EPSILON
AQUACULTURE LIMITED

The Clam Hyperbook®

Just press "Esc" on your keyboard at any time if you want to leave this Hyperbook 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**

- **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 clam 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 :

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 CLAM CULTIVATION

Native Clams

Manila Clams

Three species of clam have been cultivated commercially in the UK, namely the native clam, the Manila clam and the American clam. Our native species, (scientific name = *Tapes decussatus*), is also known as the palourde or carpet shell. Natural beds occur intermittently around our coast but are insufficient to support major fisheries.

The other two species, the Manila clam (scientific name = *Tapes philippinarum*) and the American hard shell clam or quahog (scientific name = *Mercenaria mercenaria*) are introduced species.

The Manila clam is native to far eastern countries, such as Japan, Korea, Philippines, but is cultivated now in several countries around the world. It is very similar in size and shape to the native clam although it usually has a distinct pattern of shell markings. It was introduced deliberately into the UK in 1980 through quarantine facilities. Disease-free juveniles were reared from the introduced broodstock animals and given to the industry for commercial culture.

The American clam was introduced accidentally into the UK many years earlier. Although a fishery became established in Southampton Water, this has subsequently become unsustainable.

Cultivation of all three species is dependent on the hatchery production of small seed.

The Quahog

RAZOR SHELL CLAMS - 1

Various species of razor shell clams are found throughout UK waters. The more common are *Ensis ensis*, *E. siliqua* and *E. arcuatus*. A non-native species native to America, *E. directus*, has been introduced accidentally to the east coast of England from mainland Europe, possibly in ballast water.

***E. siliqua* is the largest of the three native species, growing up to 220 mm. The others reach around 150 mm.**

Locally, significant fisheries exist in many areas, and particularly in western Scotland. Typically the clams are found in relatively sparsely populated beds from the lower intertidal area down to depths > 35m.

The Razor Clam

RAZOR SHELL CLAMS - 2

Fishing methods include hand digging, 'salting', diving, traditional and hydraulic dredging. Mechanical techniques for the harvesting of razor clams should be considered carefully to minimise damage to the target and non-target species, and to the substrate. Hydraulic dredging is considered to be far better and more effective than using traditional dredges. The use of pressurised water jets to expose the clams with hand collection by divers, is regarded as the most efficient method in terms of selectivity and minimising environmental impacts.

There is increasing commercial interest in razor clams *Ensis* sp. Natural fisheries are sustaining current production although there have been expressions of interest in its aquaculture potential. Currently, razor clam seed are not available for cultivation from commercial bivalve hatcheries.

Few studies have been made on the population dynamics of razor clams, however growth rates appear slow. It has been reported that individuals > 150mm are likely to be around 7-8 years old. The lack of detailed information on the growth rates of species of razor clams is making an assessment of its cultivation potential difficult.

COCKLES - 1

The cockle (scientific name = *Cerastoderma edule*) is another bivalve mollusc that is fished commercially from natural beds around the UK. In 2000, UK landings were over 20,000 tonnes. The main cockle sites in Britain are situated in the Thames Estuary, the Wash, the Dee Estuary, Solway Firth and the Burry Inlet. Exploitation of stocks is mostly targeted at 2-3 year olds.

In England and Wales fishing is either by hand raking or by mechanical hydraulic dredging. In Scotland, mechanised harvesting on the foreshore is banned.

Cockle recruitment can vary considerably both annually and on a site specific basis. Growth rates can also be very different between sites and within beds, and are further influenced by position on the foreshore and the density of cockles on the bed.

COCKLES - 2

While cultivation has not been undertaken on a semi-intensive basis, selective seeding of cockles has been carried out in Holland and France. Here, in the Wash and the Thames Estuary, there is increasing interest in relaying undersize (for market) cockles from areas where they occur naturally at very high densities into other areas where they are much sparser in number and even into areas where they may not occur naturally. If left at high densities, the cockles would have impaired growth rates and suffer high mortalities.

Although experimental at present, this is a practice that has shown good results with high survivals of relayed cockles. This type of extensive cultivation has the advantage of optimising the potential of wild seed supplies, ensuring faster growth rates and lower levels of mortality. Modern mechanised harvesting techniques allow for rapid removal of seed with minimal mortality and environmental impact. This should present opportunities for extensive cultivation to be carried out in many other areas around our coasts.

Clams live buried in the substrate, burrowing into the sediment using their strong muscular foot. Survival is better in sand or gravel substrates but it is possible to grow clams in muddy areas too. They can be grown in intertidal and sub-littoral locations although they will grow more slowly higher up the shore than lower down because they cannot feed when the tide is out. Many of the sheltered bays and estuaries around the UK are suitable for clam cultivation.

Suction dredging for clams

The aquaculture of clams has shown considerable development and change in Europe, where production increased from around 14 000 mt in 1988, to 55 000 mt in 1997 after peaking at 76 000 mt in 1995. The most notable change has been due to the introduction of the Manila clam into Italy, which until recently sustained a wild fishery representing 95 percent of national production. Where Portugal had been the major producer of clams (57 percent) in 1988, by 1997 it had been displaced by Italy, which had attained 73 percent of European production. An outbreak of disease has since brought about the collapse of the Italian Manila clam fishery.

A basket of cultivated clams

INTRODUCTION TO CLAM CULTIVATION - Continued

A recent study by McAllister Elliott and Partners suggested clam production demand was anticipated to rise by 6% per annum based on annual cost cutting of 2%. Italian outputs were considered to be variable, possibly rising from 40 000 to 100 000 tonnes maximum in the near future. (NB This will now have changed with the collapse of the Manila clam fishery.) Cost cutting within the extensive production process was considered to not be difficult, although for more intensive production such efficiencies were unlikely to be achieved. Overall there was considered to be a likely significant excess demand within Europe in the future.

