EPSILON
AQUACULTURE LIMITED

The Cod Hyperbook®

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HOW TO USE THIS HYPERBOOK

Navigating around this Hyperbook is easy:

- **If you just want to proceed to the next page, simply "left click" on your mouse**
- **If you want to use a "hyperlink" to jump to another part of the book, position your cursor over the appropriate button or text (a pointing finger symbol will appear), and left click**

- **You can practice this here**

- **Try clicking on this button**

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

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Click on this button to return

MAIN MENU

THE MAIN SECTIONS OF THE HYPERBOOK

(Press the appropriate action button)

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

Useful internet links WWW

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

USEFUL INTERNET LINKS PAGE

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

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

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

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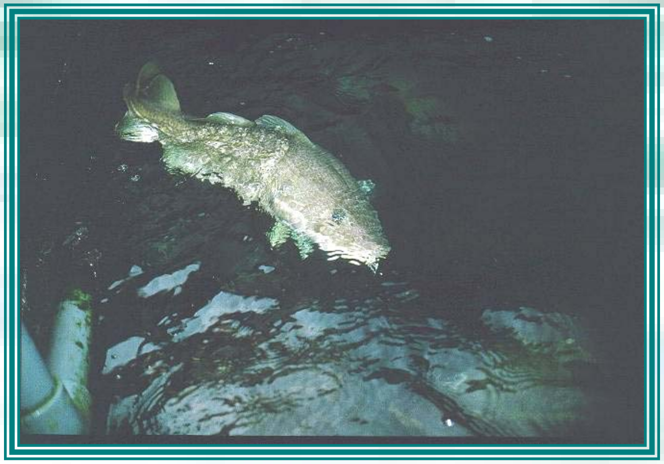
INTRODUCTION TO COD CULTIVATION

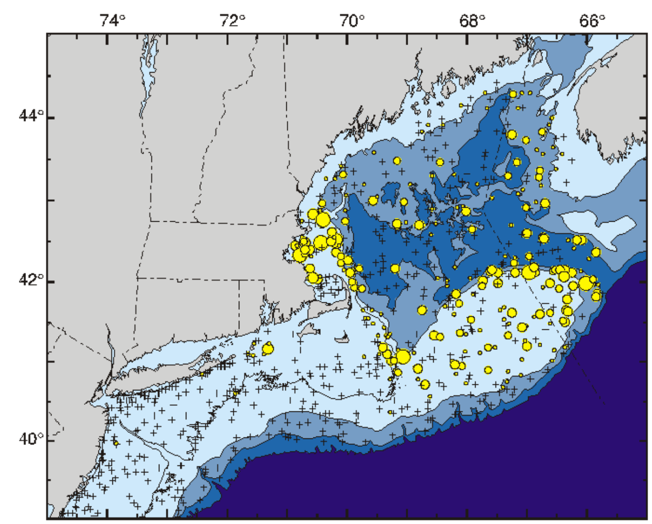
The Atlantic cod (*Gadus morhua*) has been an important food fish for centuries and has played an important role in the development of countries around the North Atlantic. Although cod has been fished for centuries, this century has seen the greatest pressure placed on cod stocks.

The Atlantic cod is a member of the Gadidae family which are medium to large size, bottom dwelling, generally marine fish, found in cool waters in the northern hemisphere. This family includes such fish as haddock, hake, and whiting. Although they are bottom dwellers, cod can be found anywhere from the surface to 500 or 600 m and from inshore waters to the edge of the continental shelf. The range of the Atlantic cod spans most of the coastal waters of the North Atlantic.



INTRODUCTION TO COD CULTIVATION - Continued

In the Northeast Atlantic cod can be found from Iceland to the Norwegian Sea and south to the Baltic Sea and the Bay of Biscay. In the Northwest Atlantic their range extends from Greenland and southern Baffin Island, south along the continental shelf to the Gulf of Maine. Their normal temperature range is between -0.5°C to 10°C, but depends on the time of year, location, and the size of the fish. They can be found in waters up to about 20°C. Generally, the southern extent of their range corresponds to the 10°C isotherm in April.



Spring 1997-1999

INTRODUCTION TO COD CULTIVATION - Continued

Full cycle cod aquaculture has been possible since the 1860's. Cod aquaculture became the focus for commercial production some 15 years ago in Newfoundland and Norway. Interest in commercialization has varied depending upon the catch levels of wild stocks. Since 1993 in Newfoundland and more recently in Norway and Britain declining stocks have renewed interest in full cycle cod aquaculture. There were two main approaches initially:

- The Canadians opted for a licensed capturing of wild juvenile cod, with subsequent short term "fattening" in captivity
- The Norwegians opted for pond-reared (extensive) juvenile production, followed by cage ongrowing

Although both systems did indeed produce market size cod (in some quantities in Canada), cod farming did not really expand rapidly in either country. At the core of this was the single fundamental fact:

