears to leave a reasonable margin for the foodservice companies, wholesalers, transporters etc – farmed mussels achieve between £0.40 and £1.00 per kg depending upon source and quality.

Note that the calculation above is speculative in so far as product weight per meal, actual meal price on the menu, and cost of other ingredients are concerned. However, the principle behind this method of assessing cost of protein ingredients into catering outlets has been well tested – readers of this report can substitute their own values and quantities. The restaurant “margin” may vary from outlet to outlet, and even from product to product. However, the level of around 66% is probably close to an industry standard.

The challenge for anyone interested in OYSTER meals is to identify the key components, as shown above.



THE MARKETS FOR OYSTERS - Continued



Many people in the UK are still unsure when it comes to eating oysters. They may not know how to handle or open them, or they recount stories of people being unwell after eating shellfish.

Oysters are very healthy seafood products, being low in cholesterol and rich in essential nutrients such as polyunsaturated fats and zinc. They are safe to eat because all oysters and other shellfish placed on UK and European markets have to meet strict health and hygiene regulations before they can be sold. Native oysters are usually eaten raw but they can also be cooked in a variety of tasty dishes.



THE MARKETS FOR OYSTERS - Conclusion



- It is *mussels* and *scallops* which dominate recorded fresh/chilled mollusc sales in UK retail – with 1.6% of all fresh/chilled seafood by volume and 1.2% by value. There is some evidence of growth in this area
- Oysters have niche acceptance in the UK - but need to have convenience and added-value components if they are to achieve a wider market
- UK consumers are tending to seek innovation and novelty in food, and some respondents feel there is a move to “trendiness” of molluscs
- UK retail customers want convenient, safe pre-packed products
- The general feeling about market opportunities is more upbeat when companies are closer to the consumer

Some oyster recipes
(click on the buttons to view)



THE PRODUCTION PROCESS

Introduction



Click here to see a description of the life cycle - Native Oysters



Pacific Oysters



This Hyperbook will focus on the main life cycle stages for cultivation of oysters:

Hatchery, ongrowing and harvesting

The Hyperbook can not provide every detail, and it is

recommended you visit the resources listed below to obtain more information.



LIFE CYCLE OF NATIVE OYSTERS

Native oysters are described as protandrous alternating hermaphrodites. This means that when they reach maturity, they function first as a male and then they go into alternate cycles of female and male stages for the rest of their life. The number of cycles each year depends on the length of the breeding season, so in the UK native oysters usually spawn twice during the summer, once as a male and once as a female. A minimum water temperature of 16°C is required before they spawn. The males release sperm into the surrounding sea water which is taken in through the inhalent siphon of the female. The eggs produced by the female are fertilised inside the parent's shell and the larvae are brooded within the mantle cavity until they have a fully-formed shell (at around 0.170 mm). This usually takes about 10 days. The parent oyster releases the larvae into the sea water where they drift in the plankton and feed on natural phytoplankton. The number of larvae released is related to the size of the parent oyster.



After 2 to 3 weeks, depending on local environmental conditions, the larvae are mature and they develop a foot. At this stage, they are called pediveligers. They sink to the seabed and explore the sediment surface with their foot until they find a suitable surface on which to settle permanently. The pediveligers cement firmly to a hard surface such as shell or stone. Next, they go through a series of morphological and physiological changes, a process known as metamorphosis (which takes 3 to 4 days), to become 'immature' adults called spat (or seed).



Fertility (number of larvae) of native oysters in relation to approximate age and size

Approximate age in years	Mean shell diameter in mm	Number of larvae
1	40	100,000
2	60	540,000
3	70	840,000
4	80	1,100,000
7	90	1,500,000



LIFE CYCLE OF PACIFIC OYSTERS

As a species not native to the UK, the Pacific oyster seldom reproduces naturally in the wild. Sea water temperatures around the UK are generally too low to support maturation or successful larval development and settlement. All juvenile oysters used for culture are produced by specialist hatchery facilities.

Pacific oysters are alternating hermaphrodites. On maturity, they can function as either a male or female. The following season, they change sex and then have alternate cycles of female and male stages for the rest of their life. However, a few remain as true hermaphrodites, acting as both male and female at the same time.

In their native environments, Pacific oysters release eggs and sperm into the sea water where fertilisation occurs. The larvae are planktonic, drifting in the surface layers for approximately 2 to 3 weeks before they sink to the bottom to take up a sessile lifestyle attached to shell, stones or rocks.





THE PRODUCTION PROCESS

Hatchery Production - 1

INTRODUCTION

The culture of bivalve larvae and juveniles (or seed), for research, commercial aquaculture or biotechnology, is dependent on a number of important factors. These include providing optimal technological and environmental conditions, adequate nutrition in terms of quantity and quality of diet for larvae, juveniles and parent broodstock, disease control and other ecological, physiological and genetic factors.

The production of seed in commercial hatcheries is an important element of shellfish aquaculture worldwide. In the hatchery, environmental conditions are carefully controlled during critical stages of the life cycle to meet the specific needs of the species being reared. This includes the conditioning and spawning of adult broodstock, the rearing of larvae through to metamorphosis and the containment of post-larval stages until they are large enough for moving to the natural environment. Commercial hatcheries are used primarily for the production of high market value species. Until recently, aquaculture of molluscs has generally been for food production but more novel applications, especially in the field of biotechnology, are the subject of an increasing number of research studies and may ultimately lead to commercial production for purposes other than food.

Hatchery production of bivalves began in the UK in the 1960s. Since that time the technological and biological requirements of a range of bivalve species including native European flat oysters (*Ostrea edulis*), Pacific oysters (*Crassostrea gigas*), Manila clams (*Tapes/Ruditapes philippinarum*), native palourde clams (*Tapes decussatus*) and American hard shell clams or quahogs (*Mercenaria mercenaria*) have been determined. Seed of all these species are produced commercially. The two commercial hatcheries where seed can be purchased are Seasalter Shellfish (Whitstable) Ltd. (with a nursery site selling seed at Seasalter (Walney) Ltd.) and Guernsey Sea Farms.





THE PRODUCTION PROCESS

Hatchery Production - 2

BROODSTOCKS 1

The parent animals that are used for the hatchery production of bivalve shellfish seed are called broodstock. Generally, broodstock are kept in the sea and brought into the hatchery when they are needed for breeding purposes.

Egg production increases with increasing adult size. Pacific oysters of 70 mm shell length (around 30 g live weight) will produce around 50 million eggs per adult; native flat oysters of 65 mm (30 g live weight) will release approximately 1 million larvae.

Pacific oysters mature first as males. As they become older, they either remain as males or change sex to become female. In 2 to 3-year-old populations of Pacific oysters, the numbers of males and females are about equal. Although flat oysters also mature first as males, afterwards they usually alternate between being male and female. (On rare occasions, some flat oysters remain either as males or females.) In the UK, each year they usually spawn once as a male and once as a female. In other areas where conditions are more favourable, they may change sex more than once per season.

Pacific oysters are not native to the UK. They were introduced in the 1960s/1970s to assess their commercial potential against their UK equivalent. On each occasion, a limited number of mature broodstock were imported from the USA into quarantine facilities, following guidelines of the International Council for the Exploration of the Sea (ICES) - see below. Broodstock were spawned and larvae and juveniles (or seed) reared in quarantine. Only after the seed had been tested and given clearance from known bivalve diseases were they moved out of quarantine for field trials and then to the industry as broodstock. Commercial hatchery production of Pacific oyster seed is still based on those original imports of broodstock animals.

(The most recent version ICES Code of Practice on the Introductions and Transfers of Marine Organisms 1994 can be obtained from ICES, Palaestra 2-4, DK-1261 Copenhagen, Denmark.)



THE PRODUCTION PROCESS

Hatchery Production - 3



BROODSTOCKS 2

Environmental and genetic factors affect the morphological and physiological characteristics of commercially produced shellfish. Genetic selection and selective breeding is a method to improve stocks for aquaculture purposes by selecting for specific traits (e.g. for faster growth, higher meat yield, better shell shape and/or colour). Research in this field will undoubtedly expand in the future if aquaculture is to follow the same pathway as agriculture where domesticated animals are very different from their wild counterparts.

The importance of broodstock genetics to subsequent performance is a factor that has been poorly studied in bivalve larvae culture in comparison to the nutritional requirements of broodstock and larvae or when compared to fin fish aquaculture. Careful management of broodstocks is essential in order to maintain genetic diversity and ensure optimum physiological performance. Using a limited number of broodstock can reduce genetic variability resulting in inbreeding depression, an irreversible loss of genetic diversity and potential detrimental interactions between wild and cultivated stocks.

Modern molecular techniques and conventional methods are available to assess genetic heterozygosity, or variability. 'Genetic markers' can be used to locate specific genes associated with desirable traits. For example, research in Australia, shows evidence of a single major gene giving faster growing and meatier oysters amongst their stocks of Pacific oysters (*Crassostrea gigas*). A selection programme has been started to improve commercial production. It is forecast that the production cycle can be reduced by up to 25% through genetic selection. In Oregon USA, broodstock of a range of shellfish species are maintained as a gene bank for commercial purposes. Here in the UK by comparison, little has been or is being done.



THE PRODUCTION PROCESS

Hatchery Production - 4



BROODSTOCKS 3

Broodstock oysters are brought into the hatchery and 'conditioned' to spawn. This is a process where the sea water temperature is raised to mimic the conditions that the animals would experience in nature during the spring when they would be laying down reserves in preparation for spawning in the summer. For example, the native flat oyster naturally spawns in July to late August around the UK. In order to fatten and ripen, the animals need to be provided with a diet of microalgae (phytoplankton). A number of microalgae species have been selected over the years for their nutrient content and their digestibility. The more commonly used species are *Tetraselmis suecica*, *T-Isochrysis*, *Skeletonema costatum*, *Pavlova lutheri*, *Chaetoceros gracillus* and *Chaetoceros calcitrans*. Generally, the best ration for oysters is equivalent to 6% of the dry meat weight of the broodstock in dry weight of microalgae per day. Mixed diets of two or three species, provided in equal proportions by weight, are best.

Larvae and seed production can often be very variable and generally depends on the maturity of adult broodstock, as well as the quantity and quality of lipid reserves in the eggs produced by the broodstock. For example, the growth rate and the ability of native European flat oyster larvae to successfully complete settlement and metamorphosis are related to the levels of total polyunsaturated fatty acids (PUFAs) and of specific essential PUFAs, such as docosahexanoic acid (DHA), in newly-released larvae. In turn, the levels of PUFAs in larvae are dependent on the reserves present in parent animals that get transferred into the eggs. As much as 50% of the variation in growth rate amongst different broods of larvae can be explained by differences in the DHA content of parent broodstock animals. In Pacific oysters DHA and another essential fatty acid called eicosapentanoic acid (EPA) are critical to hatching success of the eggs.



THE PRODUCTION PROCESS

Hatchery Production - 5



BROODSTOCKS 4

In temperate regions, most species of bivalves start to prepare for spawning (i.e. changing from somatic growth to gonad development and maturation) once the sea water temperature exceeds 10-14 °C, what is known as the threshold temperature. To determine when broodstock are likely to be ready for spawning after conditioning in the hatchery, the number of 'day-degrees' (DD) above the threshold temperature can be determined as follows:

$$DD = d (t - t_0),$$

where d is the number of days of conditioning, t is the ambient temperature of the sea water in the hatchery system, and t_0 is the threshold temperature for the species.

For most species reared in UK hatcheries, the number of 'day-degrees' is between 400 and 600. When you are estimating DD, do not forget to take into account how 'ripe' animals are when they are brought into the hatchery from the natural environment. For example, broodstock conditioned during winter and early spring will take around 6 to 8 weeks to condition whereas this will be much shorter (2 to 3 weeks) nearer the summer months when the animals are more mature naturally.

Female European flat oysters hold their developing larvae inside their mantle cavity until the larvae have a fully-developed shell. At this stage the larvae are approximately 170 μm and around 7 days old. When they are released from the parent, they are planktonic and swim close to the surface of the water in the tank. They can be collected by placing a sieve, of mesh size 90 μm , at the outlet of the tank.

Pacific oysters can be induced to spawn artificially and fertilisation of the eggs can be carefully controlled.