Manila clams

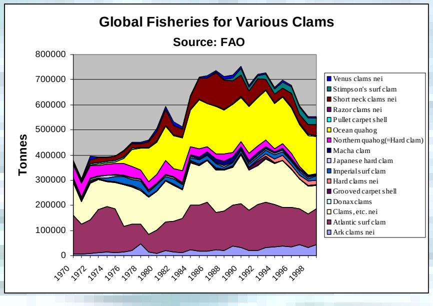
THE MARKETS FOR CLAMS

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

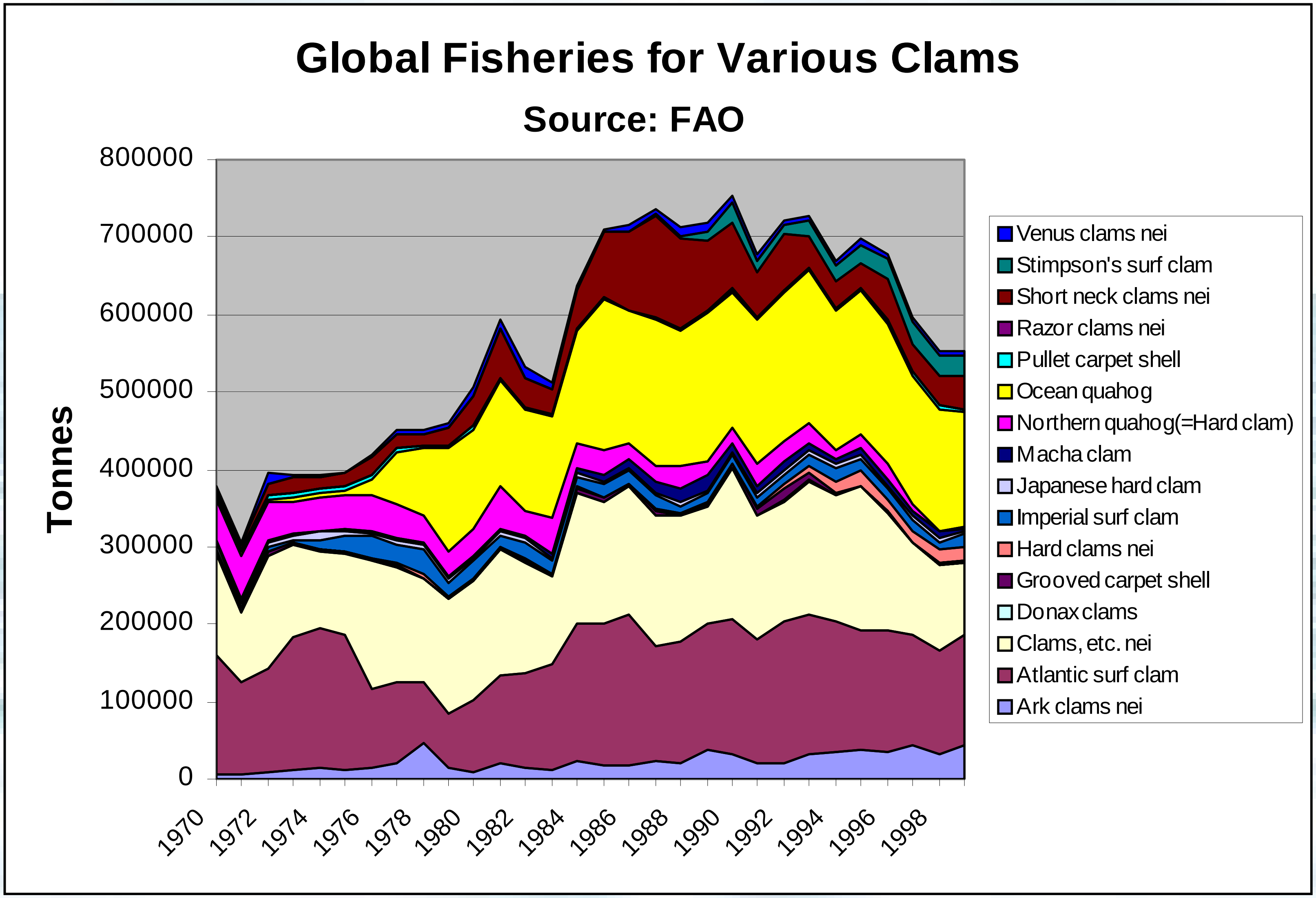
WILD SUPPLY - GLOBAL

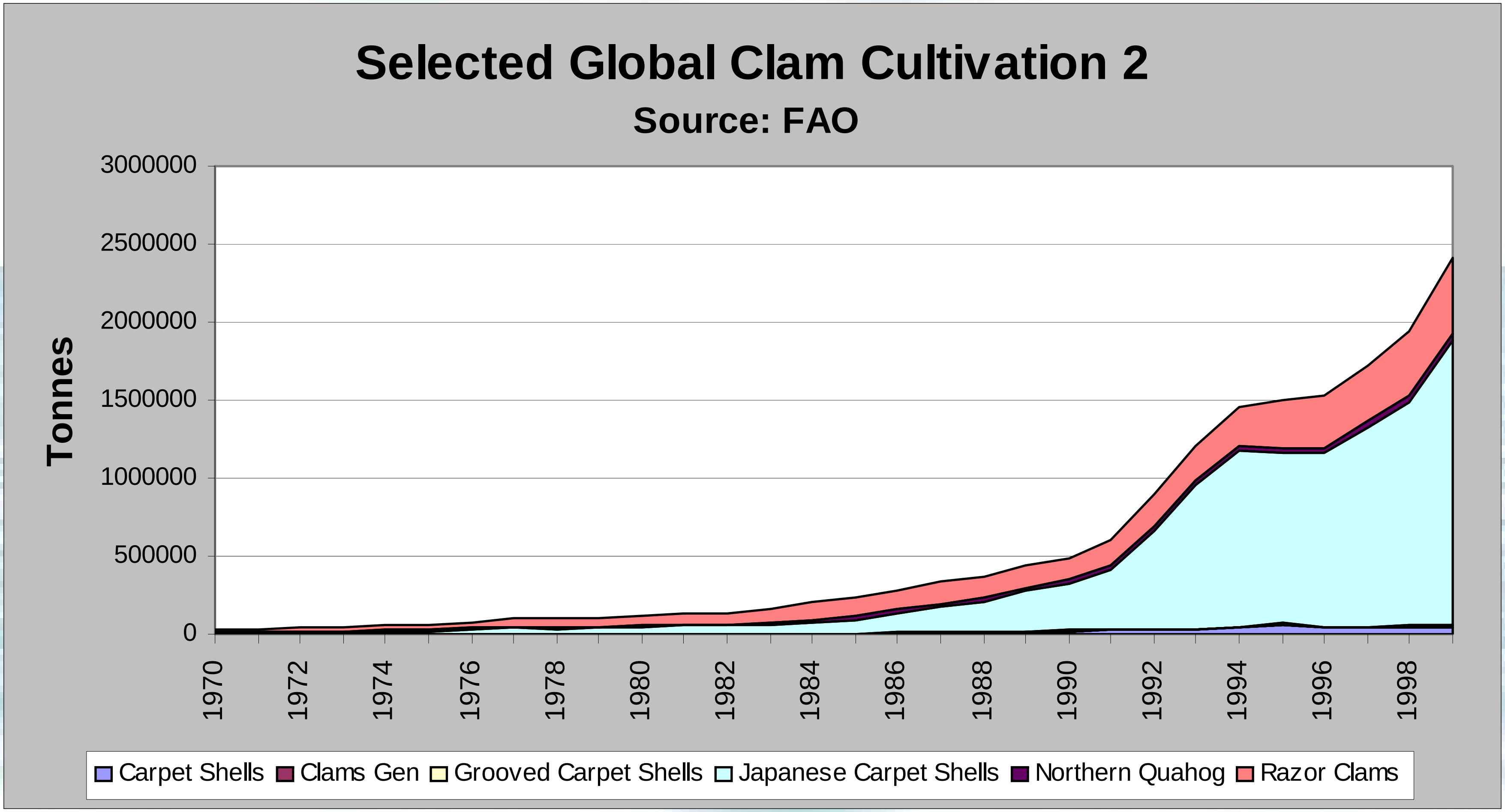
The world total wild-caught supply of one species or other of clams was 550,000 tonnes in 1999.

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



The overall supply trend from wild capture is not particularly encouraging - total landings have been steadily dropping from the record level of 754,000 tonnes in 1990.


Global Fisheries for Various Clams
Source: FAO
Tonnes
800000
700000
600000
500000
400000
300000
200000
100000
0
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Venus clams nei
Stimpson's surf clam
Short neck clams nei
Razor clams nei
Pullet carpet shell
Ocean quahog
Northern quahog(=Hard clam)
Macha clam
Japanese hard clam
Imperial surf clam
Hard clams nei
Grooved carpet shell
Donax clams
Clams, etc. nei
Atlantic surf clam
Ark clams nei

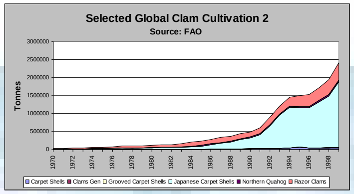


Selected Global Clam Cultivation 2
Source: FAO
Tonnes
3000000
2500000
2000000
1500000
1000000
500000
0
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Carpet Shells
Clams Gen
Grooved Carpet Shells
Japanese Carpet Shells
Northern Quahog
Razor Clams

CULTIVATED SUPPLY - GLOBAL

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

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



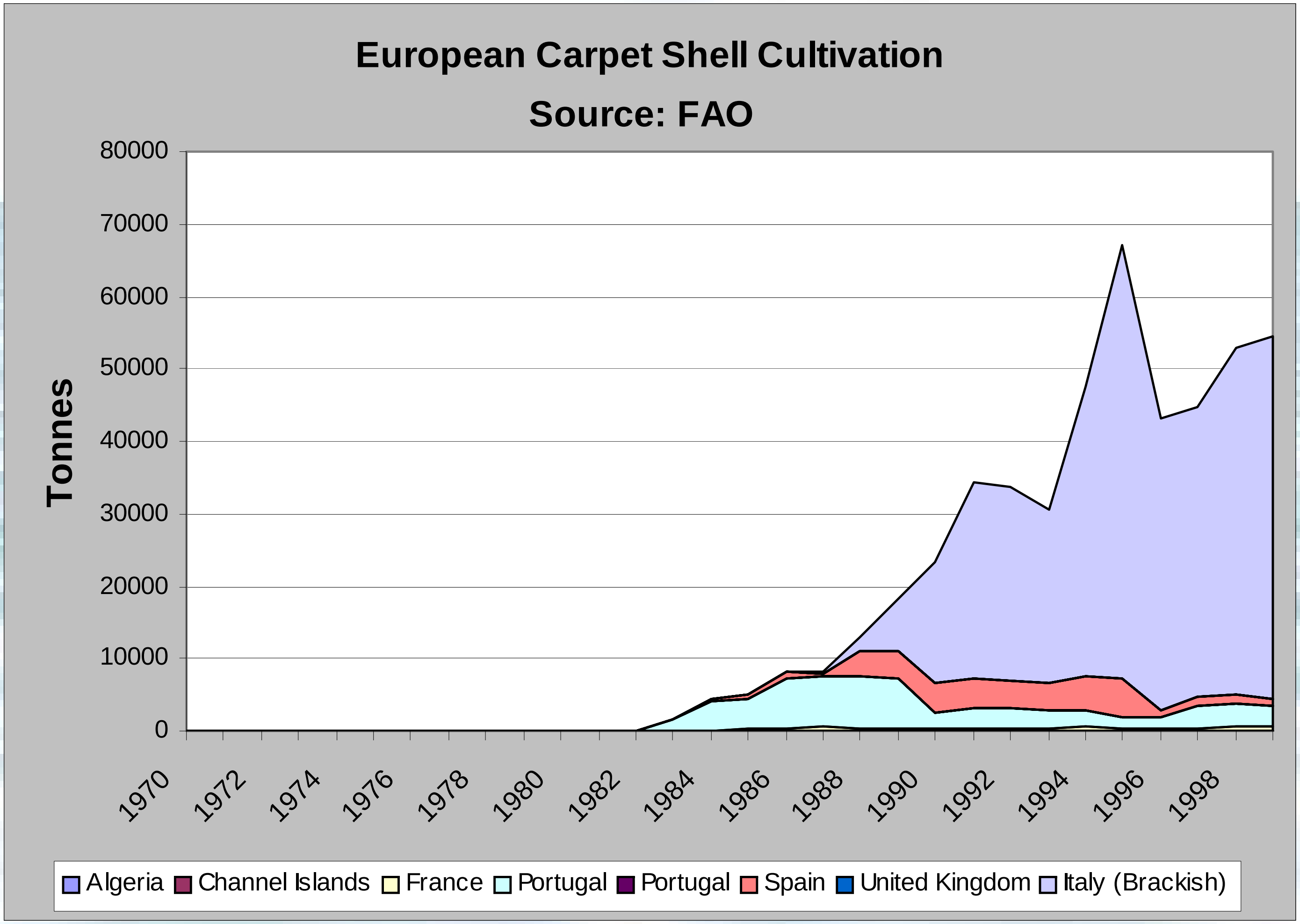
The global aquaculture of various species of clam has become significant:

- **In 1990 there were 489,000 tonnes of the major species produced**
- **By 2000, that production had increased to 2.4 million tonnes**
- **A year-on-year growth of 20% on average - faster than salmon aquaculture**

The major producing countries are:

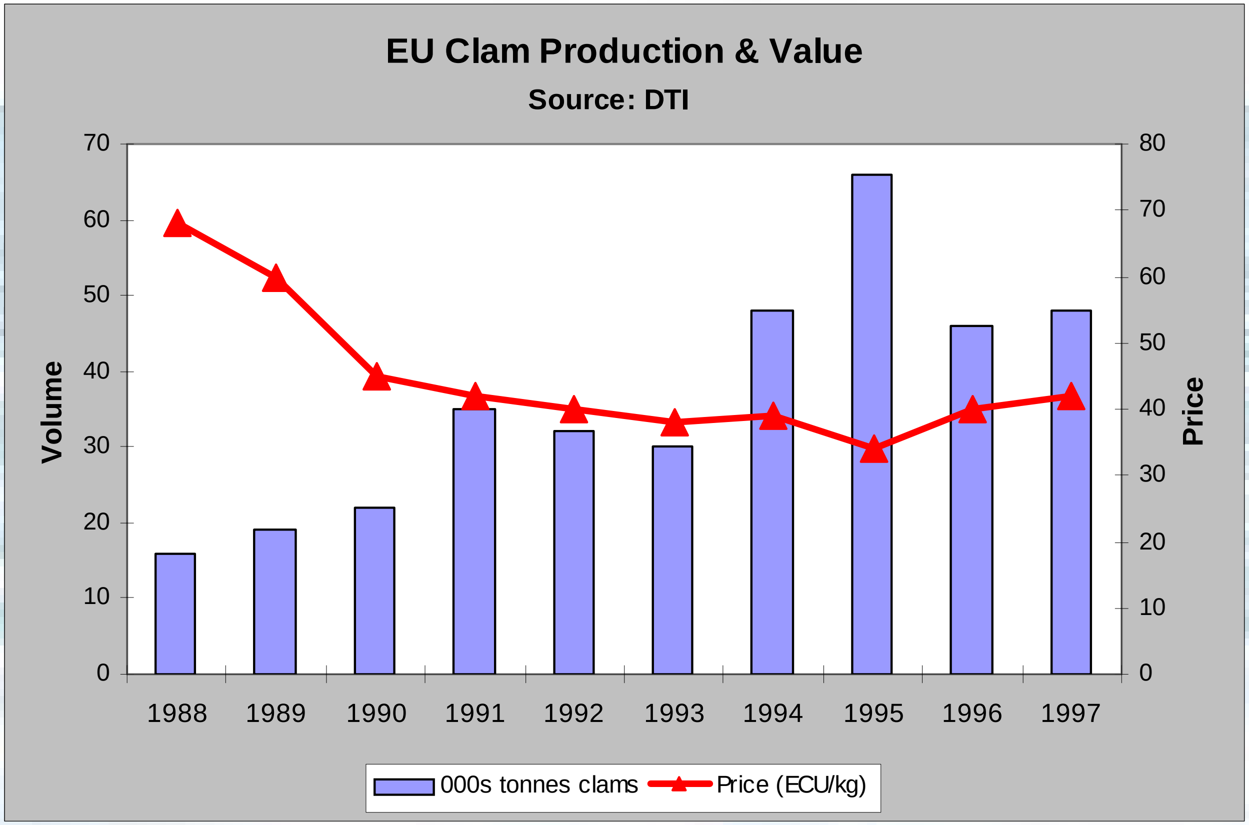
- **China - Japanese carpet shells & razor clams**
- **Taiwan - Hard clams**
- **USA - Hard clams**
- **Korea - Japanese carpet shells**

European production has been dominated by Italy



European clams make an interesting case-study in terms of supply v. value.

According to DTI data, the European clam production and value over recent years has been:



The main producers in 1997 were:

- **France 618t**
- **Ireland 165t**
- **Italy 40,000t**
- **Portugal 3,260t**
- **Spain 5,591t**
- **UK 36t**

THE MARKETS FOR CLAMS - Continued

The market for clams 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

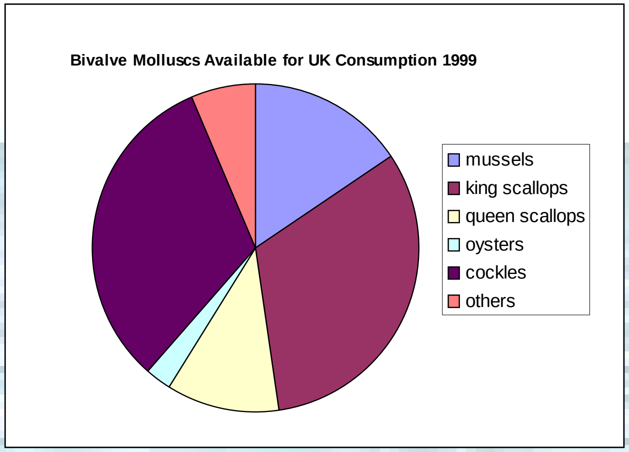
In the UK market, levels of sales of clams were low.

Nevertheless, one large wholesaler provided considerable information. Typical retail prices were £6.50 per kilogram. Sales volume amounted to 600 kilograms per annum. Almost all product was sourced from Rungis Market in Paris. Clams were supplied double-bagged in net bags. Typical mark-up was 50% over the first-purchase price.

One large multiple retailer indicated that sales of clams amounted to £65,000 per year. Product was sold live. Clams were purchased via a large UK seafood distributor. Product was supplied in waxed, waterproof cardboard containers. Delivery was by chilled vehicle.

There is some 10 tonnes per annum of Manila clams harvested in the Thames Estuary area by one company, which produces its own seed for the operation. Typical wholesale price is around £3.50 to £5.00 per kg, with retail prices around £12 per kg.

Some clams are also grown in a Several Order in Poole Harbour.