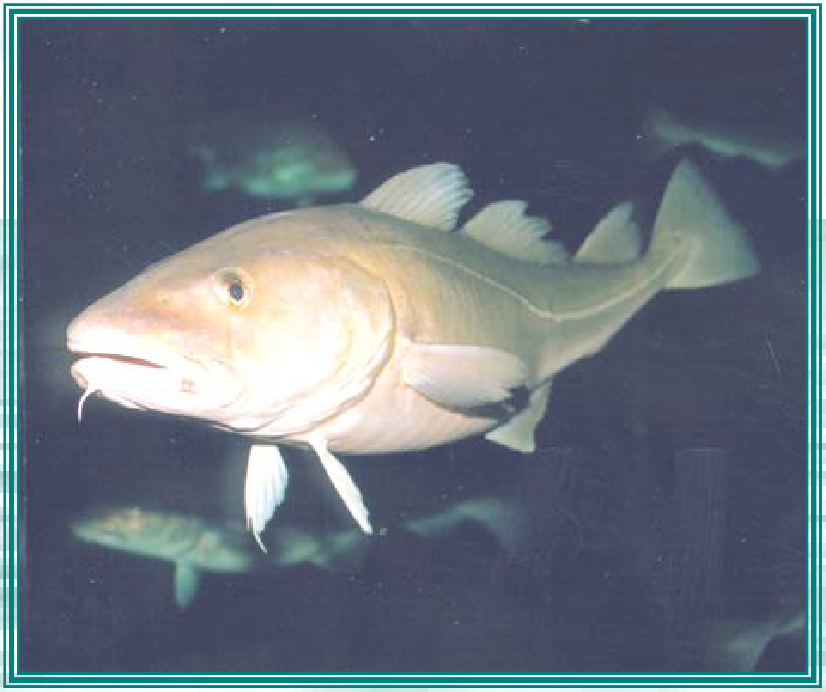
- Cod was still a species with a low-medium value in the market, and the costs of production from aquaculture, in reality, were higher than the market could pay

INTRODUCTION TO COD CULTIVATION - Continued

Considerable funds are being invested in cod farming - in Norway, Canada and the UK.

In the UK, Seafish and Highlands and Islands Enterprise took the lead in the "Cod Farming Demonstration Project". This 3-year project had some other major partners:

- Marks and Spencer
- Youngs Seafoods
- Trouw
- Several commercial aquaculture companies



One significant feature of this project was the involvement of the retail and manufacturing sector - a sure sign that the market is looking for farmed cod

INTRODUCTION TO COD CULTIVATION - Continued

The Cod Farming Demonstration Project is now complete, and has been successful enough to encourage major investment by UK industry. At the time of preparation of this draft of the Hyperbook (Spring 2002), there are 3 brand new commercial-scale cod hatcheries either built or under construction. Companies are also looking for cod ongrowing licenses for sea cage sites in Scotland.

The British Marine Finfish Association (BMFA) has a cautious and realistic target of 25,000 tonnes per annum of farmed cod by 2010 - some 7-8% of the current UK market.

This "vision" is anchored in a realistic view of :

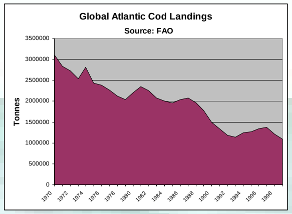
- The size of the UK market
- The value of cod in different niches within the market
- The realistic expectation for production costs of farmed cod

There is a lot of cod enthusiasm emerging from Norway at the present time, with projections of 150,000 tonnes per annum of farmed cod within a few years.

THE MARKETS FOR COD

The global and regional "market" for Atlantic cod is presently defined by the availability of supply from the wild fishery. This situation will change as aquaculture comes on-line in the future.

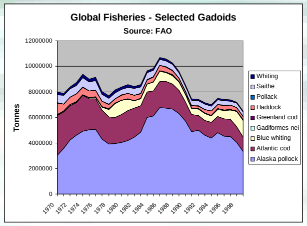
Click on the thumbnail to see the global wild supply data