THE PRODUCTION PROCESS

Hatchery Production - 6



CONTROLLING SPAWNING - 1

The easiest method of spawning Pacific oysters is to put them into a shallow spawning trough and give them alternating thermal shocks of 20 °C and 30 °C. Firstly, the trough is half-filled with filtered (to 2 µm), UV-sterilised water at 30 °C. After 20-30 minutes, the trough is drained and refilled with treated water at 20 °C. The cycle is repeated until the animals start to spawn. Microalgae is added to the water at each water change to encourage the animals to filter actively. Some eggs removed from one sacrificed animal and added to the water will help to trigger spawning. A trick is to drop a few mls of egg suspension into or close to the inhalent siphon.



Spawning male Pacific oyster

Eggs and sperm are released from one side of the shell. A grey or black spawning trough will provide a dark background against which the white eggs and sperm can be seen easily. The more mature the broodstock, the sooner they will spawn after the first thermal shock is applied.





THE PRODUCTION PROCESS

Hatchery Production - 7

CONTROLLING SPAWNING - 2

Usually, the males spawn first. The sex of each animal should be checked as it starts to spawn by placing it in a separate glass container such as a litre beaker containing 500 mls of water at the same temperature as that in the spawning trough. Eggs will appear as a granular suspension, sperm as a cloudy, milky suspension. Once the sex of the adult has been determined, female oysters are held individually to release all their eggs. This usually takes 10 to 15 minutes. With the males, it is advisable to take them out of water again until immediately before the eggs need to be fertilised. The longer the time between when the sperm is released to when it is used to fertilise the eggs, the less successful the fertilisation. After 30 minutes in sea water, the sperm becomes less active and fertilisation success is extremely low. Eggs should be fertilised within one hour of their release from the parent.

To maintain genetic diversity, a minimum of 20 parent animals (1:1 ratio of male to female) should be used in each spawning. Eggs from each female are counted and pooled into a large container. The suspension is diluted with 25 °C sea water to give a density of 4000 eggs per ml. Sperm from the males should be pooled into a separate container before it is added to the egg suspension at 2mls of sperm suspension per litre of eggs. After one to two hours, the first signs of development should be visible under the microscope as cell division proceeds.



THE PRODUCTION PROCESS

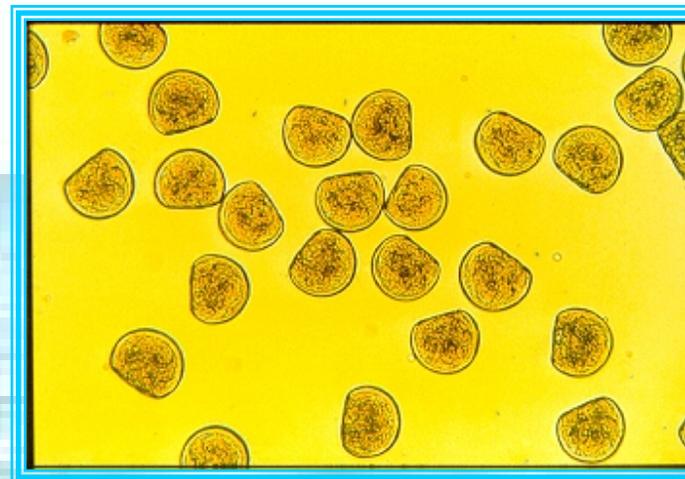
Hatchery Production - 8



EGG INCUBATION

Eggs are then incubated for 24 hours in rearing vessels containing filtered (to 2 μm) sea water at 25 °C. The optimum density is around 80 –100 eggs per ml although higher densities are achieved at a commercial scale. The optimum salinity for rearing Pacific oysters is 25 parts per thousand and for European flat oysters >30 parts per thousand. The water can be very gently aerated with filtered (to 0.45 μm) air.

After 18 - 24 hours, the eggs develop into the first shelled stage called a D-larva owing to its distinctive 'D' shape. A recovery of around 60% of the initial egg number is not uncommon for Pacific oysters. The larvae are collected from the rearing vessel by filtering the water through a series of stacked sieves (124 μm , 61 μm , 45 μm , 35 μm). The larvae will be collected on the 35 and 45 μm sieves. They measure 70-75 μm (Pacific oysters) mean shell length. (NB European flat oyster larvae are around 170 μm mean shell length when they are released from the parent broodstock.)



Oyster D-larvae



THE PRODUCTION PROCESS

Hatchery Production - 9



REARING THE LARVAE

Rearing vessels are filled with filtered (to $2\mu\text{m}$), UV-treated, heated (to $25\text{ }^{\circ}\text{C}$) sea water and D-larvae added at a density of 10 per ml. Again, initial densities as high as 200 per ml are used in some commercial hatcheries. Provided the larvae are good and the water quality and rearing environment are pristine, then this will help to reduce production costs.

Larvae can be reared in flat-bottomed or conical-based vessels. They can be operated as static systems where the water is changed approximately every 48 hours. Alternatively, they can be operated as partial-recirculation or through-flow systems. The vessels should be pigment free. Polyethylene is a material commonly used. Capacity of rearing vessels varies between hatcheries. In UK hatcheries they generally range from around 150-250 litres up to 2,000 litres. The costs of pumping and heating water will determine the method that can be used. Aeration should be provided. For a 350 l rearing vessel, for example, aeration should be 350 l/h.

At each water change the larvae should be collected and graded on a series of stacked sieves (ranging from $61\text{ }\mu\text{m}$ up to $170\text{ }\mu\text{m}$). It is good practice to check the number and condition (activity and colour) of larvae on each sieve and keep records. Periodically, the larvae on the smallest-size sieve can be discarded if they are very pale, an indication that they are not feeding and will not survive. The average growth rate of larvae is around $10\text{ }\mu\text{m}/\text{day}$. A good survival rate through the larval phase is 50-60 %.



THE PRODUCTION PROCESS

Hatchery Production - 10



LARVAL FEEDING

The larvae must be provided with a diet of microalgae. This is added at each water change and topped up between water changes. Optimum diet rations and the quality of the diet is very important. The quantity of food that needs to be provided per larva increases as the larvae grow. A D-larvae requires the equivalent of around 5,000 *Isochrysis*-size cells per day. This increases to around 40,000 cells per day when larvae are 200 μm . When oyster larvae are 250-300 μm and approaching settlement, the food levels should be increased to 60,000-80,000 cells per day for Pacific oysters and 90,000-130,000 cells per day for European flat oysters.

The essential highly unsaturated fatty acids (HUFAs) arachadonic acid (AHA) (20:4 n-3), eicosapentanoic acid (EPA) (20:5 n-3) and docosahexanoic acid (DHA) (22:6 n-3) have been shown to play an essential role in the diet of most molluscs. These are provided in mixed diets of microalgae fed to the larvae during culture. Species of microalgae that are easy to grow and that provide essential nutrients include *Tetraselmis suecica*, *T-Isochrysis*, *Skeletonema costatum*, *Pavlova lutheri*, *Chaetoceros gracillus* and *Chaetoceros calcitrans*.

During metamorphosis, flat oysters do not feed, utilising stored lipid reserves. Prior to settlement, algae species with high lipid content should be provided. Pacific oysters on the other hand use protein reserves.



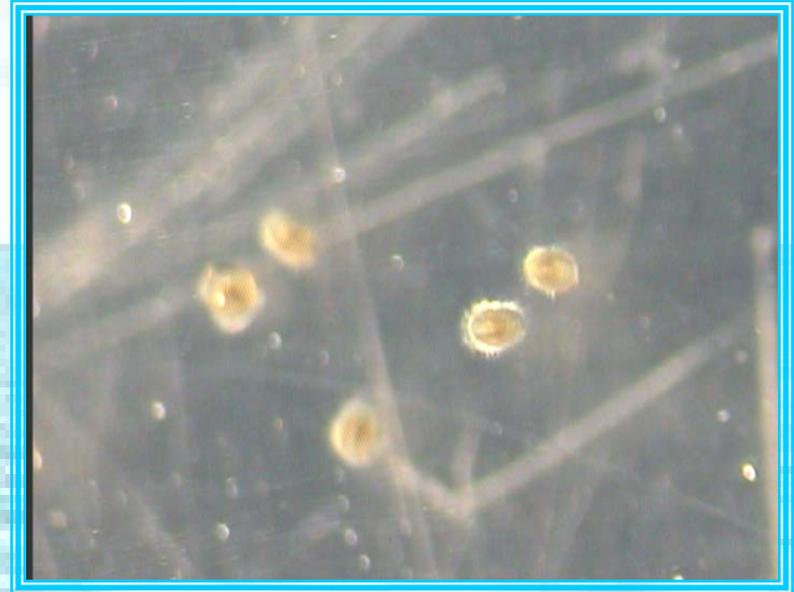
THE PRODUCTION PROCESS

Hatchery Production - 11



LARVAL PERFORMANCE

The larval stage is a critical phase in the life cycle of many species that can affect various aspects of developmental success in subsequent life stages (juvenile and adult). The performance during the larval stage is critical to success. The relationship between larval growth and subsequent juvenile performance in molluscs is far from conclusive. For example, while there was no connection between juvenile and larval growth of the clam, *Mercenaria mercenaria*, some relationship was found in the Pacific oyster.



Actively-swimming, healthy larvae

Various biochemical and physiological indicators are available to assess larval fitness at a specific point in time. These include their lipid, protein and carbohydrate content in terms of both quantity and quality, their organic meat weight in relation to ash (or inorganic) weight, their respiration rate and scope for growth. These factors give an indication of conditions encountered previously and can provide some idea of subsequent competence and performance.



THE PRODUCTION PROCESS

Hatchery Production - 12



POTENTIAL DISEASES - 1

During development, bivalve larvae are continuously exposed to microbes and their defence system is continuously reacting to prevent the accumulation of invading and pathogenic organisms. Bacteria are also thought to play a role in the nutrition of bivalve larvae although the importance of this role is far from clear. The culture of Pacific oyster larvae has been achieved under axenic conditions but growth rates were less than in non-axenic cultures. On a commercial scale, it would be relatively impossible to maintain axenic conditions.

Bacteria

Vibrios are bacteria widely implicated in hatchery mortalities of bivalve larvae. They produce ciliostatic toxins which effectively paralyse the cilia on the velum of the larvae. As a result, the larvae are unable to swim or feed and they sink to the bottom of the rearing vessel where they die.

Maintaining optimal environmental conditions is critical to ensure that the immunocompetence of larvae and postlarvae is not compromised. The performance of the immune system is reduced by stress, e.g. stress resulting from disease agents, pollutants in the water, adverse environmental conditions, excessive handling. Impairment of the defense system can lead to significant losses of stock because it makes the animals vulnerable to bacterial infection. For example, research has shown that when Pacific oyster were challenged with *Vibrio splendidus* and subjected to mechanical stress, the level of mortality and the degree of infection increased in stressed oysters but remained low in unstressed animals.





THE PRODUCTION PROCESS

Hatchery Production - 13

POTENTIAL DISEASES - 2

Controlling bacteria

The treatment of the water with ultra-violet light will remove bacteria in the incoming water. Although usually an effective method of controlling bacteria levels, it can sometimes be quite the opposite especially if harmful bacteria get into the rearing vessel, for example, with the microalgae food. In such a sterile environment, the harmful bacteria can quickly flourish and affect the larvae.

Other methods of control include the use of antibiotics such as oxolinic acid. The ban on the use of many antibiotics, because it can potentially lead to the development of disease-resistant strains of bacteria, has meant that alternative rearing methods are being investigated. Using through-flow systems or partially through-flow recirculation systems are an option.

Herpes virus

Sporadic high mortalities of Pacific oyster larvae and spat have occurred in European hatcheries and in juvenile oysters in the field, especially in France. The causative organism has been a herpes-like virus. Reports were also made of similar infections in hatchery-reared European oyster larvae and it is likely that transmission of the disease can occur between these two species of oyster. In the Pacific oyster, virus particles and lesions in the tissues were found at 25-26 °C. At lower temperatures, 22-23 °C, lesions were found but no viral particles. Mortalities of the Manila clam (*Tapes philippinarum*) and King scallop (*Pecten maximus*) have also been associated with herpes-like virus.

Although inexplicable mortalities of oysters can also occur in UK hatcheries, a herpes-like virus has not been confirmed as the probable cause.





THE PRODUCTION PROCESS

Hatchery Production - 14

POTENTIAL DISEASES - 3

Probiotics

Larvae are reared in filtered sea water at the appropriate temperature and salinity. The water can be treated with ultraviolet light to remove harmful bacteria. Using antibiotics on a regular basis is discouraged and increasingly in many countries it is not allowed. Probiotics are an alternative that is being investigated, more at a research level than commercially as yet.