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

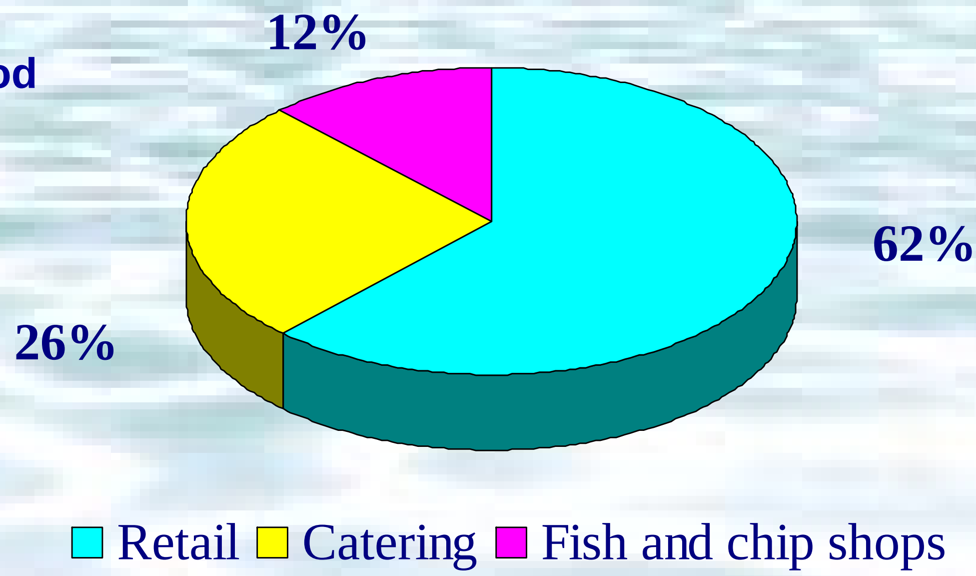
Seafood is purchased in two broad categories by consumers:

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

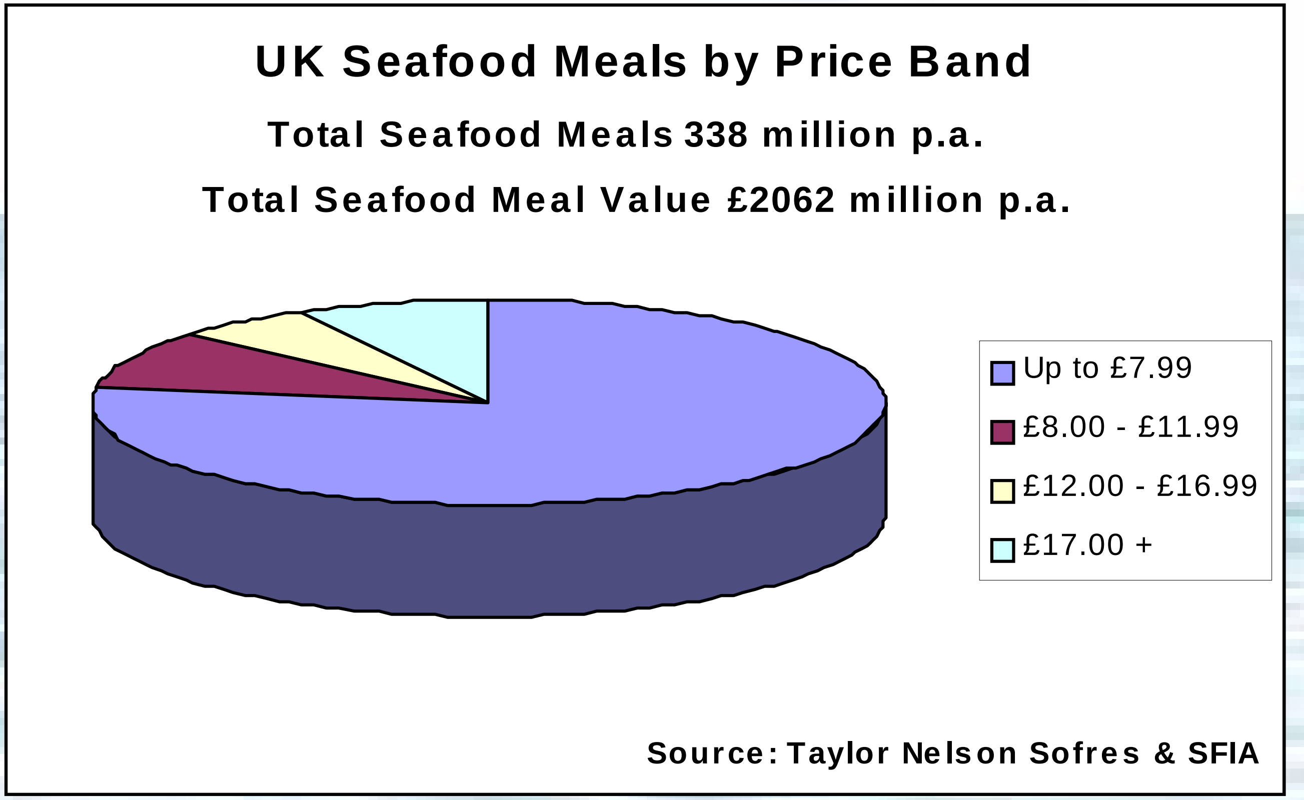
There are overlaps where shops and petrol stations sell ready-prepared meals, and sub-categories such as take-away foodservice. The main distinction between the two broad categories is that the consumer pays more per unit piece of protein in foodservice than he/she does in retail.

The balance between seafood retail and foodservice

Source: SFIA, Foodservice Intelligence & Superpanel



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 "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 CLAMS 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 CLAM meals is to identify the key components, as shown above.

Although there are markets for clams in the UK, most of the production is exported to the continent particularly France, Spain and Italy.

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

Clams are a very healthy seafood product, being low in cholesterol and rich in essential nutrients such as polyunsaturated fats. They are safe to eat because like other shellfish placed on UK and European markets they have to meet strict health and hygiene regulations before they can be sold. Clams are one of the simplest shellfish to prepare and can be cooked in a variety of tasty dishes.

Bagging clams for sale

The main clam market messages from this section are:

- 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
- Clams have regional acceptance in the UK, and are purchased by some retail multiples
- 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 clam recipes

(click on the buttons to view)

SEAFISH

THE PRODUCTION PROCESS
Introduction

Click here to see a description of the life cycle

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

- **Hatchery**
- **Ongrowing**
- **Harvesting**

The Hyperbook is a planning guidance tool, but it can not provide every detail.

It is recommended you undertake your own research into clam cultivation if you wish to proceed with a specific investment or project.

LIFE CYCLE OF CLAMS

Clams are either male or female and in their natural environment release eggs or sperm into the sea water where fertilisation takes place. The larvae are planktonic, drifting in the surface layers of the sea and feeding on microscopic algae called phytoplankton. When mature, the larvae initially attach to a settlement surface with byssal threads. Following metamorphosis into the 'immature' adult stage, called spat or seed, they soon burrow into the sediment.

In the UK, all seed for commercial clam cultivation are produced in commercial hatcheries. Adult broodstock, larvae and spat (or seed) are reared in carefully controlled environmental conditions.

Since reproduction takes place under controlled conditions in a hatchery, the animals can be conditioned and spawned almost at will. A free-swimming trochophore larva develops, which rapidly produces a two-valved shell. These are collected and transferred to tanks containing a mixture of specially cultivated micro-algae (microscopic plant cells). and provided with gentle aeration. After about 15 days, the foot develops and the 'pediveliger' larva can use it to move around and seek out settlement substrates. Then the larvae are ready to settle and metamorphose into spat (or seed). The spat are collected and transferred to nursery tanks for growing to a larger size. After 6 weeks in the nursery, the spat can either be transferred to outdoor ponds for further on-growing or sold to the growers for cultivation in the sea.

Clams live buried in the substrate, burrowing into the sediment using their strong muscular foot. Survival is better in sand or gravel substrates but it is possible to grow clams in muddy areas too. They can be grown in intertidal and sub-littoral locations although they will grow more slowly higher up the shore than lower down because they cannot feed when the tide is out. Many of the sheltered bays and estuaries around the UK are suitable for clam cultivation.

Intertidal clam plots

Like other bivalve molluscs, clams are filter feeders removing natural phytoplankton (microscopic algae) and organic detritus from the sea water. When clams are immersed, a continuous flow of water is brought in through the inhalent siphon which protrudes above the surface of the sediment, passes through the gills into the body cavity. The gills, which have a dual function of respiration and feeding, act like fine, intricate nets that trap the food particles from the water. Inorganic material is rejected off the gills as pseudofaeces while the organic matter passes into the digestive tract.

Carpet shell clams being held in water out of the sediment to show the siphons extended.

INTRODUCTION

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 flay 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.

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. Mature adult clams (35-45 mm shell length, 10-20 g live weight) will spawn 5-8 million eggs. Many species of clams mature first as males and as they become older, they either remain as males or change sex to become female. In 2 to 3-year-old populations of clams, the numbers of males and females are about equal.

The Manila clam is not native to the UK and was introduced in 1980 to assess its commercial potential against the UK native palourde. A limited number of mature broodstock were imported from the USA into quarantine facilities, following the International Council for the Exploration of the Sea (ICES) guidelines[1]. 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.

The American hard shell clam was introduced accidentally into the UK, probably through trans-Atlantic liners visiting ports such as Southampton.

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

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.

BROODSTOCKS 3

Broodstock clams 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 clam 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 clams is equivalent to 6% of the dry meat weight of the broodstock in dry weight of microalgae per day. This equates to around 200 million *Tetraselmis*, 2000 million cells of T-*Isochrysis* or *Pavlova*, and 1000 million cells of *Skeletonema* in single species diets. However, 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. The levels of total polyunsaturated fatty acids (PUFAs) and of specific essential PUFAs, such as docosahexanoic acid (DHA) and eicosapentanoic acid (EPA) are critical to hatching success of the eggs.