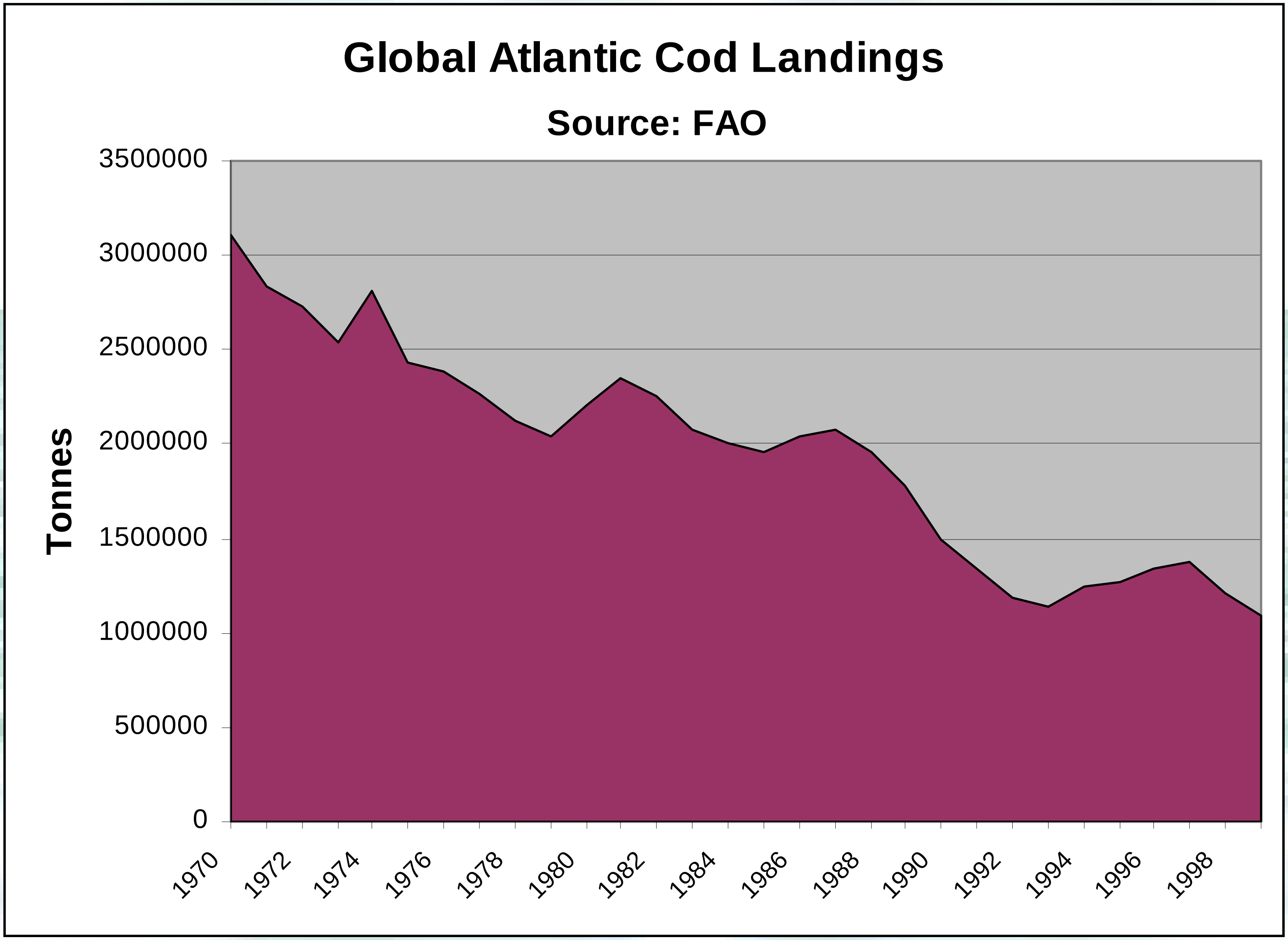


Atlantic cod landings are clearly in serious and long term decline. The FAO database stops at 1999, but it is widely recognised that total landings are now probably less than 1 million tonnes per annum.

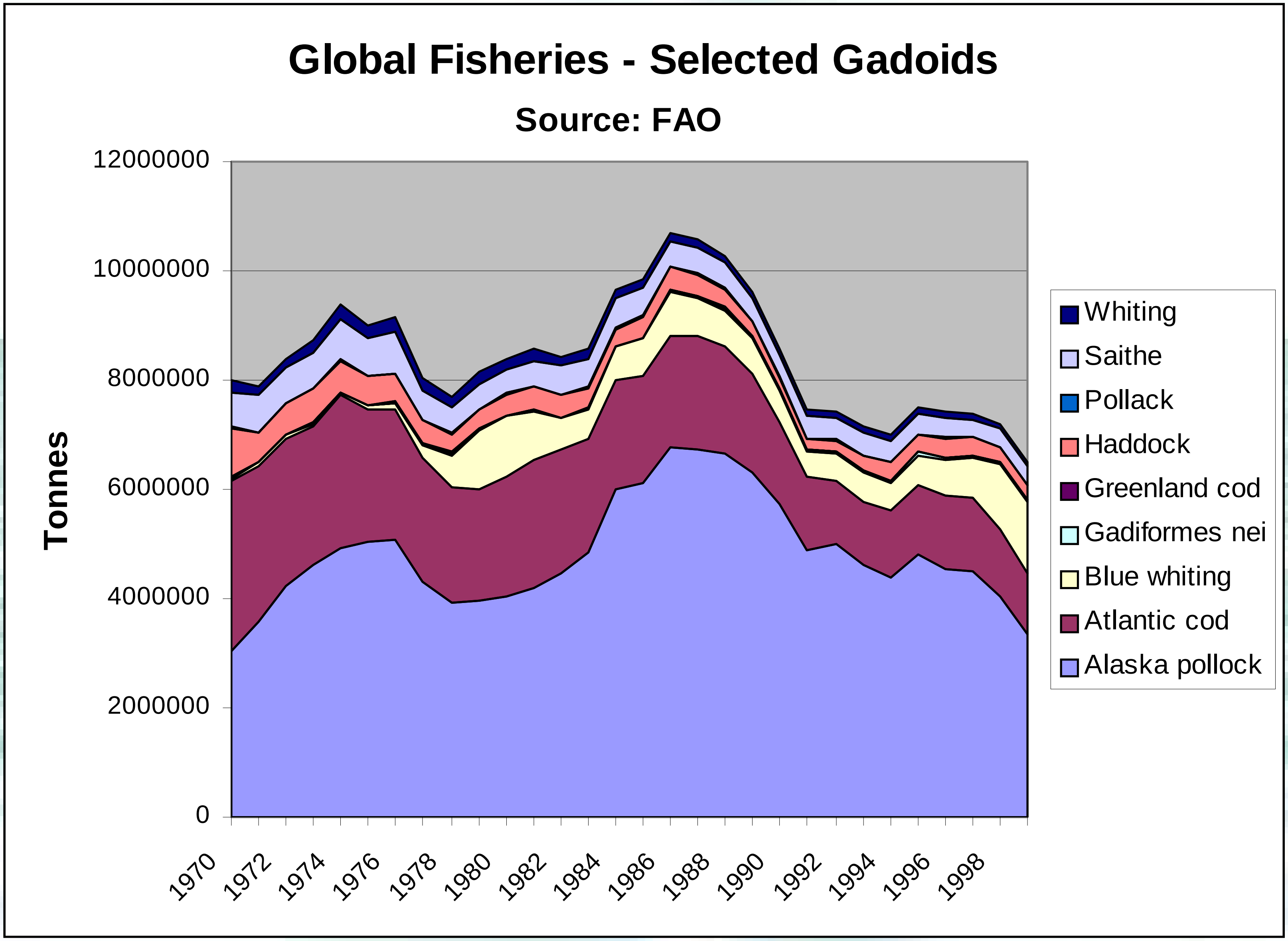
The situation for cod can be compared with some of its closely-related "gadoid" cousins:

Click on the thumbnail to see the global wild supply data





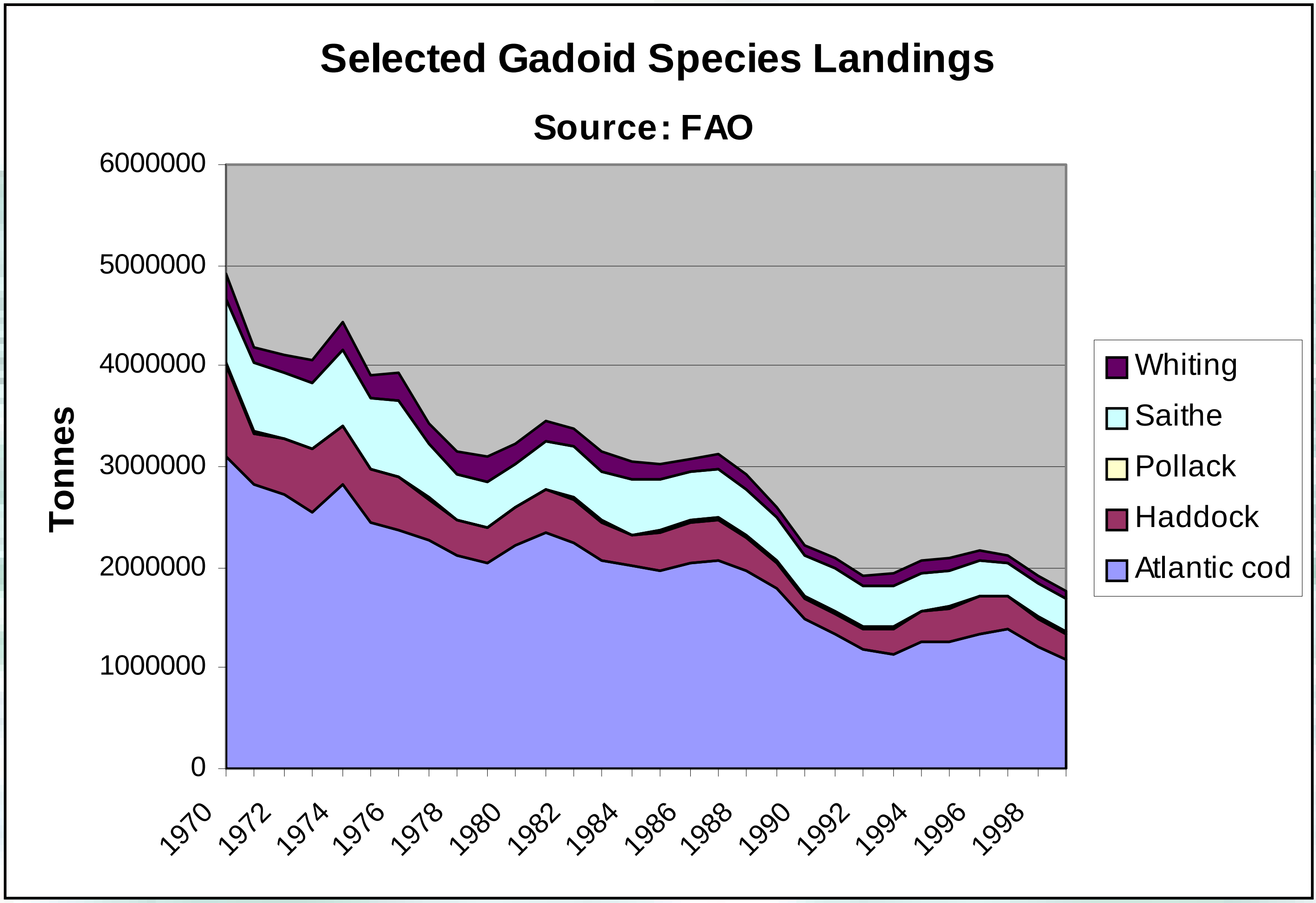
Global Atlantic Cod Landings
Source: FAO
Tonnes
3500000
3000000
2500000
2000000
1500000
1000000
500000
0
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998



Global Fisheries - Selected Gadoids
Source: FAO
Tonnes
12000000
10000000
8000000
6000000
4000000
2000000
0
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Whiting
Saithe
Pollack
Haddock
Greenland cod
Gadiformes nei
Blue whiting
Atlantic cod
Alaska pollock