Probiotics are more common as live microbial feed supplements that improve the health of man and agricultural livestock. Research into probiotics for aquaculture is driven by a demand for environmentally friendly culture techniques. Currently a stage has been reached where considerable research efforts are required to develop applications to an aquaculture scale. Probiotic microbes act by being antagonistic to pathogens, by having colonisation potential and by increasing their host's resistance to disease. In addition, many other beneficial effects are possible including competition with pathogens for nutrients and adhesion sites.

In research studies, vibriostatic bacteria were isolated from the rearing water of oyster broodstock and some of them were potentially useful for controlling vibriosis in oyster larvae; the most effective strain had no effect on the larvae themselves. Studies have also been carried out to establish the feasibility of incorporating bacteria capable of producing substances inhibitory to pathogenic bacteria (e.g. *Vibrio anguillarum*) into axenic algae cultures that can be ingested by larvae.

The gastrointestinal microbiota of shellfish is dependent on the external environment because of water continually passing through their digestive tract. Most bacteria are transient in the gut with new microbes invading continuously with the water and food cells passing through the gut. Those bacteria that are diet supplements that survive in the gut and that improve the health of the host can become probiotics.





THE PRODUCTION PROCESS

Hatchery Production - 15

SETTLEMENT

Oyster larvae eventually develop a pigmented eye spot that is easily visible under the microscope. This is an indication that the larvae are mature and ready to undergo metamorphosis into the benthic juvenile stage which is called a 'spat'. They also develop a foot which is used to crawl over the substrate when seeking a place to settle. Pacific oysters take approximately 15 to 18 days to reach this stage; European oysters around 10 to 12 days since they are already at a more advanced stage of development when released from the parent.

Once oyster larvae become mature, suitable materials and/or settlement cues are added to larval rearing bins to encourage settlement and metamorphosis. Biofilms form on settlement surfaces and these encourage settlement by providing a sticky surface on which to attach, by acting as a nutrient source and by increasing alkalinity to facilitate calcareous cements. Suitable settlement surfaces include shell chip and settlement cues include oyster extracts and chemicals. Adrenalin-like substances, such as epinephrine and nor-epinephrine at concentrations of 1×10^{-4} or 1×10^{-5} M, can be used to induce settlement and metamorphosis without the need for a suitable settlement material.

When oyster larvae are mature, they can be sent from the hatchery to a remote site for settling. This is a practice more commonly used for Pacific oysters by commercial hatcheries in the United States. The shellfish farmer or nursery operator prepares tanks on his/her site that are filled with sea water, settlement material and microalgae. On receiving the oyster larvae from the hatchery, they are added to the settling tank.

The oyster larvae are transported in moist conditions, e.g. on damp filter paper in a Petri dish provided delivery can be guaranteed within 24 hours. Once the larvae have had a chance to attach firmly to the settlement material, or 'cultch', the cultch can be placed out in the farm or into the nursery system.



THE PRODUCTION PROCESS

Hatchery Production - 16



NURSERY

In the commercial hatchery production of bivalve shellfish, the nursery stage is the most demanding in terms of food requirements and rearing space. The development of upwelling systems was a major improvement in nursery rearing techniques. These systems are used inside the hatchery and larger versions, sometimes called silos, can be used outdoors in ponds and pits where natural algae can be bloomed. Small hatchery upwellers can be made quite cheaply using inverted clear plastic drinks bottles. The water is circulated upwards through the containers by air lift or pumps. Flow rate is controlled by a valve at the outlet of each upweller. An optimum flow rate through the upweller is 30-40mls/min/g (live weight) of clams or oysters. This approximates to a 20% removal of particles in one pass of water through the upweller.

Nursery upwelling systems need to be large volume since experimental studies have shown that 200 mg/litre of the total system volume is the optimum stocking density. To ensure good growth and survival, the juvenile spat should be graded every week. Under hatchery conditions, a mixed diet of cultured algae is provided at 0.3 – 0.4 g (organic weight of algae) per g (live wt of spat) per week.

Once the spat have grown to a minimum of 2 – 4 mm they can be sold as seed by the hatchery. Usually, the hatchery offer a range of sizes from the minimum up to 25 – 30 mm seed.





THE PRODUCTION PROCESS

Hatchery Production - 17

NURSERY - 2

ALGAE REQUIREMENTS

Research has shown that under hatchery conditions, Pacific oyster spat require 0.3 g (organic weight of algae) per g (live wt of spat) per wk when fed a mixed diet of cultured *Chaetoceros calcitrans* + *Tetraselmis suecica*. To obtain a similar rate of growth when fed on pond water, a ration of 0.5 g/g/wk is required.

The amount of food is higher because some of the species of algae in the pond water are likely to be less nutritious than intensively grown algae which have been selected over the years for their nutritional value. To calculate the ration, you need to make an assessment of the number of food cells (individual algae) in the water within specific size ranges and multiply by the average weight of each food cell. Average weight is approximately 15 pg (for algae of 2-5 μm diameter), 170 pg (5-10 μm diameter), 680 pg (10-15 μm diameter) and 2270 pg (15-20 μm diameter).

Commercial hatcheries need to produce large quantities of microalgae to feed animals, especially during the nursery phase. The estimated cost of producing marine microalgae species is approximately 30% of the total cost of seed production. Therefore, efficient means of production, good utilisation of the food to promote rapid growth and selecting high value algae species are critical.

Continuous flow algae systems, using bag cultures, have been developed commercially for a range of the commonly cultured algae species. The method is now used in a number of countries worldwide.

See an image of continuous algal cultivation





Continuous culture system for algae





THE PRODUCTION PROCESS

Hatchery Production - 18

REDUCING ALGAL COSTS

Commercial hatcheries need to produce large quantities of microalgae to feed animals, especially during the nursery phase. The estimated cost of producing marine microalgae species is approximately 30% of the total cost of seed production. Therefore, efficient means of production, good utilisation of the food to promote rapid growth and selecting high value algae species are critical.

Continuous flow algae systems, using bag cultures, have been developed commercially for a range of the commonly cultured algae species. The method is now used in a number of countries worldwide.

The rearing of juvenile invertebrates can be very demanding in terms of manpower and other resources needed to supply sufficient quantities of food. One option adopted by commercial bivalve hatcheries is to transfer juveniles to outdoor ponds in which natural species of microalgae can be produced extensively. The addition of inorganic nutrients and fertilisers (such as urea, triple superphosphate and sodium metasilicate) to the water can enhance the amount of algae in the ponds. The species composition of the naturally bloomed algae is more difficult to control due to seasonal conditions. The reliable management of ponds can take several months, even years to perfect. Growth of algae in outdoor ponds is dependent on light and temperature as well as nutrients. Therefore, in temperate latitudes, the productivity of algae during the spring and summer is greater than in late autumn and winter. The cost of producing algae extensively in ponds has been estimated at less than 1% of the cost of producing algae in intensive, indoor systems. Sprinkler systems can be used to distribute the water and manage ponds more effectively.

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To reduce the reliance on live algae, alternatives such as spray-dried algae and algal pastes are available commercially. Generally, none of these alternatives can replace live diets but they can be useful as supplements for larvae, juveniles and broodstock.

Lipid emulsions have also been used to successfully supply DHA and EPA to clam and oyster postlarvae as well as oyster broodstock and scallop broodstock. They provide a tool for assessing lipid requirements of invertebrates. However, there is one drawback. As particles in lipid emulsion are very small (majority < 2 μm), it has been assumed that the uptake of the emulsion is at a rate equal to that observed for the uptake of microalgae also provided in the diet. This may not be the case and quantitative estimates of HUFA requirements may be subject to error. It is essential that a method for measuring the true uptake of emulsions can be found (e.g. tracer dye or radioactive marker) if meaningful projections on food requirements are to be established.



THE PRODUCTION PROCESS

Hatchery Production - 19



NOVEL ALTERNATIVES TO LIVE ALGAE

Algae culture can sometimes be unreliable with unforeseen collapses of cultures, usually at the time when they are most needed. To reduce the reliance on live algae, alternatives such as spray-dried algae and algal pastes are available commercially. They come in easy to use, 'off-the-shelf' packages needing only to be reconstituted in sea water.

On an experimental and semi-commercial scale, lipid emulsions have also been used to successfully supply the essential fatty acids DHA and EPA to clam and oyster postlarvae as well as oyster broodstock and scallop broodstock. They provide a reliable tool for assessing lipid requirements of bivalves. However, there is one drawback. As particles in lipid emulsion are very small (majority $< 2 \mu\text{m}$), it has been assumed that the uptake of the emulsion is at a rate equal to that observed for the uptake of microalgae also provided in the diet. This may not be the case and quantitative estimates of HUFA requirements may be subject to error. It is essential that a method for measuring the true uptake of emulsions can be found (e.g. tracer dye or radioactive marker) if meaningful projections on food requirements are to be established.

Generally, none of these alternatives can replace live diets but they can be useful as supplements for the feeding of larvae, juveniles and broodstock.





THE PRODUCTION PROCESS

Hatchery Production - 20

TRIPLOIDS

In the 1980s, a market for triploid Pacific oysters and consequently for hatchery produced triploid oyster seed was developed in the United States. Triploids have an extra set of chromosomes. As such they are rendered almost sterile but otherwise they resemble the diploid. They are not GMOs. As they are practically sterile, maturation (ripening) of the oysters during the summer months is prevented resulting in a more meaty, sweet tasting oyster.

Triploid seed can be produced in the hatchery usually by treating eggs with the chemicals cytochalasin B (CB) or 6-dimethylaminopurine (6-DMAP), but it is also possible to produce them with heat or cold shock, and pressure treatment. Generally 70-90% triploids can be produced from a treated batch of eggs. An alternative method is through the mating of tetraploid broodstock and diploid broodstock. This guarantees a 100% triploidy rate but it is difficult to obtain tetraploid at the outset.

Triploids of a wide range of bivalve species have been produced on a research scale. Commercially, production of triploids is limited to oysters, clams and scallops. A large proportion of the hatchery produced Pacific oyster seed in the USA, where most of the pioneering work was carried out, is triploid.

Performance of triploids has been variable and their commercial production is variable. In some situations, triploids outperform diploid counterparts, whereas the reverse can also be true depending on local environmental conditions.





MAIN ONGROWING TECHNIQUES

Pacific oyster spat can be bought direct from the hatcheries, usually at sizes between 3 mm and 14 mm. The larger the size, the greater the cost. An alternative to buying seed oysters is to purchase part-grown animals (> 40 mm, often referred to as half-ware) from certain growers who specialise in rearing from the smaller sizes for between 6 – 18 months.

In the case of *native oysters*, some of the natural fisheries that are not self-sustaining continue to produce because half-grown oysters are relayed for one growing season from other natural beds. There are strict controls over the areas for fishing and relaying to reduce the risk of high mortalities from *bonamiasis*. Seed native oysters are available from commercial hatcheries at a range of sizes (from 4-5 mm shell length up to 25-30 mm). The larger the seed, the more expensive they are to buy but this is offset by the higher survival rate of larger seed. Generally, it is good practice for a new investor in a shellfish business to buy the larger seed in the first instance. A financial return from sales of mature oysters will be achieved much sooner (within 2 to 3 years, rather than 4 to 5) and larger seed should be more tolerant to handling by inexperienced growers.





THE PRODUCTION PROCESS

Ongrowing - 2

PACIFIC OYSTERS - 1

In the most commonly used system, oyster spat are held in trays or bags attached to metal trestles on the foreshore. Home-made wooden trays covered with plastic mesh are the cheapest option, but a range of plastic trays and bags (poches) are available commercially. The size of the meshes is increased and the stocking density decreased as the animals grow. As a rough guide, at 3 mm long spat would be stocked at approximately 2 per cm², at 14 mm the density would be 0.25 per cm².

An alternative is to hold seed for a period in trays or lantern nets suspended from rafts or longlines where conditions allow. Under these circumstances, the oysters should grow more quickly, because they are permanently submerged, but the shell may be thinner and therefore more susceptible to damage.

In all cases, early stages of predator species such as crabs and starfish can settle inside the containers. They can cause significant damage unless the containers are opened and checked on a regular (monthly) basis. A final consideration is the additional financial burden of buying rafts or longline systems and this may be prohibitive.



Ongrowing - 3



PACIFIC OYSTERS - 2

Commonly, Pacific oysters are grown from spat right through to market size in bags on trestles. The bags are turned frequently, usually a minimum of low water on every spring tide, to promote even growth and prevent the build-up of seaweed, silt and other fouling on the bags. They are changed regularly to larger meshes, to allow grading, thinning, predator removal and to promote water flow. As the stock grows, it may also be moved progressively up the shore so that it is exposed to the air for longer. This promotes the formation of a thicker shell and is thought to 'harden off' the animal before it is sold.