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 ^{o}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:

$DD = d\ (t - t_o)$,

where d is the number of days of conditioning, t is the ambient temperature of the sea water in the hatchery system, and t_o 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.

When mature, clams can be induced to spawn and fertilisation of the eggs can be carefully controlled.

CONTROLLING SPAWNING

The easiest method of spawning clams 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 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.

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.

CONTROLLING SPAWNING - Continued

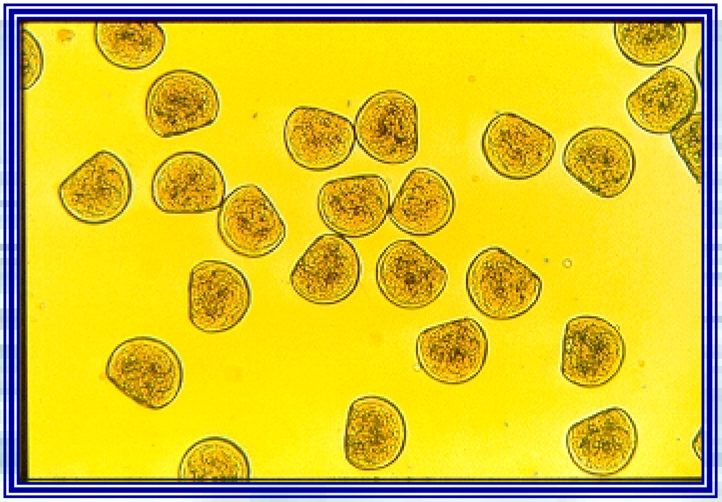
Usually, the males spawn first. The sex of each animal should be checked as it starts to spawn by placing it in a separate glass container such as a litre beaker containing 500 mls of water at the same temperature as that in the spawning trough. Eggs will appear as a granular suspension, sperm as a cloudy, milky suspension. Once the sex of the adult has been determined, females 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 ^{o}C sea water to give a density of around 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.

EGG INCUBATION

Eggs are then incubated for 24 hours in rearing vessels containing filtered (to 2-5 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 clams is > 25 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 it's distinctive 'D' shape. A recovery of around 60% of the initial egg number is not uncommon for Pacific oysters and Manila clams. 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). They measure 90-95 µm mean shell length.



D-larvae

REARING THE LARVAE

Rearing vessels are filled with filtered (to 2μm), UV-treated, heated (to 25 ^{o}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, 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 μm up to 170 μm). It is good practice to check the numbers 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 which is an indication that they are not feeding and will not survive. The average growth rate of larvae is around 10 μm per day. A good survival rate through the larval phase is 50-60%.

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.

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*.

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 oyster, *Crassostrea gigas*.

Various biochemical and physiological indicators are available to assess larval fitness at a specific point in time. They give an indication of conditions encountered previously and can provide some idea of subsequent competence and performance.

POTENTIAL DISEASES

During development, larvae are continuously exposed to microbes and their defence system is continuously reacting to prevent the accumulation of invading and pathogenic organisms. 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.

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, larvae cannot swim or feed, they sink to the bottom of the rearing vessel where they die.

On the plus side, bacteria are also thought to play a role in the nutrition of bivalve larvae although the importance of this role is far from clear.

Herpes virus

Sporadic high mortalities of Pacific oyster larvae and spat have occurred in European hatcheries. 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. Mortalities of the Manila clam have also been associated with a 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.

CONTROLLING DISEASE - 1

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. 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. This helps to maintain a more natural population of bacteria in the water. Pasteurisation of the water used for larval and algae culture is another method used in some hatcheries.

Reducing the level of organic material in the incoming water through foam fractionation, and fine filtration, e.g. through a bed of charcoal, are methods that may help to improve water quality.

CONTROLLING DISEASE - 2

Probiotics

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 to 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 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. *V. 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 act as probiotics.

SETTLEMENT

Clam 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. It takes approximately 15 to 18 days to reach this stage.

Unlike oysters, clams do not cement firmly to a substrate. In nature they would bury into the substrate. Once they reach 200 μm, they are placed in down-welling systems for two weeks where they complete the stage of metamorphosis. Then they are moved into upwellers in the hatchery.

Simple upwellers made from inverted clear plastic drinks bottles

NURSERY - 1

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. 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 30-40 mls/min/g (live weight) of clams. 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.

NURSERY - 2

ALGAE REQUIREMENTS

Feeding requirements of clam spat are likely to be very similar to those of oysters of a similar size. 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

NURSERY - 3

REDUCING ALGAL COSTS

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.

To manage the ponds more effectively, aeration or sprinkler systems can be used to help mix the water in the pond.

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 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.

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

MAIN ONGROWING TECHNIQUES

Clam seed are planted in the spring to make the most of the growing season. They can be sown by hand or by machine at a density of 400 m^{-2}. Initial densities up to 800 m^{-2} can be considered at good growing sites so it is always wise to test a range of stocking densities at your site.

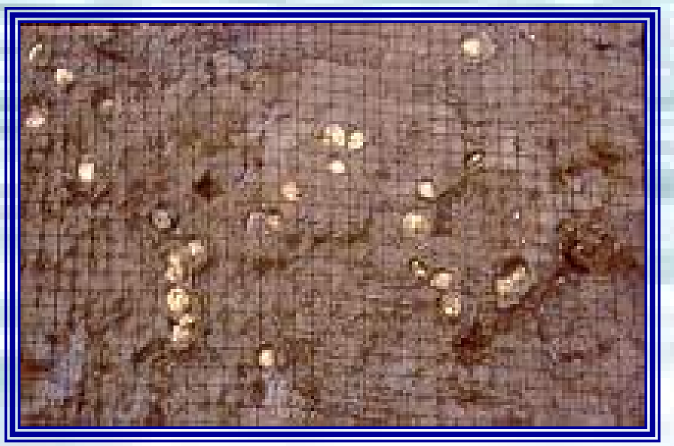
Clams are usually grown in plots under lengths of netting (25m x 2m, with 5 x 5 mm mesh size) to protect them from predators, and in the case of non-native species, to also keep them in containment to satisfy the conditions of the Wildlife and Countryside Act (1981). The edges of the netting should be buried in the substrate down to 10 cm and can be kept in place with rope stapled round the edges and steel hooks every 0.5 m pushed through the mesh into the substrate.

Seeding clams into prepared plots

It is advisable to place ropes across the width of the netting at 5m intervals along the length so that if crabs manage to break through the mesh they can only get at a proportion of the clams. It also helps to prevent the sediment moving in stormy conditions and suffocating the clams.

In France where cultivation is more mechanised, seed are planted at 400 m^{-2} using a modified agricultural planting machine that also covers the seed with mesh.

Once the seed have been sown, the netting on the plots has to be cleaned periodically to remove macroalgae and other organisms that settle on it. Since the clams will take around 3 years to grow to a harvest size, it will be necessary to change the netting at least once during this time, increasing the mesh size at the same time.



Relaying clam seed under mesh

Clams can also be grown in oyster bags although this is probably most effective on less muddy substrates. Sediment is removed from a rectanglar plot (0.8 x 0.5 m) and put into the bag. Then the clams are added (400 to 500 seed @ 8-10 mm), the bag is rolled back into the depression created and staked into place leaving about 2.5 cm protruding above the sand. As the clams grow, the bags need to be kept clean of fouling material and checked periodically to ensure that the stock does not need thinning or that no predators have entered the bags.

Clams in an oyster bag

Culture of clams in trays on trestles is a less common method used. Unless a substrate of coarse sand or small stones (2-20 mm) is placed in the trays, it usually leads to mis-shapen shells. Also, when exposed at low tide, the clams will be subjected to extremes of temperature in winter and summer compared to clams buried in the sediment in plot cultures. If using tray culture, initial stocking density of seed should be 400-800 m^{-2}. The meat yield and survival of clams grown in trays can be higher than those grown in plots in the sediment.

An important consideration when selecting the cultivation method is cost. Production costs using bag and tray culture can be up to four times more expensive than sowing seed into meshed plots.

Experimental culture of clams in trays

PREDATORS

The shore (or green) crab (*Carcinus maenas*), which is abundant in estuaries and coastal waters, is probably the most significant of all the predators. Shore crabs move up and down the intertidal area with the incoming and outgoing tide; in the winter, they tend to remain in the sub-littoral zone. Smaller clams (15-35 mm) are generally more vulnerable than larger clams to crab predation because the crabs can crush and prise open their shells more easily. Unless clam plots are covered with netting, you could lose all your stock very quickly.

Shore birds will feed on clams although netting on the plots should help to detract them. Some fish species are potential predators, nipping off the tips of the clams' siphons as they protrude from the sediment surface.