THE MARKETS FOR COD - Continued

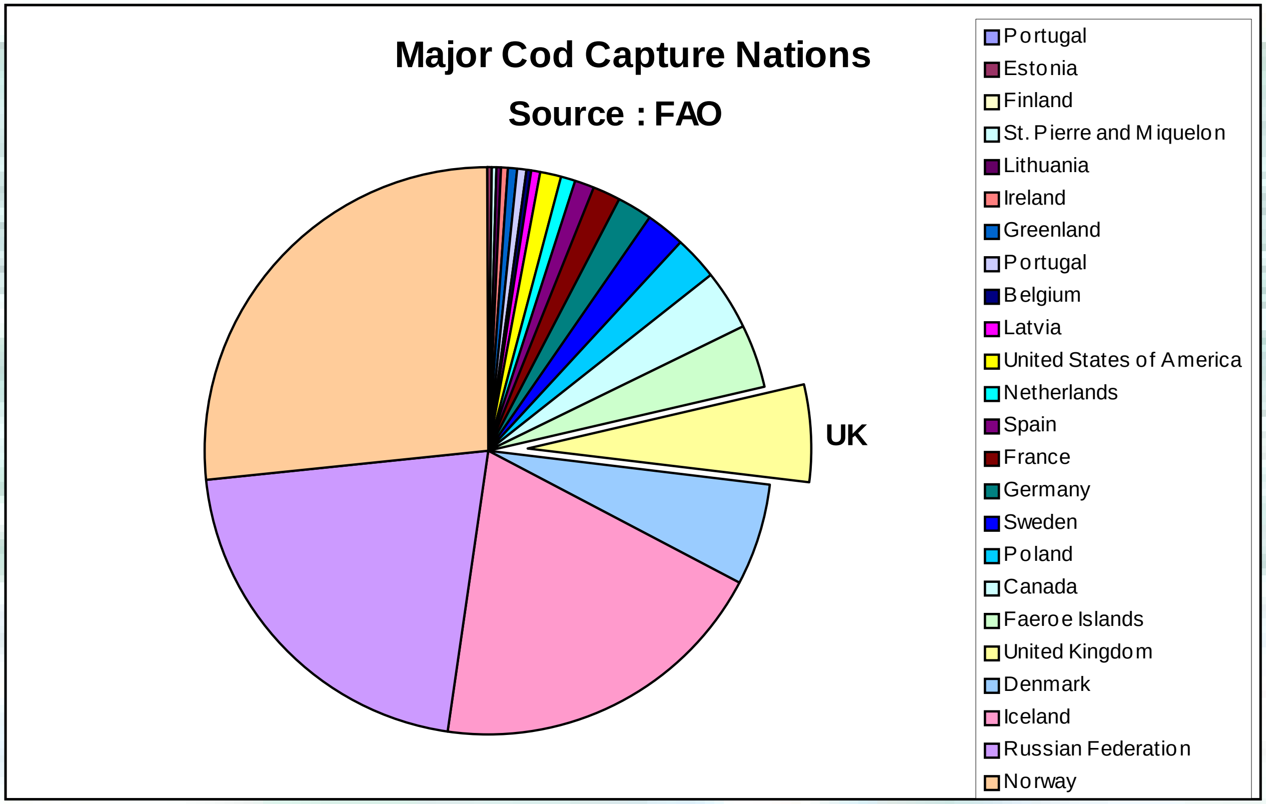
The situation becomes even more alarming when one considers only the "cod family" species with which UK consumers are normally familiar:



THE MARKETS FOR COD - Continued

It is worthwhile knowing which the main capture nations are for cod - these will be the potential competitors (in terms of imports into the UK) to domestic cultivated cod.

The main players are: Norway, Russian Federation, Iceland, Denmark & UK



The data are 3 year averages - 1997-1999

UK's catch average for the period was 68,000 tonnes

Quite a different picture for 2000 and beyond

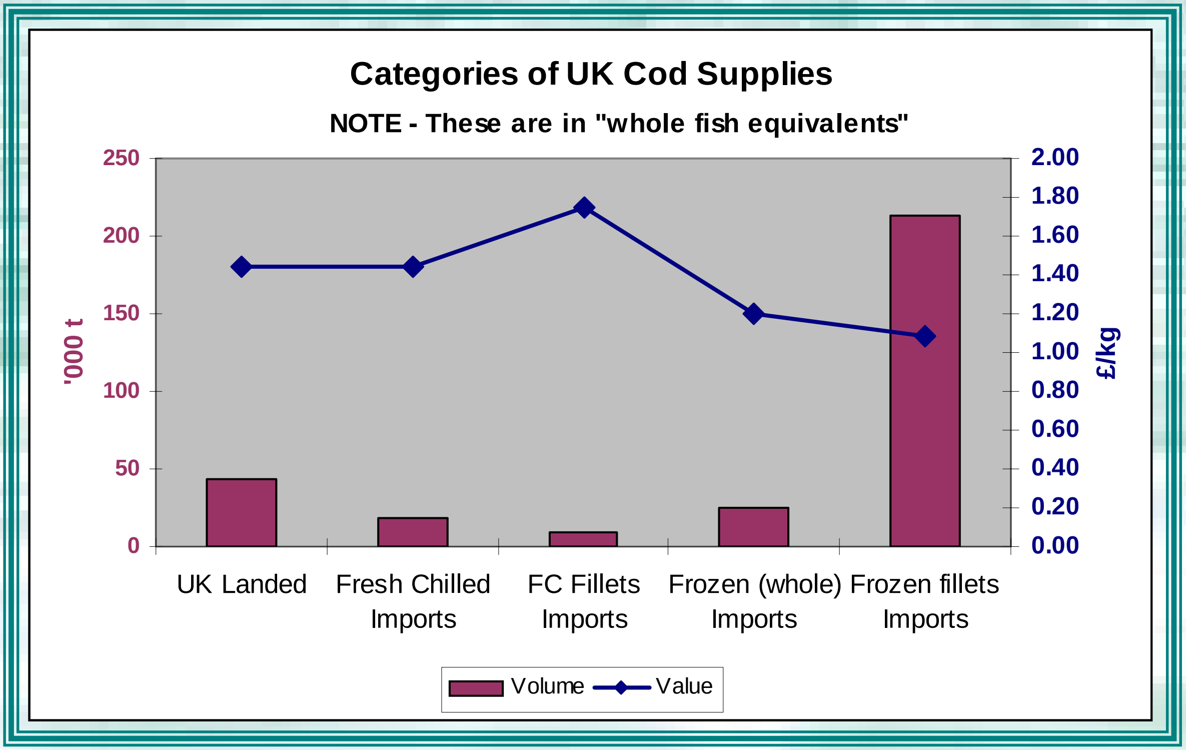
See next slide ..