In certain areas, half-ware Pacific oysters, which are large enough to withstand pressure from the common predators, may be placed directly on to the seabed (if suitable) or on to a 'mat' laid on the bottom, if it is too soft. This eliminates the need to turn the stock and change bags for part of the growing cycle. Initially, the plots (or 'parcs') may be sub-tidal, to promote growth, but the stock will be relaid inter-tidally later, to promote shell hardening.

Depending upon water temperature and food availability, it takes between 2½ and 3 years to rear a Pacific oyster to a market size of around 85 g (75 g – 100 g +). However, the actual size at harvest is determined by the preferred size in the destination market. Some markets prefer a smaller animal, others a larger one.



THE PRODUCTION PROCESS



Ongrowing - 4 NATIVE OYSTERS

Bottom culture, i.e. the laying of part-grown oysters (40 mm = 10 g) directly on to the substrate, is the normal practice for native oysters. Trials in Essex showed densities of 10 oysters m⁻² were better than 20 or 30 m⁻² and those animals grown on the seabed were better than those held in oyster bags on racks, even when trestles were sited low on the shore. Protective fences can be put up around plots to give some degree of protection from shore crabs. The walls of the fences can be made from 10 mm plastic netting and are about 50 cm high with another 15 cm buried into the substrate. An overhang at the top, made of a smooth material such as metal or fibreglass, points outwards at a 45 or 90 degree angle to the vertical. Potting crabs in the area of the lays is another method of removing them.

If you buy oysters smaller than 10 g, you will need to hold them in trays or bags attached to metal trestles on the foreshore until they are large enough to be put directly on to the substrate and be safe from predators, strong tidal and wave action, or siltation. Home-made wooden trays covered with plastic mesh are the cheapest option, increasing the mesh size the oysters grow. Also, a range of plastic trays and poches are available commercially. Holding seed oysters in trays suspended from rafts and longlines may be an alternative method in locations where current speed will allow. The oysters should grow more quickly because they are permanently submerged but the shell may be thinner and therefore more susceptible to damage. In all cases, early stages of predator species such as crabs and starfish can settle inside the containers where they can cause significant damage unless containers are opened and checked on a regular (monthly) basis. A final consideration is the additional financial burden of buying rafts and longline systems and this may be prohibitive.



Ongrowing -5



PREDATORS

If oysters are on-grown in a bag and trestle system many problems with predators can be avoided with good husbandry. Oysters are most vulnerable to predation when growing sub-tidally, the juveniles of many predators, particularly the common starfish (*Asterias rubens*) and the shore (or green) crab (*Carcinus maenas*), can settle from the plankton in to the bags. If not removed and left to grow unchecked, they can cause high mortalities.

Starfish and crabs are abundant in estuaries and coastal waters where they are probably the most significant of all oyster predators. This can be problematic for some seabed culture plots and removal by trapping (potting) or other methods, such as dredges or mops, may be necessary. Larger shore crabs (up to 65 mm carapace width) can prey on oysters up to 10g. However, shore crabs of this size are relatively rare. Starfish pull apart the shell valves to consume the oyster meat inside.

In certain parts of the country, the American tingle or oyster drill (*Urosalpinx cinerea*) and European tingle (*Ocenebra erinacea*) can be problem species. Both are predatory marine gastropods (sea snails) that consume oysters by drilling through the shell to inject a poison that kills the oyster. The European tingle is locally abundant in some areas of west and south-west Britain. It was once much more extensively distributed, but has gradually disappeared as a result of exceptionally cold winters. The Oyster drill is found in Essex and Kent and was introduced originally from America in consignments of American oysters (*Crassostrea virginica*). (Half-grown American oysters were introduced into Britain until the early 1960s to sustain commercial oyster production.) Oyster spat are the tingles' main prey although oysters up to 45mm are susceptible to attack.





COMPETITORS AND FOULING ORGANISMS

If the bags or trestles are allowed to become heavily fouled with mussels (*Mytilus edulis*) or other filter-feeders, such as sea squirts, they can compete with the oysters for food particles and restrict the water flow by smothering the meshes. High densities of other bivalves in the area can also compete for food reserves.

In certain parts of the UK, notably the south, American slipper limpets (*Crepidula fornicata*) can compete with seabed-laid oysters for space and food. In extreme cases they can smother the oysters on the plots. They are relatively fast growing, often individuals remain attached to each other forming chains and mats, with a wide tolerance to temperature and salinity and no natural predator. They are more of a problem for those involved in the culture of our native or Flat oyster (*Ostrea edulis*). The slipper limpet was also introduced to the UK from America in consignments of American oysters.

Pests & Parasites

A small red-orange copepod, *Mytilicola orientalis*, can infest the guts of the oyster. In large numbers they can cause a partial blockage and lead to a loss of condition. It was imported along with the oysters in to France in 1977.

Infestation of the shell by marine worms of the genus *Polydora* can cause unsightly brown blemishes on the inner surface and decrease marketability of the stock.





DISEASE ORGANISMS

Pacific Oysters

Few diseases which are likely to prove troublesome to cultivators of Pacific oysters in the UK have been described. A number have been described in wild populations. The protozoan *Marteilia refringens*, which has been implicated in mortalities, has been reported from France, Spain and the Netherlands, but it has not been recorded in UK waters.

Native Oysters

While harmless to man, the protozoan parasite *B. ostreae* causes lesions in the gills and digestive gland leading to death. There is a link between disease susceptibility and physiological stress caused by handling and overcrowding. Disease tends to occur in oysters at 2 years and older. (NB Studies in Spain suggested that size of oyster was more important than age because it was found in the fastest growing oysters.) Once infection appears, it can spread quickly. The prevalence and intensity of infection can rise rapidly within a few months. Male and female oysters appear to be equally affected. The outbreaks that occurred in the 1980s, when *B. ostreae* was first discovered in the UK, resulted in large losses of stock.

'Dutch shell disease' is a fungal infection that can affect oysters. The adductor muscle of infected oysters is weakened with the result that the oyster cannot close its shell properly. In extreme cases, oysters lose condition and die.





ENVIRONMENTAL ISSUES

The environmental impact of Pacific oyster cultivation in the UK is minimal. At the current scale of production, and given the preferred method, environmental issues with native oysters are even less significant. However, there are some points that you might like to consider.

During regular management and maintenance of the trestles or plots, there may be some disturbance to shore-feeding birds, particularly waders and wildfowl. Usually, this is intermittent and of a localised nature and should cause no more harm than someone walking or bird watching on the beach. Keeping to defined tracks can minimise the effects of treading and of tyre pressure from vehicles that may be brought on to the foreshore.

The visual impacts of trestles set out for Pacific oyster cultivation can be noticeable if they are particularly extensive. However, most of the cultivation occurs low down on the shore and they are exposed only at low water and then for limited periods of a few hours. With careful site selection and arrangement, such impact can be minimised. Trays and trestles may cause localised changes to water circulation which can lead to the deposition of sediments. Siting them where there is good water flow will reduce this as well as ensuring that the oysters receive adequate levels of food.

Oysters layed on the seabed or other substrate, either inter-tidally or sub-tidally, have virtually no visual impact. If marker buoys are required, care should be taken to minimise their visual intrusion.





Harvesting - 1

Harvesting of mature *native oysters* begins after 4-5 years (depending on where in the UK the cultivation site is located) when they have reached a minimum size of around 70 g. Oysters are graded, purified where necessary and packaged before sale to wholesalers, retailers or catering outlets in the UK. There is also an export market, mainly to France and Spain.

Pacific oysters are available for harvesting after 2.5-3 years, again depending upon location. Minimum size is around 75g



THE PRODUCTION PROCESS

Harvesting - 2

Purification or depuration of shellfish means holding them in sterilised sea water for 48 hours under conditions that allow them to filter normally. This removes any bacteria accumulated in the gut. The sea water can be sterilised by ozone or ultra-violet light although the latter is the most common method used. The design and operation of purification systems must be carefully controlled and have to be approved for commercial use.



Clams ready for depuration



THE PRODUCTION PROCESS

Health & Safety Issues



The health and safety aspects of any cultivation enterprise are extremely important and can be quite diverse. Working practices and safety standards should be reviewed on a regular basis.

Areas for consideration will include:

A responsibility for personnel working on the site, ensuring that they are working under safe conditions and with gear and equipment that is appropriate and adequate for the job. All staff should have received the necessary training and/or guidance when using equipment that could be dangerous or when working on boats or out in isolated or dangerous conditions such as tidal waters or during the hours of darkness or poor light.

Divers may be required at certain stages of cultivation e.g. fitting moorings or during harvesting and this will need additional considerations including having an appropriate number of divers for the job with the relevant diving qualifications and equipment.

All gear on the foreshore or in the water should be marked clearly so that they are not a hazard to navigation or to other users of the area.

Boats and other vehicles and large machinery should comply with any statutory safety requirements.

For more information refer to the Legal and Administrative Section.





THE TECHNOLOGIES AND EQUIPMENT EMPLOYED Introduction

This section of the Hyperbook will “mirror” the previous section (PRODUCTION PROCESS), but will focus on the hardware and systems aspects of oyster production



THE TECHNOLOGIES Growing Locations

A “typical” oyster farming location (and see also Site Selection)



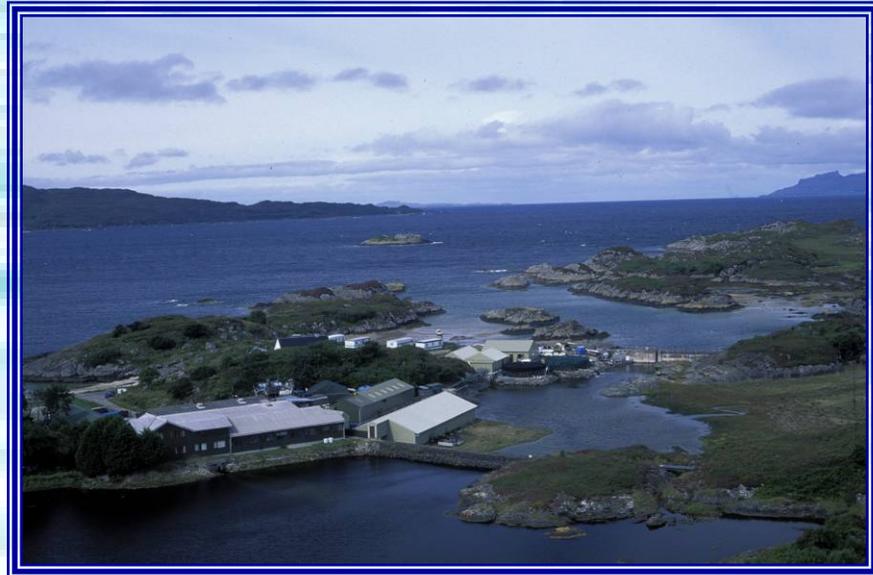


THE TECHNOLOGIES

Hatchery - 1

A “typical” marine bivalve hatchery would be located near to the sea, and housed in one or more buildings. In addition there may be outdoor tanks for water storage and other purposes. The seawater supply would be pumped into the unit - either continuously or on an intermittent basis .

Hatcheries can make use of existing buildings or be housed in a wide variety of building types, from simple commercial polyethylene tunnels to elaborate brick constructions.



The Seafish facility at Ardtoe has housed both shellfish and fin-fish hatcheries





BROODSTOCK HOLDING

During conditioning in the hatchery, broodstock animals are held in tanks and supported off the bottom of each tank in a mesh-based tray so that faecal material can fall to the bottom of the tank. Clams also prefer to be in a substrate of fine gravel and shell in the tray. This is not needed for oysters. An approximate guide is to have 2 litres of water for every animal of 20 g live weight, 3 litres for 30 g animals. For example, a tank of 150 litres containing 120 litres water should hold 60 animals @ 20 g live weight per individual. Generally, systems are constructed with a through-flow of heated (to 20-22 °C) sea water passing through the tanks at 25 mls min⁻¹ per animal. Salinities of 25 parts per thousand and above are suitable for clams and Pacific oysters but European flat oysters prefer salinity of 30 parts per thousand or above. Natural phytoplankton in the sea water is also an important food source so fine filtration of water before it enters the conditioning system is not recommended. Cultured algae can be added to the incoming seawater using peristaltic pumps or by gravity feed.