COMPETITORS AND FOULING ORGANISMS

Within 6 months of netting being put down, small spionid worms dominate the benthic infauna under the mesh. In the following 24 months, larger deposit feeding worms appear. These can compete for organic detritus that forms part of the clams' food intake.

The main fouling material is likely to be seaweeds (macroalgae) on the mesh netting. This will do no harm provided it is removed on a regular basis to allow a good water flow over the clams contained under the mesh.

Mechanised cleaning of meshed plots

DISEASE ORGANISMS

Adult Manila clams are susceptible to brown ring disease which is characterised by a brown colouration (deposit) on the inner surface of the shell. A bacterium called *Vibrio tapetis* is the causative agent and is thought to be widespread in marine sediments. The incidence of the disease is seasonal. It is highest after the winter when the disease resistance of the clams is low because energy reserves are low. Environmental conditions seem to affect the incidence rate and research to date has shown that temperature is a factor and sub-optimal salinity may also be a factor.

'Spring mortality' of clams can be a problem too although native clams seem to be less susceptible than Manilas. Although the cause is still unknown, it may be associated with low energy reserves in the animals, particularly after milder winters when the reserves continue to be utilised.

ENVIRONMENTAL ISSUES - 1

The UK cultivation industry to-date has an extremely good environmental track record and it is generally recognised that in order to function, it requires access to anthropogenically clean and naturally productive waters. Indeed, the successful operation of the industry is widely acknowledged to act as an environmental indicator with respect to water quality and pollution levels.

Environmental issues can arise particularly in relation to the use of non-native species and intrusive harvesting techniques. Potential impacts (positive as well as negative) will be related to the scale of cultivation. Most of the issues that are likely to arise will need to be addressed at a local level with the regulatory authorities and with other users of the coastal zone. These are some of the points that you might like to consider.

Most of the environmental concerns on clam cultivation relate to harvesting methods, especially intrusive mechanised techniques such as suction dredges. Harvesting can cause changes to the sediment and non-target benthic organisms, changes that can take up to 4 and 12 months respectively to recover in extreme cases. Meshed plots in estuarine sandy silt substrates can lead to localised sedimentation and an increase in the organic content of the sediment. The effects soon disappear once netting is removed.

ENVIRONMENTAL ISSUES - 2

The visual impacts of cultivation will be minimal, since most of the cultivation will occur low down on the shore and is exposed only at spring tides and then for limited periods of a few hours. The colour and size of any marker buoys etc. should be considered to minimise adverse visual impacts.

If small clams are bought from a commercial hatchery at a size too small (I.e. < 10 mm) for relaying immediately under mesh on the shore, they are held in trays on trestles. Siting these where there is good water flow will reduce sedimentation as well as ensure that the young clams receive adequate levels of food and oxygen.

During regular management and maintenance of plots in intertidal areas, there may be some disturbance to birds feeding. Usually, this is intermittent and of a localised nature and should cause no more harm than someone walking or bird watching on the beach. The seeding of clams into an area is likely to increase the food resources available to local populations of shore-birds. Keeping to recognised tracks can minimise the effects of treading and of tyre tracks from vehicles that may be brought on to the foreshore.

In southern parts of the UK, Manila clams generally reach market size (around 45 mm shell length) in 2-3 years; native clams and American hard shell clams take 3-4 years. Further north, all species will take longer, possibly another year for each depending on local conditions.

The normal harvesting season is from late August/September through to April. Clams harvested at around 20g live weight usually have a meat yield representing from 20% to 30% of the total weight depending on the productivity of the bed and the time of year.

Meat quality is at its lowest in early summer. Total yield can be very variable, depending on local conditions. However, assuming a 50% survival of seed, an initial seeding density of 400 m^{-2} and a harvest size of 20 g, then a return of 40 tonnes ha^{-1} can be expected. In good conditions with a better survival and/or higher seeding densities, a higher return should be possible.

ENVIRONMENTAL ISSUES TO CONSIDER

The environmental impacts of harvesting clams should be considered carefully. Where production levels are low and manual methods of harvesting are used, such as hand raking, the impacts will be short-term and low impact. As the scale of production is increased, more mechanised harvesting methods have to be used. Then, the potential impacts of physical disturbance to the substrate and to the benthic organisms in the sediment are likely to be greater although much depends on the location of the cultivation site. Within designated conservation areas, some harvesting methods may not be permitted.

Modifications to suction and hydraulic dredges and the development of new harvesting technologies and equipment will help to reduce environmental damage as well as ensuring a better quality product for market.

(See the Technologies and Equipment Section for more information)

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 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

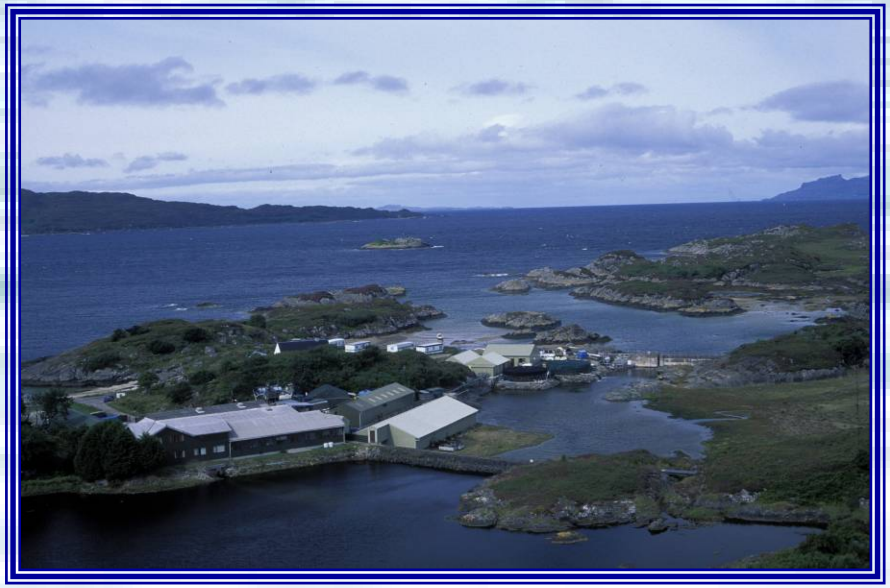
Introduction

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

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

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 conditioning

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

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

Larval rearing bins

The requirement for some sort of “nursery” unit has been discussed elsewhere. These units provide sheltered temporary accommodation for the small clam seed, and are normally upwelling systems.

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

The use of tractors or small boats, and the requirement for plastic netting and ropes for the planted-out clams, are the main technical components for the ongrowing phase.

Tractor and trailer on the shore

Laying netting over a plot

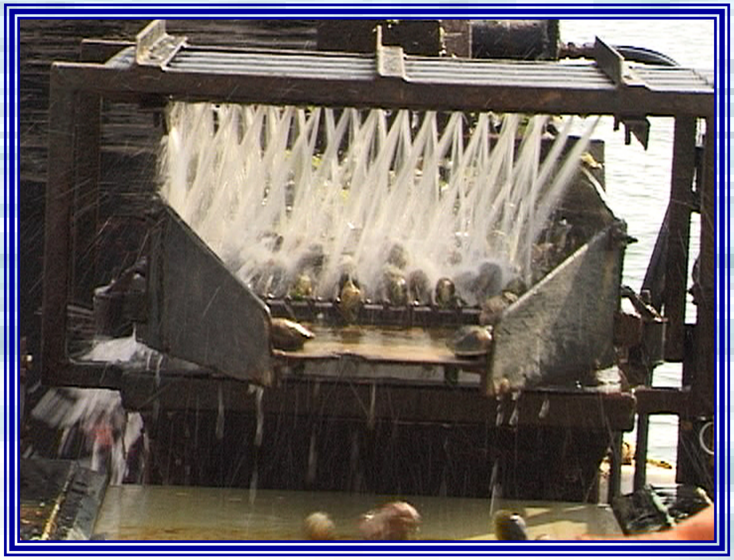
OTHER EQUIPMENT

A clam 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)

Harvesting methods vary in relation to scale of production and the location of the cultivation site. On intertidal plots exposed at low tide, hand raking and mechanised methods such as modified potato or carrot harvesters towed by tractors can be used when clams are grown in the substrate. Hydraulic dredging is another method for collecting clams from sites very low down on the shore or sub-littoral plots. Water jets fluidise the sediment immediately ahead of the dredge and a hollow blade penetrates into the sediment to lift out the clams. A backwater jet is often used to lift clams up through a pipe into a collecting device.