THE MARKETS FOR COD - Continued

THE UK MARKET FOR COD

Government statistics about fisheries are available from DEFRA, and clearly show that cod becomes available to UK consumers from several sources: UK vessel landings and imports of whole fish or fillets, either fresh or frozen. The picture is completed by looking at balancing exports of cod.

There is some equivocation about how the statistics should be interpreted - specifically whether the volumes of imported cod fillets have been quoted as just fillet weight, or have been back-converted to “whole fish equivalents (WFE)”. On the former assumption, with one’s own back-calculation to WFE, the supply picture for year 2000 looks like this:



The “average” whole fish value in 2000 is £1.19 per kg

The 9,700 tonnes of chilled fillet imports are £1.70 per kg (as whole fish equivalents)

The UK-landed fresh cod are £1.45 per kg

THE MARKETS FOR COD - Continued

In a cod market study market conducted as part of the Cod Farming Demonstration Project, the author's main conclusions were:

- UK Consumption around 170,000 tonnes p.a.
- An opportunity for farmed if:
  - Similar farm-gate price to salmon - £1.80 per kg
  - Prefer 3kg fish
- 10,000 t p a of farmed cod would have "an impact on the UK market"
- There is probably a "high value niche" at around 15% of the total = *.c* 25-30,000 tonnes p.a.
  - For example - Icelandic fillets @ 7,000 t whole fish
  - "Large cod & chips" - the fryers use a lot of cod

You can find this report as a .pdf document "CodMarket" inside the main Hyperbook folder. Click "exit" to leave this show, if you want to see the report now

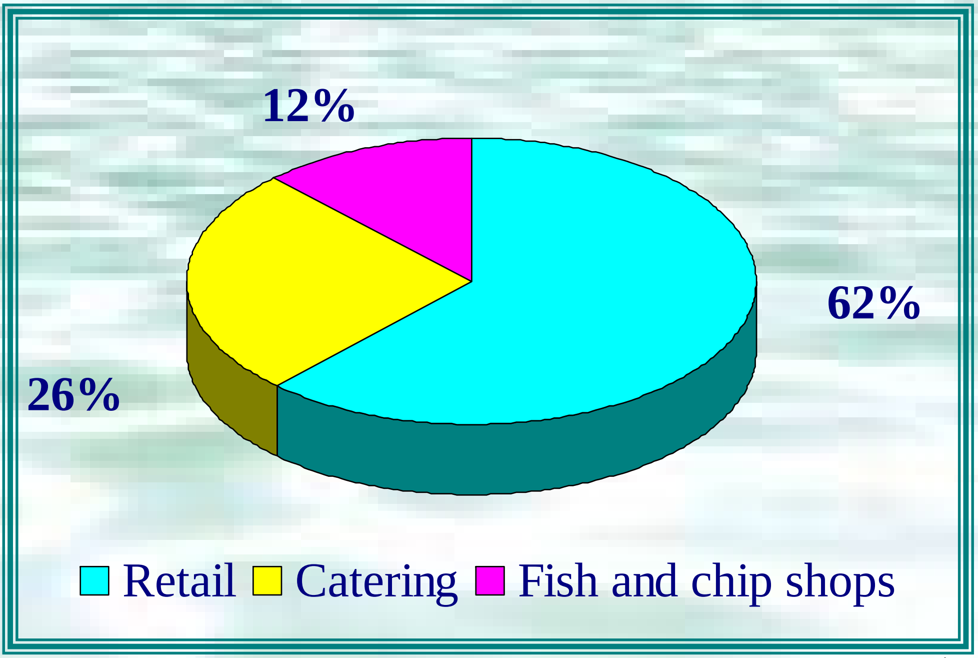
THE MARKETS FOR COD - Continued

Seafood is purchased in two broad categories by consumers:

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

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

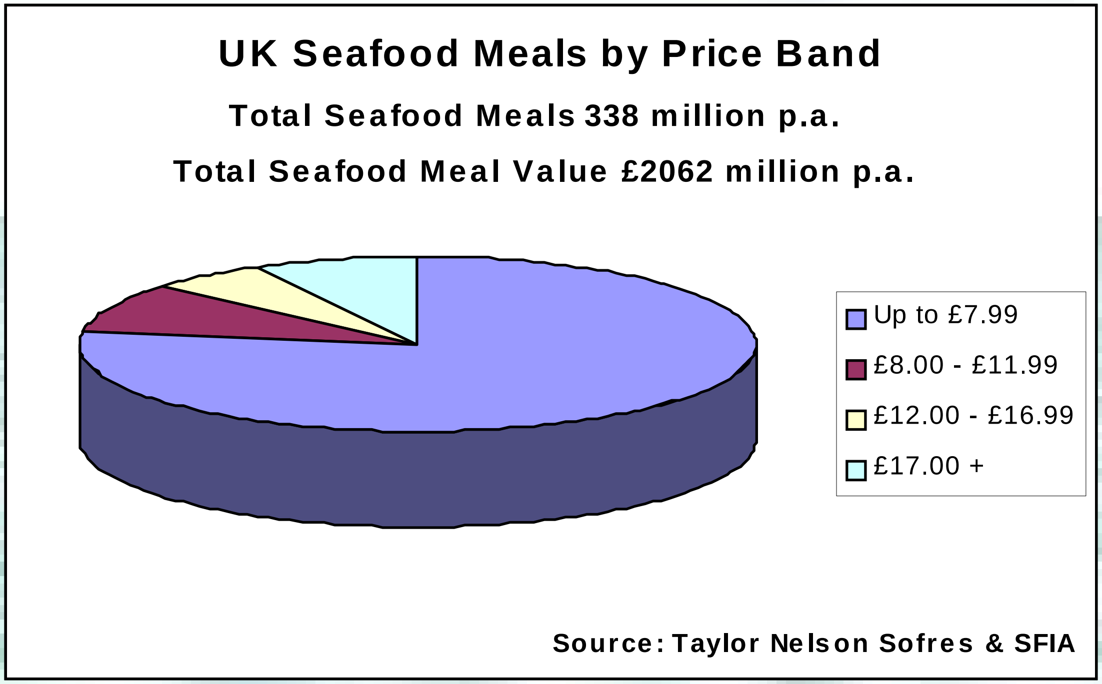
The balance between seafood retail and foodservice



Source: SFIA, Foodservice Intelligence & Superpanel

THE MARKETS FOR COD - Continued

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



- **338 Million seafood meals per annum**
- **25% of them costing more than £8 per meal**
- **Imported farmed seabass has become a "staple" of the UK restaurant trade - in the absence of any other high quality farmed product**

THE MARKETS FOR COD - Continued

The "Farm to Fork" concept is a way of understanding how aquaculture products are valued by consumers - and how the value of the product works backwards through the supply chain to the aquaculturist at the edge of his tank or cage.

EXAMPLE - Cod in a "family food" pub

• Cover price (150g flesh)		£6.00
– Less VAT		£5.11
– Less chef's 65% margin		£1.70
– Less veg, sauces etc. (at £0.50)		£1.20
• So restaurant can buy fillets for		£8.00/kg
• Cod fillet yield	40%	
• So restaurant can buy whole fish for		£3.20/kg

- Farmers have to think how to get their fish from "edge of cage/tank" to restaurant - perhaps being in partnership with the rest of the supply chain
- *(Note that the consumer is paying the equivalent of > £30 per kg for whole cod in this example!)*

THE MARKETS FOR COD - Continued

The other important factor in considering the "real" value of cultivated cod relates to the current trends which are being exhibited by the consumer - and by the foodservice and retail sectors:

- **UK consumers are increasingly opting for fillet only (no bones, skin, eyeballs)**
- **This trend is probably happening across Europe - but more slowly**
- **It is reflected in the sale of "fillet recipes" in foodservice, and in pre-packed fillets in the retail chill cabinets**
- **Aquaculture has a certain cost of production for whole fish**
- **But the consumer is only really valuing the flesh component**
- **So any consideration of "inherent value" of the product has to take into account the yield of the fish in question**

- **Farmed cod, fortunately, is likely to have a better fillet yield than wild cod - estimated at some 40% in trials so far**

THE MARKETS FOR COD - Conclusion

The main cod market messages from this section are:

- Atlantic cod is declining in terms of wild supply
- The UK is already a significant consumer of Atlantic cod - perhaps some 33% of world supply
- Cod is massively popular with UK consumers, in a wide range of forms and purchasing locations
- The farmed fish should provide a good fillet yield - and be available to a consistent size and quality
- The reliability of supply which will come from aquaculture may be an important feature in some niches - allowing business to be grown
- These top-end niches might be able to afford cod at aquaculture prices - and they probably amount to some 20-25,000 tonnes of whole fish per year in terms of volume