Some research has been carried out on conditioning bivalves in re-circulation systems. Although this is possible and will reduce the costs of heating the sea water, through-flow systems are more common.



THE TECHNOLOGIES Hatchery - 3



BROODSTOCK HOLDING 2

The tanks should be drained and cleaned to remove sediment and particulate material that settles on the bottom of the tank. The frequency of cleaning will depend on the amount of particles and silt in the water but once a week is a good guide. The closer the broodstock get to spawning, the more care is needed during cleaning to prevent the animals from releasing their gametes. Broodstock need to be kept in a quiet part of the hatchery with the minimum of disturbance.



**Holding
broodstock in the
hatchery**





ALGAL CULTURE UNIT

Reliable daily production of high-quality microalgae is essential in any marine bivalve hatchery. Whilst not technically complex, there are a range of production options to consider. Algae is usually sub-cultured in 250 mL, 1L and 10L flasks.

Bulk algae can be grown in carboys for regular daily cropping. Polythene bags or even large tanks are also common, and cropping can be semi-continuous or on a batch production basis.



Algal production in carboys



Algal production in 100L bags





LARVAL CULTURE VESSELS

Oyster larvae can be held in a variety of tanks and vessels during the algae feeding phase.



Larval rearing bins



THE TECHNOLOGIES Hatchery - 6



The requirement for some sort of “nursery” unit has been discussed elsewhere. These units provide sheltered temporary accommodation for the small oyster seed, and are normally made up of a series of upwellers.

With newly-settled oyster spat cheap upwellers can be made from empty plastic soft drinks bottles.



THE TECHNOLOGIES Nursery Units

The longer the spat and seed are held in the nursery, the larger the space required.

Nursery upwelling systems need to be large volume since experimental studies have shown that 200 mg per litre of the total system volume is the optimum stocking density.



Water circulates from the reservoir upwards through the mesh on the base of each upwelling cylinder. Flow rate is controlled by a valve at the outlet of each cylinder.

Nursery upwelling system





Juvenile oysters in a tray



THE TECHNOLOGIES Ongrowing - 1



Trestles, meshes and mesh bags are important for Pacific oyster culture





Ongrowing -2

OTHER EQUIPMENT

An oyster farmer will need an assortment of smaller pieces of equipment and safety clothing in addition to more specialised items

Examples of the equipment required include:

- First Aid kit
- Lifejackets/Buoyancy aids, especially when working from small boats
- Gloves
- Knives
- Rakes
- Measuring and weighing equipment
- Brushes and brooms
- Communication equipment (mobile phone or VHF radio)



THE TECHNOLOGIES Harvesting - 1

Harvesting methods vary in relation to scale of production and the location of the cultivation site.



An example of chaland boat used extensively in France for Pacific oyster cultivation





A large scale oyster line



THE TECHNOLOGIES Harvesting - 3



An example of an oyster grader





Oysters can be packed in a variety of ways for the market.



THE TECHNOLOGIES

Depuration



Purifying or “depurating” oyster is probably essential for commercial sales in the UK



A small depurating unit

Depuration generally involves holding oysters in clean water for 48 hours, and letting their systems flush out any material from the digestive tract which might contain bacteria harmful to humans.

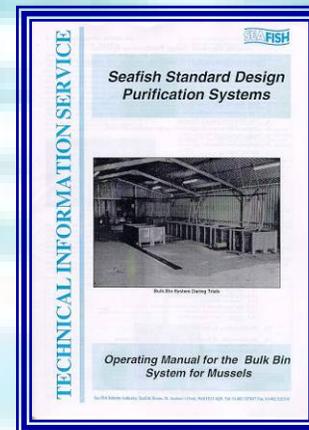
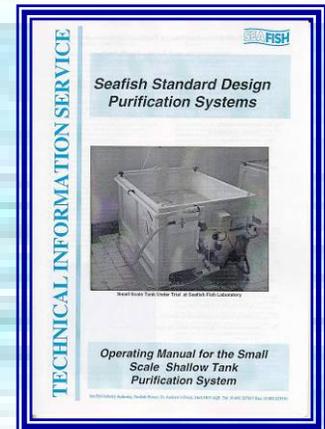
The process often uses recirculated water systems, with simple UV sterilisation of the water on each pass



THE TECHNOLOGIES Depuration 2

The grower may chose to install their own depuration unit or purchase the service from a dedicated facility.

Advice on different scales of depuration facility design, installation and operation are available from Seafish.





SITE SELECTION

Introduction

This section of the Hyperbook will consider how locations for oyster cultivation projects might or should be chosen. Good site selection is critical to the success of any aquaculture venture, and there are some obvious considerations.

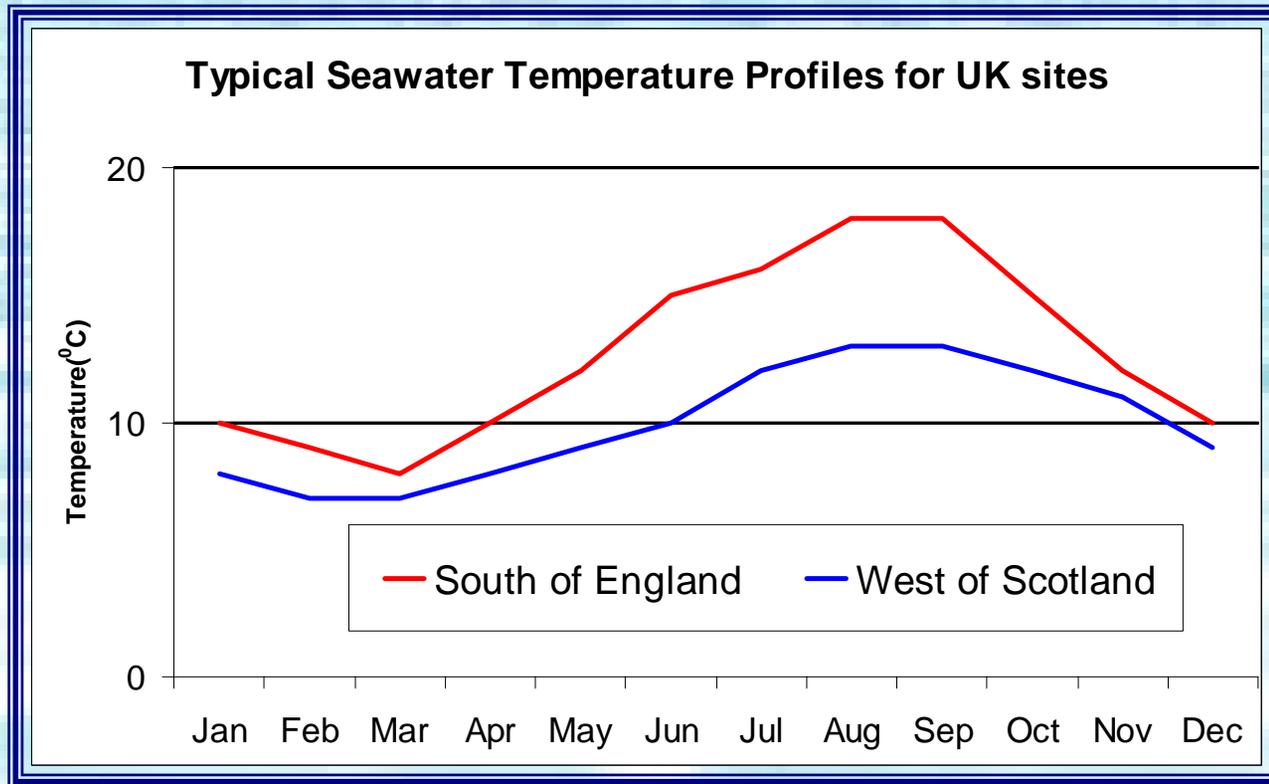
The selection of a suitable site is crucial to the success or failure of an oyster farm. Growth and survival of oysters are influenced by a range of physical, biological and chemical factors including sea water temperature and salinity, water flow rate and phytoplankton content, exposure to air and wind, substrate type, predators, competitors and fouling organisms, dissolved nutrients, oxygen and pollutants. Many of these are subject to seasonal and annual variation and it is advisable to monitor the conditions at your prospective site for at least a year before any commercial culture begins and carry out a pilot study to see how well oysters grow and survive.



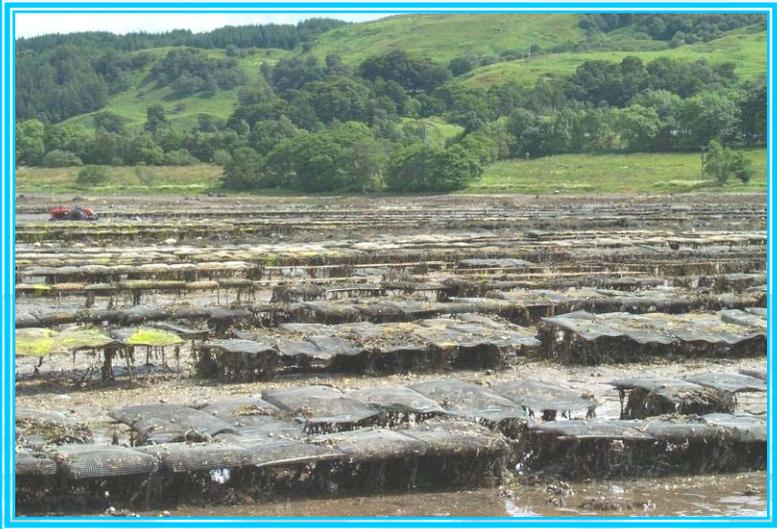
SITE SELECTION

Seawater Temperature Profile - 1

In the UK, oysters start to grow in the spring when sea water temperatures reach 8-9 °C. Growth rate reaches a maximum in July or August when temperatures peak (usually 16-18 °C) and then falls off again as the temperature drops to below 8-9 °C in November or December. Oysters can die in very cold winters if exposed to chill winds and air temperatures close to freezing. When exposed to the air, they close tightly to prevent desiccation of the internal tissues. They can respire anaerobically (i.e. without oxygen) when out of water but have to expel toxic metabolites when re-immersed as the tide comes in. To grow well, native oysters need sheltered areas with fully saline water (> 30 parts per thousand) and tidal flows of 1–2 knots (50-100 cm sec⁻¹). Plots low down the beach which allow access at spring tides for essential husbandry and maintenance are most suitable.



SITE SELECTION Typical Sites



SITE SELECTION

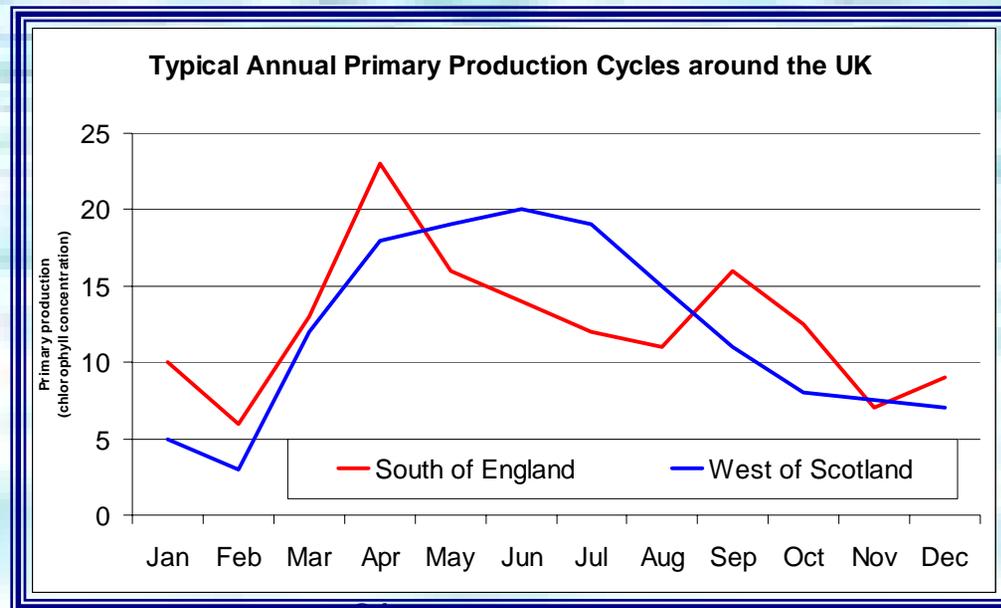
Algal Situation

Oysters feed only when they are immersed, therefore for optimum growth they should be kept submerged as much as possible.