An example of a dredge towed by tractor

A jet dredge operated from a boat

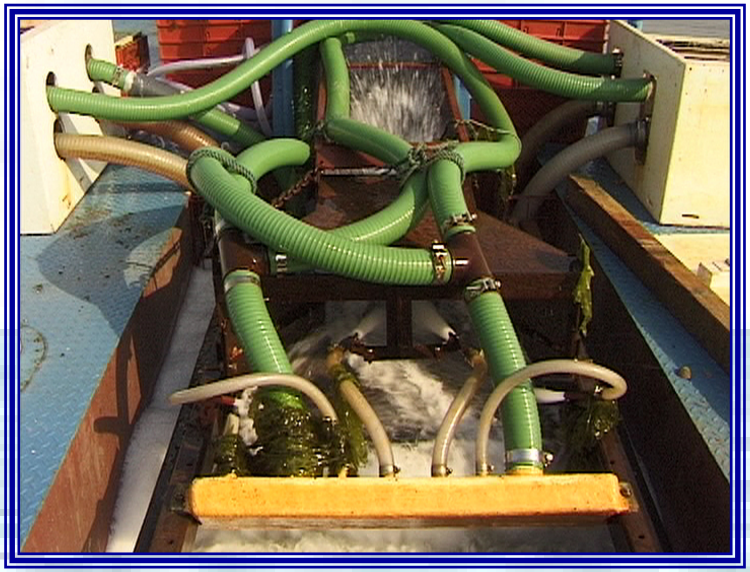
Other devices are becoming available that cause less disturbance to the substrate and as a result, to the animals too.

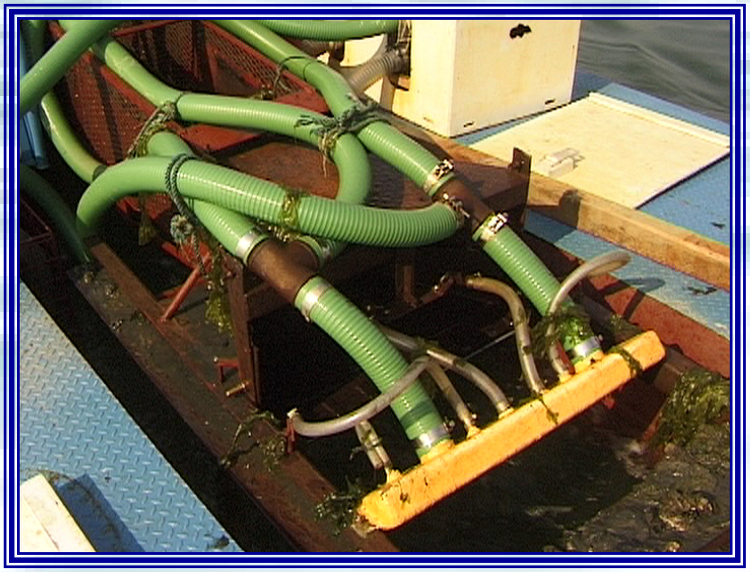
For example, some growers developed an elevator dredge that lifts animals from the sea bed with hydraulic jets and a blade (much the same as for a hydraulic dredge) on to a continuous elevator belt (such as used in agriculture for lifting vegetables) for delivery into boxes on deck. The jets only draw 10% of the power used in conventional hydraulic dredges so the sediment and clams are lifted only a few centimetres above the seabed. Consequently, there is less damage to the clams because they are not carried up a delivery pipe in highly turbid water flows and sediment.

Undersize animals fall straight back into the trench behind the dredge and can re-burrow. A catamaran-style boat is built around the dredge. It is possible to harvest well over a tonne of marketable clams per day using this method.

An example of a catamaran elevator dredge

Harvesting - 3 - continued





Details of the elevator dredge system

Clams can be washed, graded and bagged on moored rafts, and then moved to the intertidal area for collection and transportation to shore premises for purification and packing for the market. Alternatively, clams can be taken ashore for washing and grading. Once ashore, the clams can be graded, purified and packed in mesh bags or wooden punnets.

Washing clams prior to depuration in a modern packing and dispatch centre

Weighing and bagging clams ready for dispatch

Purifying or "depurating" clams is probably essential for commercial sales in the UK

A small depurating unit

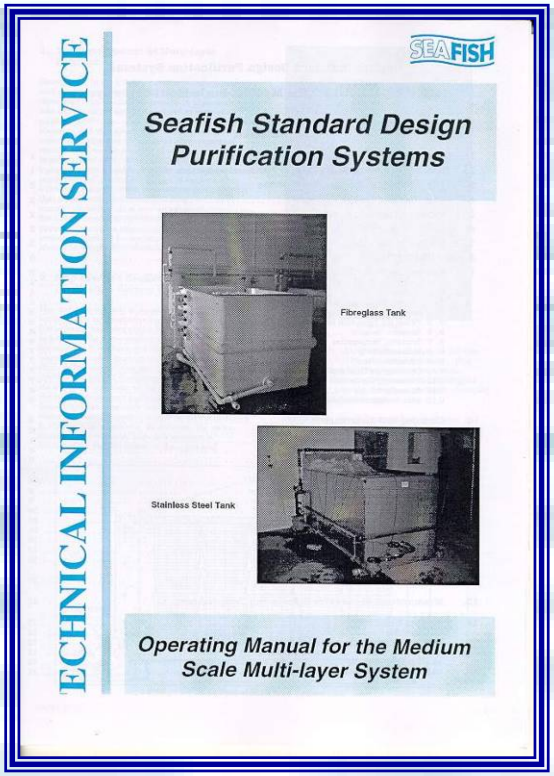
Depuration generally involves holding clams in clean water for 48 hours, and letting their systems flush out any material from the digestive tract which might contain bacteria harmful to humans.

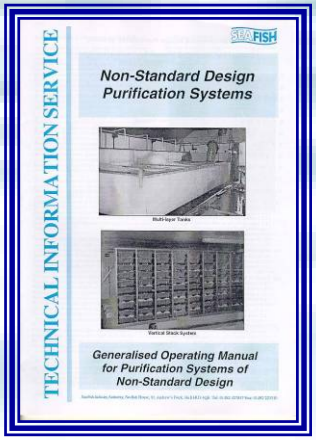
The process often uses recirculated water systems, with simple UV sterilisation of the water on each pass

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.





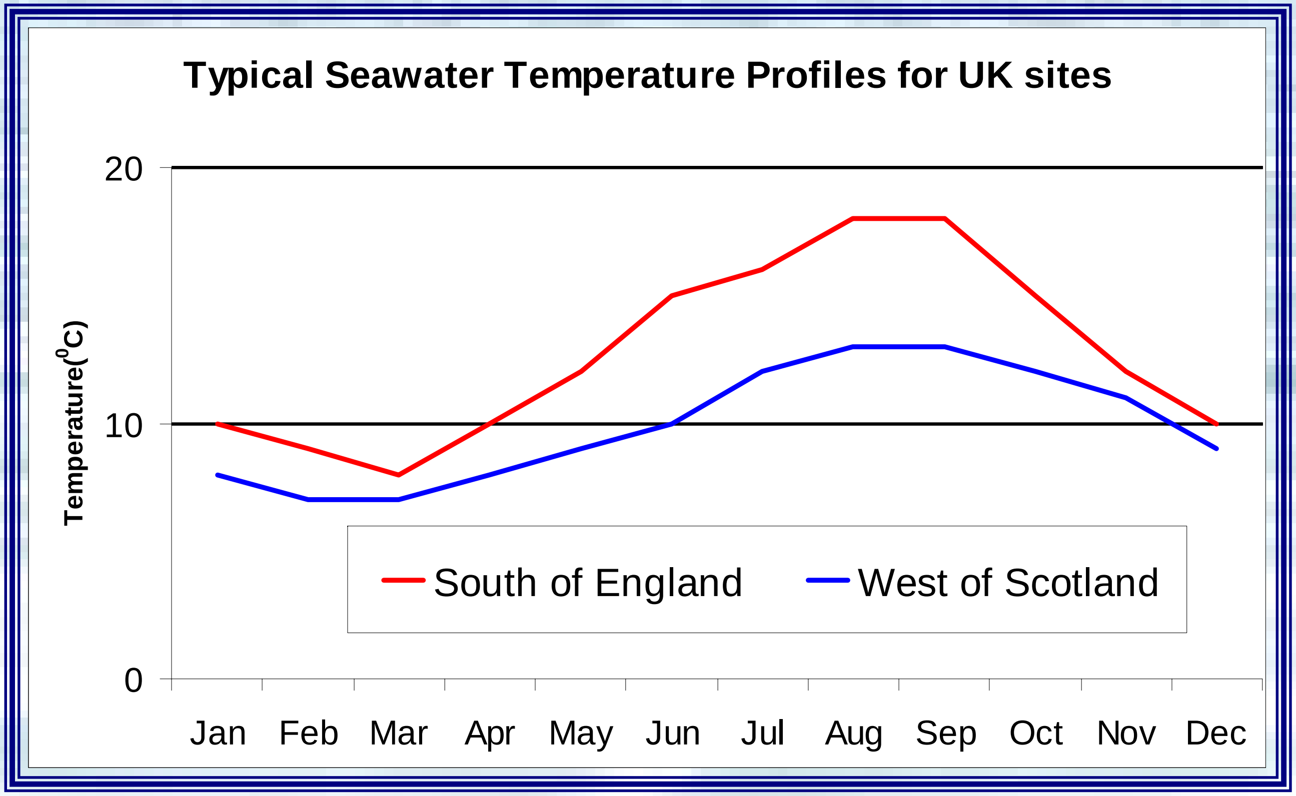
SITE SELECTION

Introduction

This section of the Hyperbook will consider how locations for clam 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 a clam farm. Growth and survival of clams 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 clams grow and survive.