Most coastal sites have sufficient quantities of algae in the water to support cultivation. However, some species of algae can cause shellfish to accumulate biotoxins in their flesh. Routine testing is carried out to monitor biotoxin levels and once they exceed permitted values shellfish beds are closed (statutory or voluntary) and stock can no longer be harvested or offered for sale. The beds remain closed until two consecutive samples return values below the threshold levels. Such closures can adversely affect a business so this factor should be considered when selecting a site. Unfortunately, past track record (where available) can only offer limited guidance, it can not guarantee that a problem will not occur in the future.

Also, sites near large urban and industrial developments are unsuitable for shellfish cultivation because of potential pollutants in the water.

Tri-butyl tin (TBT), a substance once used extensively in antifoulant paints, has been a particular problem for oyster growers. Although its use is now banned, TBT can remain in sediments for some time, therefore sites next to boatyards and marinas should generally be avoided.





Site access and ownership

Any cultivation site should be readily accessible for bringing gear on to the site and for transporting harvested clams away to market. Ownership of the area and its availability are important considerations in the initial site selection.

Many shellfish cultivation operations directly co-exist beside and even within designated environmentally sensitive areas including statutory sites such as Sites of Special Scientific Interest (SSSIs), Special Areas of Conservation (SACs), Special Protected Areas (SPAs) and Ramsar sites, as well as local voluntary sites. It is the co-existence with such sites that industry operations possibly face the greatest challenge. The Habitats Directive 92/43/EEC and the Birds Directive 79/409/EEC make provision for the conservation of wildlife habitats and of birds through the designation of SACs and SPAs respectively. Designated areas can, and are encouraged, to include estuaries, shallow bays and coastal waters. Within such areas, cultivation practices are likely to be subject to local management plans.

As legislation on these and other aspects can be changed, it is wise to consult the appropriate regulating bodies for the most recent information.

See Legal & Administrative Contact Pages





Suspended Solids & Classifications

As with all bivalves, oysters also filter bacteria and viruses from the water. These are often attached to particles that are filtered from the water during normal feeding. Shellfish growing and harvesting waters are classified according to their level of bacterial contamination and the treatment of shellfish before marketing is dependent on that classification (See below).

When looking for a site, you should visually inspect for outfalls etc. and contact the local Environment Agency office for information on the location of consented outfalls and overflows. The local Environmental Health Department or Port Health Authority may be able to provide you with information on shellfish hygiene and water classifications if the site is already a shellfish harvesting area. (NB Different species react differently in the same water. For example, mussels show higher levels of *E coli* than Pacific oysters.) If there are no classification data available, then you should collect samples of naturally occurring bivalves from your selected area or place bagged shellfish in the area for testing. (NB If the EHD/PHA can be involved and sampling is done according to strict protocol (every 2 weeks for 3 to 4 months) it may be possible to get a provisional classification straight away. If the sampling is done independently, the results will not count towards a provisional classification.

Press the button to see the classifications table



Shellfish Waters Classifications

Classifications of shellfish harvesting areas under the Shellfish Hygiene Directive 91/492/EEC	
Classification	Treatment required
A	Shellfish can go direct for human consumption.
B	Shellfish can go for human consumption after purification in an approved plant, or after an EU approved heat treatment process, or after relaying in an approved relaying area (whether or not combined with purification).
C	Shellfish can go for human consumption only after relaying for at least 2 months in an approved relaying area followed, where necessary by treatment in a purification centre or after an EU approved heat treatment process.
Prohibited (D)	Shellfish from these areas must <u>not</u> be subject to production or be collected.

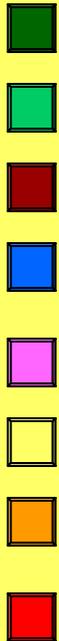




Introduction

To set up an oyster farm the minimum a grower needs is to own or lease an area of the seabed and have the right of access to that site. There are national and local variations to legislation on this, therefore it is always advisable to contact the Local and Regional Authorities in the first instance. In England and Wales the regional Sea Fisheries Committee may also be able to offer advice. If structures are to be placed in the sea, they may be hazardous to navigation so the Harbour Authority and/or Maritime & Coastguard Agency should be notified.

Many areas of the coastal zone have been designated for their conservation value so it is also advisable to contact the appropriate conservation agency. These are English Nature; Countryside Council for Wales; Scottish Natural Heritage; Environment and Heritage Service (Northern Ireland).





There are various regulations specific to shellfish farming that must be followed when cultivating oysters. These are summarised below, with links to pages with further information.

1. A shellfish farmer must *register* a farm. This should usually be done within two months of commencing operation.
2. The shellfish beds must be *classified* for hygiene purposes.
3. Samples may be collected for monitoring of *algal toxins*.
4. *Movements* of shellfish, including *imports and exports*, may be controlled





1. Registration

The Fish Farming and Shellfish Farming Business Order, 1985 (or equivalent legislation) obliges a shellfish farmer to register his or her business with the Department for the Environment, Food and Rural Affairs, the Welsh Assembly Government, or the Scottish Executive. The Fish Culture Licence fulfils a similar function for the Department of Agriculture and Rural Development in Northern Ireland.

The purpose of registration is to assist the departments in dealing with outbreaks of disease if these should occur. Registered businesses are required to keep a record of the stock movements on and off site and to submit a simple summary of movements each year.

It is necessary to register the shellfish farm within two months of commencing operations.



LEGAL AND ADMINISTRATIVE Legislative Controls - 3

1. Registration - continued

Applications for registration are made to:

In England and Wales:

The Fish Health Inspectorate, CEFAS Weymouth Laboratory, Barrack Road, The Nothe, Weymouth, Dorset, England, DT4 8UB

Tel: 01305 20 6673 / 6674

Fax: 01305 206602

E-mail: Fish.Health.Inspectorate@cefas.co.uk

In Scotland:

Fisheries Research Services, Marine Laboratory, PO BOX 101, Victoria Road, Aberdeen, AB11 9DB

Tel: 01224 295645

Fax: 01224 295620

E-mail: fishhealth@marlab.ac.uk

In Northern Ireland:

Department of Agriculture and Rural Development, Fisheries Division, Annex 5, Castle Grounds, Stormont, Belfast. BT4 3PW

Tel: 028 9052 0100

Fax: 028 9052 3121

Further information on shellfish farm registration can be found on:

<http://www.cefas.co.uk/fhi/farm%20registration.htm>



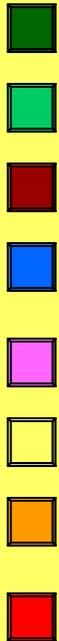


2. Harvesting Area Classification

It is a statutory requirement [Food Safety (Live Bivalve Molluscs and Other Shellfish) Regulations, 1992] that shellfish beds must be classified according to the faecal coliform (or *Escherichia coli*) levels of the bivalve flesh. Treatment of shellfish before marketing is dependent on that classification. In harvesting areas with a 'B' classification the scallops must be purified of any faecal bacterial content in cleansing (depuration) tanks before sale for consumption.

The local Environmental Health Department (EHD) or Port Health Authority (PHA) may be able to provide you with information on shellfish hygiene and water classifications if the site is already a shellfish harvesting area.

New sites must be graded. You should collect samples of oysters from your selected area or place shellfish (contained in a tray) in the area for testing. If the EHD/PHA can be involved and the sampling is done every 2 weeks for 3 to 4 months according to strict protocols it may be possible to get a provisional classification almost immediately thereafter. If the sampling is done independently, the results will not count towards a provisional classification. Full classification may be achieved after a year of continuing sampling at monthly intervals. It may be possible to shorten the sampling period if additional information is available for the same species on nearby beds, from other species in the same area, or from historical monitoring.





3. Algal toxins

The risks to consumers from shellfish poisoning due to the presence of algal toxins in the tissues are minimised by a statutory requirement for sampling. The monitoring programme for algal biotoxins is a requirement of the Shellfish Hygiene Directive 91/492/EEC, which is implemented in the UK by the Food Safety (Fishery Products and Live Shellfish Hygiene) Regulations 1998 as amended. The monitoring programmes are undertaken on behalf of the Food Standards Agency (FSA), FSA (Scotland) and FSA (Northern Ireland). You may be required to provide samples. If the amount of toxin exceeds a certain threshold, the collection of shellfish for consumption is prohibited until the amount falls to a safe level, giving a temporary closure of the fishery. Sampling frequency is increased if toxins are detected. Samples of seawater from selected sites are also examined routinely for the presence of the phytoplankton species that produce these toxins, as an early warning system.

Further information on the algal toxin monitoring programme, together with a list of the areas currently affected can be found on the following link:

<http://www.foodstandards.gov.uk/foodindustry/shellfish/algaltxin/>

If the water samples exceed the specified action levels, then samples of shellfish within the same harvesting area are collected for biotoxin screening. If the maximum permitted levels for ASP or PSP toxins exceed the maximum permitted levels, or if DSP is detected then the harvesting area will be closed, preferably by means of a voluntary closure agreement. If for any reason a voluntary agreement is not possible or the detection of toxicity is over a large area then the production area is closed by statutory means.

Press the button to see the toxins table



Algal toxins - Action limits and maximum permitted levels

WATER		SHELLFISH FLESH	
ALGAL GROUP	Action Limit (cells/l)	TOXIN	Maximum Permitted Levels
<i>Alexandrium</i> Spp.	Presence	PSP	80 µg per 100 g
<i>Dinopysis</i> / <i>Procentrum</i> Spp.	100	DSP	Presence
<i>Pseudonitzschia</i> Spp.	150 000	ASP	20 µg per g

Situation as at Sep 2002 – Consult FSA website for updates





4. Movement controls

There are certain restrictions on the deposit of bivalve molluscs around the coast of Great Britain, to prevent the introduction and spread of diseases.

The UK has now achieved Approved Zone status for most of the coastline for the oyster diseases *Marteilia* and *Bonamia*, except for three restricted areas where *Bonamia* is found. These areas are (1) from the Lizard to Start Point; (2) from Portland Bill to Selsey Bill and (3) from Shoeburyness to Felixstowe (Commission Decision 2002/300/EC of 18 April 2002).

Movements of oysters within the UK are controlled according to the health status of these areas. Anyone wishing to deposit or relay oysters taken from the controlled (restricted) areas listed above must apply for permission to the Fish Health Inspectorate (FHI) at the CEFAS Weymouth Laboratory (for England and Wales) or the Fisheries Research Services (FRS) at the Marine Laboratory, Aberdeen (in Scotland). It is advisable to check with DARD for the current position within Northern Ireland.

Approved zone status also enables the UK to operate import controls.





4a. Import and export controls

EU Imports

Import controls are aimed at preventing the introduction of shellfish diseases from elsewhere in the EU, where they are known to occur, or where no sampling and testing is carried out. Imports for the purpose of deposit into coastal waters are subject to controls based on the health status of shellfish growing areas in the region of origin. Each import must be accompanied by a *Movement Document* signed by the competent Veterinary Authority in the Member State of origin. The FHI (for England and Wales), FRS (for Scotland) and DARD (Northern Ireland) are responsible for ensuring that any shellfish imports are made in accordance with these rules. They should be consulted well in advance of any intended import if there is any doubt. In any case, at least 24 h notice is required before the arrival of any consignment.

Other imports

Oysters from non-EU countries may only be deposited within the EU waters so long as they are certified free from disease by a testing programme as stringent as that which applies in the EU and comply with the other conditions of import. The FHI, FRS or DARD will have the latest information.





4a. Import and export controls - continued

Exports

If you wish to export oysters to another EU country you should contact the FHI, FRS or DARD to discuss what documents, if any, are required. Five working days notice is needed so that the documents can be produced by the intended export date. Anyone intending to export oysters to countries outside the EU should check the requirements of the destination country. If any health certification requirements exist you should contact the FHI, FRS or DARD to establish whether they can be met.

Further more detailed information on movements, imports and exports (in relation to disease control) can be found on:

<http://www.cefas.co.uk/fhi/movements.htm#Shellfish>





Rights of shellfish cultivators in the sea

At present, the cultivator has limited legal protection of the stock. Bivalves grown in containers, e.g. pearl or lantern nets, in public waters are protected by the *Theft Act, 1968* and the *Criminal Damage Act, 1971* (or equivalent legislation in Scotland and Northern Ireland).

Shellfish beds covered by private right of fishery or by Several Order are protected against theft or damage by the provision of *Section 7 of the Sea Fisheries (Shellfish) Act, 1967* (or Northern Irish equivalent), provided that the beds are adequately marked.