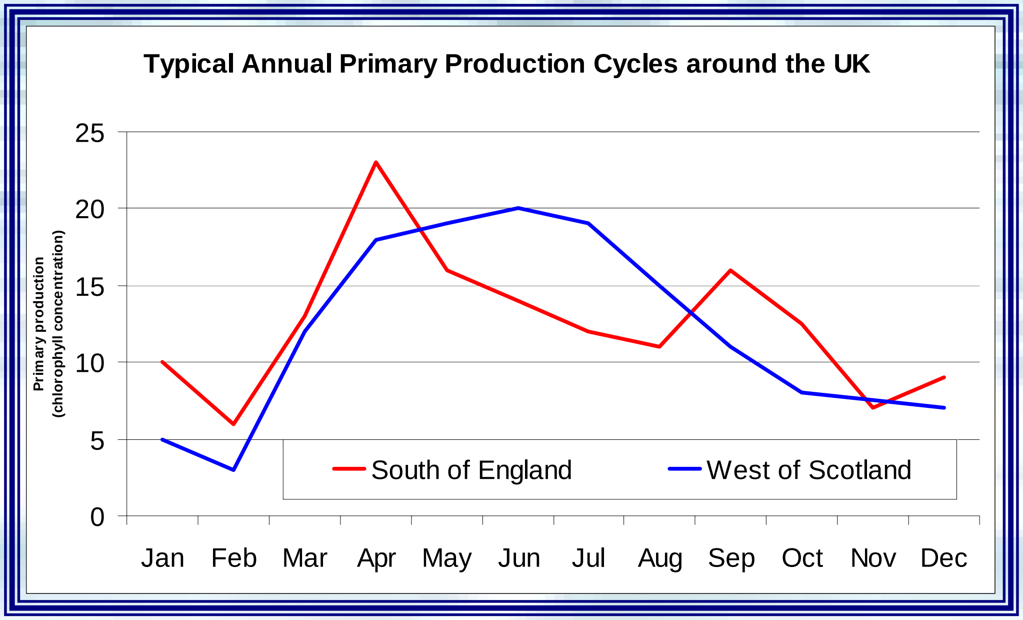
In the UK, clams start to grow in the spring when sea water temperatures reach 8-9 °C. Growth rate reaches a maximum in July or August when water temperature peaks (usually 14-18 °C) and then falls off again as the temperature drops to below 8-9 °C in November or December. Growth of Manila clams continues up to 25 °C. Clams can tolerate salinities > 25 ppt and are suited therefore to most estuarine and coastal conditions in the UK. 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.



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 so this should be considered when selecting a site. Also, sites near large urban and industrial developments are unsuitable for clam cultivation because of potential pollutants in the water.

Like other bivalve molluscs, clams are filter feeders removing natural phytoplankton (microscopic algae) and organic detritus from the sea water. When clams are immersed, a continuous flow of water is brought in through the inhalent siphon which protrudes above the surface of the sediment, passes through the gills into the body cavity. The gills, which have a dual function of respiration and feeding, act like fine, intricate nets that trap the food particles from the water. Inorganic material is rejected off the gills as pseudofaeces while the organic matter passes into the digestive tract.

Filtration rate depends on a number of factors including animal size, sea water temperature and the concentration of suspended particles in the water.



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

As with all bivalves, clams 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 not be subject to production or be collected.

LEGAL AND ADMINISTRATIVE ISSUES

Introduction

To set up a clam 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 clams. 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.

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 Labroatory, 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 clams 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 clams 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/algaltoxin/
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
Alexandrium Spp.	Presence	PSP	80 µg per 100 g
Dinopysis / Procentrum Spp.	100	DSP	Presence
Pseudonitzschia Spp.	150 000	ASP	20 µg per g

Correct as of Sep 2002 – check FSA for any 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. While there are no serious diseases of clams, the controls still apply, to ensure that the clams do not carry disease to stocks of other species.

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 clams within the UK are controlled according to the health status of these areas. Anyone wishing to deposit or relay clams 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

Clams 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 clams 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 clams 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

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

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.

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.

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.cefas.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 clam 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)

- *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)

Boats

•Alexander Noble & Sons, Girvan, Ayrshire. KA26 9HL Tel: 01465 712223 Fax: 01465 715089 E-mail: nobel@boatbuilders.fsbusiness.co.uk

•Alnmaritec, Willowburn Industrial estate, Alnwick, Northumberland. NE66 2PQ. Tel: 01665 602917 Fax: 01665 605399 E-mail: sales@alnmaritec.demon.co.uk Web: www.alnmaritec.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

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

- ***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).

- *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)

Depuration systems

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

The Falmouth Oyster Company, Unit 2A Empire Way, Tregoniggie 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

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

•Hydrospehere 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.hydroshpere.co.uk

•Gael Force Marine (see moorings)

•EYE Co (see moorings)

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, Ardvasar, 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, Ardvasar. 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

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. Shetalnd. 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

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 clam cultivation. The section will provide an overview of business planning, but mainly introduces the two Clam Economic Models - Microsoft Excel-based planning tools. The overview and the models 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.

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

- To simply use this Hyperbook in order to improve their general understanding of clam cultivation
- To use this Hyperbook to inform them about other people's plans concerning clam 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 clam 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 quanitified
    - 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

There are two economic models accompanying this hyperbook:

- **Manila Clam Economic Model**
- **Native Clam Economic Model**

- **If you want to work with any of these files now:**
  - **Exit this Hyperbook presentation by pressing “Esc” on your keyboard**
  - **Locate the Excel or Word file within the Main Folder**
  - **Double-click and launch that programme in the usual way**
  - **(You must agree to “enable” macros in the Excel models)**
  - **Follow the on-screen commands and instructions**

- **If, while you are working through an economic model, if you want to refer to the information in the Hyperbook:**
  - **Save the working economic model with a unique file name (but leave it running)**
  - **“Minimise” it on screen**
  - **Click the Hyperbook icon, and browse the Hyperbook until you find the information you need – then exit it again (“Esc”) and return to your economic model**

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Moroccan Clam Cakes

1kg (2lb 3oz) clams, fresh or defrosted, cooked and removed from shell
510g (1lb 2oz) potatoes, cooked and mashed
1 x 5ml spoon (1 teaspoon) cayenne pepper
1 x 15ml spoon (1 tablespoon) lime juice
2 x 15ml spoon (2 tablespoons) fresh chopped parsley
2 x 15ml spoon (2 tablespoons) fresh chopped coriander
salt
2 large eggs, beaten
100g (3 and a half oz) plain flour
200g (7oz) breadcrumbs
sunflower oil, for frying

Preheat the oil to 190°C/275°F

Combine the potatoes, cayenne pepper, lime juice, herbs and 1 egg in a bowl. Season.

Fold through the clams. Shape into 8 x 15cm (6") rounds.

Coat each cake in flour, egg and breadcrumbs.

Deep fry for 4-5 minutes until crisp and golden. Drain on kitchen paper. Serve with a crisp green salad.

Serves 4

NUTRITIONAL VALUES PER PORTION (APPROX) 640 Kilocalories; 53g Protein; 12g Fat; 85g Carbohydrate; 3g Fibre.

See a picture

Moroccan Clam Cakes

Back to Markets Section

Clams and Mushroom Mariniere

1kg (2lb 2oz) fresh clams, cleaned
30g (1oz) butter
125g (4 and a half oz) mixed exotic mushrooms
2 cloves garlic, finely sliced
600ml (1 pint) white wine
small bunch basil, torn
lemon wedges, to garnish

Melt the butter in a large saucepan, add the mushrooms and garlic and cook for 3 minutes.

Add the wine and clams, cover and cook for 5-7 minutes or until the shells open, discarding any clams that remain closed once cooked.

Add the basil, shake until mixed and serve with lemon wedges and crusty bread.

Serves 2 as a starter

NUTRITIONAL VALUES PER PORTION (APPROX) 686 Kilocalories; 78g Protein; 15g Fat; 11g Carbohydrate; 0g Fibre.

See a picture

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Markets
Section

Clams and Mushroom Mariniere