Several Orders

A cultivator who wants to have additional protection for stock kept in public waters may apply for a right of Several fishery. These are granted in England by the Department for the Environment, Food and Rural Affairs, and in Wales and Scotland by the fisheries departments of the respective devolved governments. In Northern Ireland, the Shellfish Fishery Licence fulfils a similar function. They are granted for a fixed period, to an individual, a co-operative, or a responsible body, to enable the grantee to cultivate the sea bed within a designated area of water and to conserve, develop and enhance the specified stocks of shellfish thereon. The Several fishery concept is designed to give the lessee a much greater management control of the stocks. Several rights may also be granted to a Sea Fisheries Committee, which cannot cultivate stocks in its own right but may lease rights of Several fishery. The applicant must provide a management plan, and this must show that the fishery will benefit from cultivation. The Several fishery rights may be terminated if the grantee fails to meet the terms of the order.

Application for and granting of a Several fishery right can be a time-consuming process, which may take up to 3 years. If there are any objections to the application then this can force a public enquiry, the cost of which falls to the applicant. Subletting from a Several Order that is held by a Sea Fisheries Committee is often easier, where this is an option. However, areas already covered by Several Orders may only be suitable for cultivation of certain species of bivalve.

Guidance notes on applying for a Several Fishery (for England and Wales, but general principals apply elsewhere) can be found on:

<http://www.defra.gov.uk/corporate/regulat/forms/fish/Fis3.pdf>



LEGAL AND ADMINISTRATIVE Planning issues - 1



A focus on the the main agencies involved in the approval of an application for a new aquaculture site is provided in this section . Once an application has been granted, and aquaculture operations commence, the number of regulators with a significant ongoing operational concern reduces.

For a bivalve aquaculture site application, the following decision making bodies are involved:

- The Crown Estate (CEC). Effectively the “landlord” in terms of ownership of the seabed, the Crown grants a lease and issues development consent to the operator, and levies a “rent” which is based upon tonnage of production
- Local Authorities. Considers applications and issues opinions to the Crown (within England, Wales and Scotland and will eventually be the lead body in this regard). Also provide planning permission for any on-shore facilities
- Department of Agriculture and Rural Development (Northern Ireland) Administers all aspects of marine aquaculture applications in Northern Ireland.
- Foyle, Calingford and Irish Lights Commission For those waters in Northern Ireland
- National fishery advisory bodies- CEFAS and SEERAD
- Health and Safety Executive. Concerned with health and safety



LEGAL AND ADMINISTRATIVE Planning issues - 2



In addition, there are statutory consultees, who will pass their views on the local authority for consideration:

- Statutory Conservation Agencies- EN, CCW, SNH, EHS(NI). Have an interest in the natural environment
- Statutory Environmental Protection Agencies - EPA, SEPA etc. As above

Other groups and individual also have an opportunity to comment upon aquaculture applications:

- Maritime and Coastguard Agency
- Northern Lighthouse Board
- Local communities
- Private individuals
- Other groups e.g. FOE, WWF, RSPB, RYA, moorings associations etc

Once fish farms are up and running, they have to be concerned with ongoing interaction with some of the groups above - and with others such as:

- Food Standards Agency (FSA)
- Environmental Health Offices (EHO's)





When divers are engaged in harvesting or other work all diving operations must be carried out in accordance with the relevant national legislation (Health and Safety at Work Act 1974 and Diving at Work Regulations 1997 or subsequent revisions) and the most appropriate Approved Code of Practice (ACoP). Depending upon the work to be undertaken this may be that for 'Commercial Shellfish Diving in Inshore Waters' or that for 'Commercial diving projects inland/inshore'. Compliance is checked by the Diving Inspectorate of the Health and Safety Executive (HSE)

Particular attention should be paid to preparation of the dive plan and risk assessment which, in turn, will indicate the minimum number of persons (usually 4) required in the dive team for the particular operation. Failure to fulfil these requirements is the most common complaint made by the HSE against those involved in shellfish diving. This can result in prosecution and those who contract-in divers are equally liable in these circumstances.





LEGAL AND ADMINISTRATIVE Useful Internet Links

Before proceeding any further with this Hyperbook, you could quickly review the current position of various organisations *vis-a-vis* aquaculture (click on the blue buttons, and “exit” your browser to return to this page):

- The Crown Estate (CEC) 
- The Scottish Environmental Protection Agency (SEPA) 
- Scottish Executive Environment and Rural Affairs Department (SEERAD) 
 - Fisheries Research Service (FRS) 
- Scottish Natural Heritage (SNH) 
- Maritime and Coastguard Agency (MCA) 
- Northern Lighthouse Board 
- Health and Safety Executive (HSE) 
- Food Standards Agency (FSA) 
 - Specifically:  for algal toxins

Note that you should be “on-line” during this part of the Hyperbook session, if you want these internet links to function automatically. You may have to do some searching within each organisation’s website to find material relevant to aquaculture - use their search engines and common sense about their site maps.



LEGAL AND ADMINISTRATIVE Useful Internet Links - Continued



Before proceeding any further with this Hyperbook, you could quickly review the current position of various organisations *vis-a-vis* aquaculture (*click on the blue buttons, and “exit” your browser to return to this page*):

- The Centre for Environment, Fisheries and Aquaculture Science (CEFAS) 

Specifically: www.cefasc.co.uk/fhi 

- Department of Environment, Food and Rural Affairs (DEFRA) 

Specifically: www.defra.gov.uk/fish 

www.defra.gov.uk/corporate/regulat/forms/fish 

- Department for Agriculture and Rural Affairs, Northern Ireland (DARDNI) 

- English Nature 

- Northern Ireland Environment and Heritage Service (NIEHS) 

- Foyle, Carlingford and Irish Lights Commission (FCILC) 

- General Guide to Government Websites 





SUPPLIERS

Introduction

This section of the Hyperbook covers suppliers to the industry who might be able to support oyster cultivation operations. The list is not exhaustive, nor does inclusion within the list denote any particular endorsement of the company in question by Seafish or Epsilon Aquaculture Ltd. Wherever possible the supplier's website address is the main reference - readers can access these sites directly from this Hyperbook if they are "on line" during the Hyperbook session.

This list includes only some of the companies that supply to the aquaculture industry. Reference to these companies should not be construed as an official endorsement of these companies, nor is any criticism implied of similar companies that have not been mentioned.

Suppliers of aquaculture equipment can be found advertising in the trade papers and journals. The annual 'Fish Industry Yearbook' contains an aquaculture supplier section. Suppliers can also be contacted at conferences and trade exhibitions, such as the biannual Aquaculture International exhibition in Glasgow.

Suppliers are broadly grouped into:

- Biological suppliers (seed)
- Hardware suppliers (equipment)
- Services suppliers (advisors, utilities, financial)





Suppliers

Biological Suppliers

- **Seed for on-growing:**

Guernsey Seafarms Ltd., Parc Lane, Vale, Guernsey, Channel Islands.. (Tel: 01481 47480; Fax: 01481 48994; website: www.avnet.co.uk/gsf).

Seasalter Shellfish (Walney) Ltd., Old Gravel Works, South Walney Island, Barrow-in-Furness, Cumbria, LA14 3YG. (Tel: 01229 474158; Fax: 01229 470500; e-mail: seasalter_walney@compuserve.com) 

- **Continuous algae culture units:**

SeaCAPS, Seasalter Shellfish (Whitstable) Ltd, The Hatchery, Old Roman Oyster Beds, Reculver, Kent, CT6 6SX (Tel: 01227 363359/272003; Fax: 01227 740518/273775; website: seasaltershellfish.co.uk). 

- **Algae pastes:**

(Instant Algae) Reeds, www.seafarm.com 

- **Nutrients for algae culture:**

Cellpharm Ltd., Malvern Hills Science Park, Geraldine Road, Malvern, WR14 3SZ. (Tel: 01684 585345; Fax: 01684 585388; www.cellpharm.co.uk) 





Suppliers Hardware Suppliers

Boats

- Alexander Noble & Sons, Girvan, Ayrshire. KA26 9HL Tel: 01465 712223 Fax: 01465 715089 E-mail: nobel@boatbuilders.fsbusiness.co.uk
- Almaritec, Willowburn Industrial estate, Alnwick, Northumberland. NE66 2PQ. Tel: 01665 602917 Fax: 01665 605399 E-mail: sales@almaritec.demon.co.uk Web: www.almaritec.demon.co.uk
- Bow & Stern, Unit 7B4, Industrial Estate, Lisigary, Portree, Skye. IV51 9HD Tel/Fax: 01478 613334
- Malakoff & Wm Moore, North Ness, Lerwick. Shetland. ZE1 0LZ Tel: 01595 695544 Fax: 01595 695720 E-mail: enquiries@malakoff-moore.co.uk Web: www.malakoff-moore.co.uk
- Wood & Davidson, North Esplanade East, Aberdeen. AB11 5FR Tel: 01224 581221 Fax: 01224 584007 E-mail: info@wood-davidson.co.uk
- Corpach Boatbuilding Company, The Slipway, Annat Point, Corpach, Fort William. PH33 7NN Tel: 01397 772861 Fax: 01397 772765

Longline Floats

- C G Paxton, 28 Carmyle Avenue, Glasgow. G32 8HF Tel: 0141 778 8676 Fax: 0141 778 3708 E-mail: mail@paxton.co.uk Web: www.paxton.co.uk
- Viking Ecosse, 4 Braeside, Irvine. KA11 1BX Tel: 01294 213716 Fax: 01294 212604 E-mail: vikingecosse@ndirect.co.uk Web: www.vikingecosse.ndiresct.co.uk
- Gem Plastics, Regaskin, Cavan, Co Cavan, Ireland. Tel: ++ 353 49 4331077 Fax: ++ 353 49 4361157 E-mail: sales@gemplastics.ie Web: www.gemplastics.net





Suppliers Hardware Suppliers - continued

Ropes

- Gael Force Marine (see moorings)
- Marlow Ropes, Diplocks Way, Hailsham, East Sussex. BN27 3JS Tel: 01323 2 847234 Fax: 01323 440093

Moorings

- F P M Henderson, Unit 27B, Whiteinch Business Centre, Jordan Street, Glasgow. G14 0RR Tel: 0141 950 1800 Fax: 0141 950 1777
- Gael Force Marine, 136 Anderson Street, Thornbush, Inverness. IV3 8DH Tel: 01463 229400 Fax: 01463 229421 E-mail: sales@gaelforce.net
- E Y E Co, The Gunshed, Levington, Ipswich. IP10 0LX Tel: 01473 659666 Fax: 01473 659995 E-mail: info@eyecochain.com Web: www.eyecochain.com 

Lantern and Pearl Nets

- Loch Fyne Seafarms, Tarbet Industrial Estate, Campbelltown Road, Tarbet. Argyll. PA29 6SX Tel: 01880 820100 Fax: 01880 820120.
- Pacific Rim Aqua Products, Dinghai, Zhoushan, Zhejiang. China. 316000. Tel: ++ 86 580 3695958 Fax: ++ 86 580 3695960





Suppliers Hardware Suppliers - continued

- **Netting:**

Intermas Nets SA, Ronda de Collsabadell 11, Poligono Industrial, 08450 Llinars del Valles, Barcelona. Spain. Tel: ++ 34 938 425 700 Fax: ++ 34 938 425 701 E-mail: info@intermas.com Web: www.intermas.com 

Tilldenet, Hartcliffe Way, Bristol. BS3 5RJ. Tel: 0117 966 9684 Fax: 0117 923 1251 E-mail: enquiries@tildenet.co.uk Web: www.tildenet.co.uk 

- **Pumps:**

Honda (UK) – Power Equipment, 470 London Road, Slough, Berks, SL3 8QY (Tel: 01753 590500; Fax: 01753 590000; website: www.honda.co.uk). 





Suppliers Hardware Suppliers - continued

- **Pipework:**

Motherwell Industrial Plastics Ltd., Braidhurst Industrial Estate, Bellshill Road, Motherwell, Strathclyde. (Tel: 01698 261414; Fax: 01698 275424).

Pisces Aquacultural Engineers, Easter Poldar, Stirling, FK8 3QT (Tel: 01786 870014; Fax: 01786 870379; website: www.pisces-aqua.co.uk)

Everyvalve Equipment Ltd., 19 Station Close, Potters Bar, Herts., EN5 1TL (Tel: 01707 642018; Fax: 01707 646340; website: www.everyvalve.com).

Glynwed Pipe Systems Ltd., Headland House, New Coventry Road, Birmingham, B26 3AZ (Tel: 0121 700 1000; Fax: 0121 700 1001; e-mail: enquiries@glynwedpipesystems-uk.com).

- **Washers/graders:**

All in a Shell Ltd., Dooniskey, Lissarda, Co Cork, Ireland. (Tel: + 353 26 42267; Fax: + 353 26 42645; e-mail: allinashell@tinet.ie)





Suppliers
Hardware Suppliers - continued

Depuration systems

CJ Skilton Aquarist (Fax: 01245 400585; e-mail: cjskilton@aquaskil.co.uk)

The Falmouth Oyster Company, Unit 2A Empire Way, Tregonigge Industrial Estate, Falmouth, Cornwall, TR11 4SN. (Tel: 01326 374748; Fax: 01326 377668)

Tropical Marine Centre Ltd., Solesbridge Lane, Chorleywood, Herts, WD3 5SX. (Tel: 01923 284151; Fax: 01923 285840; website: tmc-ltd.co.uk). 

Depur, Moneycarragh Fish Farm, 60 Dromara Road, Dundrum, Newcastle. Co Down. BT33 0NS Tel: 028 437 51860 Fax: 028 437 51940

General shellfish equipment & machinery:

Dryden Aquaculture Ltd., Butlerfield Industrial Estate, Bonnyrigg, Edinburgh, EH19 3JQ. (Tel: 0187 5822222; Fax: 0187 5822229). 

Website with a comprehensive page of links to other suppliers sites

•Web:

www.stir.ac.uk/departments/naturalsciences/Aquaculture/fishing/fish/f_web.htm 





Suppliers Hardware Suppliers - continued

Clothing and safety

•ARCO, for nearest regional supply centre contact: Tel: 01482 222522 Fax: 01482 218536 E-mail: sales@arco.co.uk

•Gael Force Marine (see moorings)

•Crewsaver, Mumby Road, Gosport. PO12 1AQ Tel: 02392 528621 Fax: 02392 510905

•Cosalt (Scotland), Unit 1 & 2, Kessock Road Industrial Estate, Freaserburgh. AB43 5UE Tel: 01346 513721 Fax: 01346 515158

•Mullion Manufacturing, 44 North Farm Road, South Park Industrial Estate, Scunthorpe. DN17 2AY Tel: 01724 280077 Fax: 01724 280146

•Guy Cotton, BP538 29185 Concarneau Cedex, France. Tel: ++ 33 02 98 97 66 79 Fax: ++ 33 02 98 50 23 62
E-mail: info@guycotton.com Web: www.guy.cotton.com 

•McMurdo, Silver Piont, Airport Service Road, Portsmouth. PO3 5PB Tel: 023 9262 3900 Fax: 023 9262 3998
Web: www.pwss.com Web: www.mcmurdo.co.uk 

Navigation buoys and lights

•Hydrosphere UK, Units C&D, West End Centre, Colthouse Lane, Upper Froyle. Hampshire. GU34 4JR
Tel: 01420 520374 Fax: 01420 520373 E-mail: sales@hydrosphere.co.uk Web: www.hydrosphere.co.uk

•Gael Force Marine (see moorings) 

•EYE Co (see moorings)





Suppliers Services Suppliers

Insurance

Aquaculture Risk(Management) Ltd., The Esplanade, Sunderland, SR2 7BQ. (Tel: 0191 5682000; Fax: 0191 5658625).

Aquarius Underwriting Agencies Ltd., 60 Mark Lane, London, EC3R 7ND.

Trade Associations

Association of Scottish Shellfish Growers (ASSG): Doug McLeod (Chairman), Mountview, Ardsvar, Isle of Skye, IV45 8RU. (Tel: 01481 844324; e-mail: DouglasMcLeod@aol.com).

Shellfish Association of Great Britain, (SAGB), Fishmonger's Hall, London Bridge, London, EC4R 9EL. (Tel: 0207 283 8305; www.shellfish.org) 

Training

Scottish Aquaculture Training Association, Mountview, Ardsvar. Skye. IV45 8RU Tel/Fax: 01471 844324 E-mail: DouglasMcLeod@cs.com

North Atlantic Fisheries College (see information next page)

Scottish Association for Marine Science (see information next page)

Inverness College, 3 Longman Road, Longman South, Inverness. IV1 1SA Tel: 01463 273000 Fax: 01463 273001 E-mail: admissions.officer@inverness.uhi.ac.uk Web: www.uhi.ac.uk/inverness 





Suppliers Services Suppliers - Continued

Information, technical advice etc

Sea Fish Industry Authority, Aquaculture Development Service, Marine Farming Unit, Ardtoe, Acharacle, Argyll. PH36 4LD Tel: 01397 875000 Fax: 01397 875001 E-mail: aquaculture@seafish.co.uk Web: www.seafish.co.uk

Sea Fish Industry Authority, Technology Division, Seafish House, St Andrew's Dock, Hull. HU3 4QS Tel: 01482 327837 Fax: 01482 223310 E-mail: technology@seafish.co.uk Web: www.seafish.co.uk

C-Mar, Centre for Marine Resources and Mariculture, Marine Biology Station. The Strand, Portaferry. Co Down. BT22 1PF Tel: 028 4272 9648 Fax: 028 4272 9672 or 8902

Cross-boarder Aquaculture Initiative Team, Unit 14-15, Gray's Lane, Park Street, Dundalk, Co Louth. Ireland. Tel: ++ 353 42 9385074 Fax: ++ 353 42 9352490 E-mail: cbait@oceanfree.net

North Atlantic Fisheries College, Port Arthur, Scalloway. Shetland. ZE1 0UN Tel: 01595 772000 Fax: 01595 772001 E-mail: admin@nafc.ac.uk Web: www.nafc.ac.uk

Scottish Association for Marine Science, Dunstaffnage Marine Laboratory, Oban. Argyll. PA34 4AD Tel: 01631 559000 Fax: 01631 559001 E-mail: marine.science@dml.ac.uk Web: www.sams.ac.uk

Marketing Associations

Scottish Shellfish Marketing Group, Suite 3, Block 20, The Motherwell Food Park, Bellshill. Lanarkshire. ML4 3NP Tel: 01698 844221 Fax: 01698 841723 E-mail: sales@ssmg.demon.co.uk Web: www.scottishshellfish.co.uk





Suppliers Services Suppliers - Continued

Government Departments

Scottish Executive Environment and Rural Affairs Department, Fisheries Research Service, Marine Laboratory, PO box 101, Victoria Road, Aberdeen. AB11 9DB. Tel: 01224 876544 Fax: 01224 295511

Department of Agriculture and Rural Development, Fisheries Division, Annex 5, Castle Grounds, Stormont Estate, Belfast. BT4 3PW Tel: 028 9052 0100 Fax: 028 9052 3121 Web: www.dardni.gov.uk

National Assembly for Wales, Agriculture Department, Fisheries Division, New Crown Buildings, Cathays Park, Cardiff. CF10 3NQ Tel: 029 2082 5111 Fax: 029 2082 3562 Web: www.cymru.org.uk/subiagriculture

Department for Environment, Food and Rural Affairs, Centre for Environment, Fisheries and Aquaculture Science, Weymouth Laboratory, Barrack Road, The Nothe, Weymouth. Dorset. DT4 8UB Tel: 01305 206600 Fax: 01305 206601 Web: www.cefas.co.uk

Development agencies

For access to a network of local development agencies in Scotland contact:

Highlands & Islands Enterprise, Cowan House, Inverness Retail & Business Park, Inverness. IV2 7GF Tel: 01463 234171 Fax: 01463 244469 E-mail: hie.general@hient.co.uk Web: www.hie.co.uk

Scottish Enterprise, 150 Broomielaw, Atlantic Quay, Glasgow G2 8LU Tel: 0141 248 2700 Fax: 0141 221 3217 Web: www.scottish-enterprise.com

For Northern Ireland:

Department of Agriculture and Rural Development, Northern Ireland (DARDNI) (see government departments)

For Wales:

Welsh Development Agency, Principality House, The Friary, Cardiff. CF10 3FE Tel: 08457 775577 Fax: 01443 845589

Additional local or regional development initiatives may be operational in your area. To check the current position consult the agencies above or local council development departments. Organisations providing technical advice and support may also be able to advise (see Information etc).





BUSINESS PLANNING

Introduction

This section of the Hyperbook covers the development of business plans to support oyster cultivation. The section will provide an overview of business planning, but mainly introduces the Oyster Economic Model – a Microsoft Excel-based planning tool. The overview and the model must be seen as a starting point only - they do not replace the need for professional technical and financial planning, but might assist that process.

Seafish and Epsilon Aquaculture Ltd can take no responsibility for any business decision based upon this section (or other sections) of the Hyperbook, and readers are urged to seek professional and experienced assistance if they wish to proceed towards investment in this sector of aquaculture.

However, readers who are investigating initial scenarios within this sector might find the economic modelling tools within this section useful - they may serve to “scope” discussions with other professional advisors or suppliers.





Business Planning General Principles

Readers should be clear at this point what their purpose is:

- To simply use this Hyperbook in order to improve their general understanding of oyster cultivation
- To use this Hyperbook to inform them about other people's plans concerning oyster cultivation
- To use this Hyperbook to help them plan an expansion or diversification of their existing business
- To use this Hyperbook to help them plan a new oyster cultivation project

Products which might arise from use of this Hyperbook will depend upon the purpose - but there are certain basic truisms about cultivation of any aquaculture species:

- Aquaculture is a business - it needs to make sufficient profit to continue to develop and to repay its shareholders or investors
- Any successful business needs a good initial plan - and whilst the reality of operations might diverge from that plan, a good business will continually review those operations in the context of the initial plan
- Aquaculture is considered to be a "high risk" business in financial terms - and the history of the spectacular failures within the industry over the last three decades confirm that judgement
- An aquaculture business plan needs to be robust:
 - any technical uncertainties must be highlighted and numerically quantified
 - a realistic view of the short, medium and long term market prospects must be taken
 - the Management Team must demonstrate capability to carry the plan to fruition
- Raising new finance for aquaculture is not easy. The sector's profitability potential normally falls below the criteria for true Venture Capital, and therefore requires more conventional bank finance - which means the provision of full security for any debt capital. Aquaculture is probably more readily financed from industrial sectors (either other aquaculture or related businesses) than from any other source.

Readers are urged to contact their Local Enterprise company, a qualified consultant or their financial advisor for guidance in business plan preparation

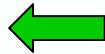


ECONOMIC MODELS



The core Economic Model for Oyster Cultivation is contained within your OYSTER HYPERBOOK Folder. Access the READ ME FIRST file once again, just to remind yourself how to use the model.





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Oysters in Garlic Butter

8-12 fresh native oysters

55g (2oz) unsalted butter, softened

1 x 15ml spoon (1 tablespoon) fresh chopped parsley

1 clove garlic, crushed

black pepper

Preheat the grill

In a small bowl mix the butter, parsley, garlic and seasoning together.

Place a knob of garlic butter onto each oyster.

Grill for 3-4 minutes until cooked and serve with crusty bread.

Serves 2 each as a starter, or as part of a selection of cocktail savouries.

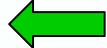
NUTRITIONAL VALUES PER PORTION (APPROX) 81

Kilocalories;

2g Protein; 8g Fat; 0g Carbohydrate; 0g Fibre.

See a
picture



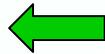
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Oysters in Garlic Butter



[Next recipe](#)





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Fiery Oyster with Tarragon Sauce

6 fresh oysters, cleaned
30g (1oz) light brown sugar
juice of 1 small lime
1 x 15ml spoon (1 tablespoon) tarragon or cider vinegar
half a green chilli, deseeded and finely chopped
half a small red onion, finely chopped
few sprigs fresh tarragon

Place the sugar, lime juice and vinegar into a small pan and heat gently to dissolve the sugar.

Remove from the heat, add the chilli, onion and a couple of roughly chopped tarragon sprigs. Leave to cool.

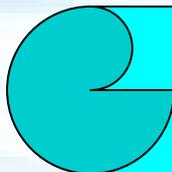
Lay the oysters onto a metal steamer and place into a large pan filled with boiling water. Steam for 8-10 minutes over a medium heat until the oysters start to open.

Using a cloth to protect your hands, ease the shells open. Take a knife and loosen the flesh from the shell, leaving the oyster meat in the deeper half of each shell. Discard the upper shell.

Add any cooking liquor to the tarragon sauce before spoon over the oysters.

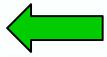
Garnish with the remaining tarragon and serve immediately.

Serves 2



See a
picture





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Markets
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Fiery Oyster with Tarragon Sauce