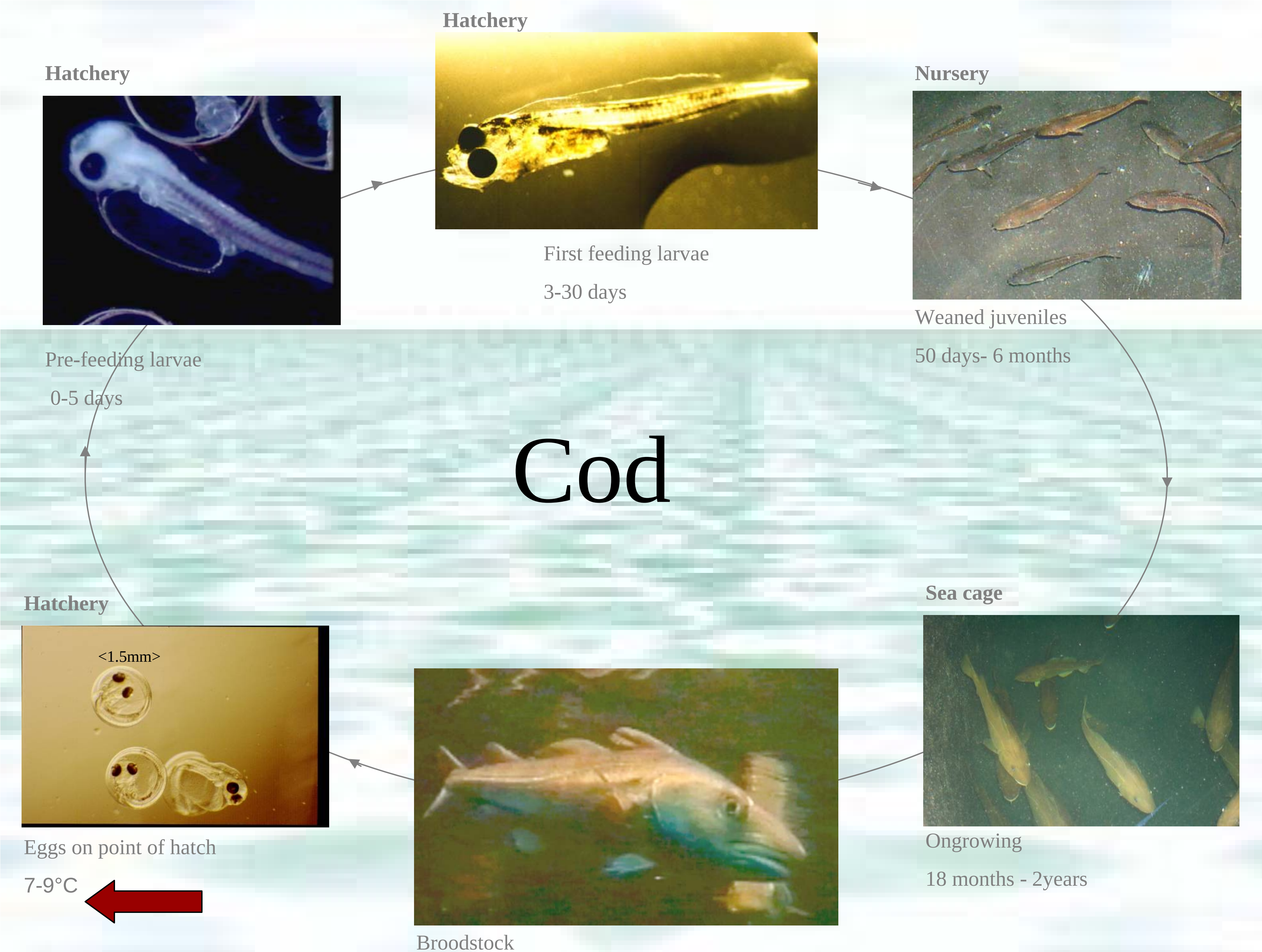
Some cod recipes

THE PRODUCTION PROCESS

Introduction

Click here to see a graphic representation of the life cycle

This Hyperbook will focus on the main life cycle stages of production of Atlantic cod: hatchery, nursery and ongrowing. The Hyperbook can not provide every detail, and it is recommended you visit the resources listed below to obtain more information.


Hatchery
Hatchery
Nursery
First feeding larvae
3-30 days
Weaned juveniles
50 days- 6 months
Pre-feeding larvae
0-5 days
Cod
Hatchery
Sea cage
<1.5mm>
Eggs on point of hatch
7-9°C
Broodstock
Ongrowing
18 months - 2years

Hatchery - Broodstock 1

In the wild, studies of various cod populations have shown that most populations tend to concentrate spawning in time and space. These patterns differ between stocks and often seem to be related to phytoplankton production in a particular area. It seems that the cod time their spawning to coincide with the peak in phytoplankton production so food will be plentiful when their larvae hatch. This correlation is stronger in some areas than others.

Spawning occurs between February and June. The timing varies between regions, tending to be later in the south.

The odds of a cod egg surviving to adulthood are roughly one in a million. In order to overcome this adversity, cod produce large numbers of eggs. A 50 cm female may produce 200 000 eggs while a 140 cm female may produce as many as 12 million eggs. The eggs are 1-2 mm in diameter and are round, transparent, and buoyant. Once they are released, the eggs will begin to rise slowly to the surface and drift with the currents. Incubation varies depending upon temperature. Once hatched the embryos have a yolk sac which they will live on for 1 or 2 weeks. After several weeks of living in the upper water column, they will begin to settle to the bottom when they are approximately 4 cm in size.

Wild Spawning Areas

Main cod spawning Concentrations around UK

Source: MAFF

Hatchery - Broodstock 2

In captivity, broodstock tanks for cod range from 10 to 150 m3 in volume, and are typically stocked with fish at densities of up to 3 kg/m3.

Hatchery - Broodstock 3

Cod broodstock nutrition can be based on either a semi-moist pellet, or on the use of dry pellets.

Early trials at Ardtoe tended to suggest that fertilisation of cod eggs was considerably more successful (72% v 38%) when the moist diet was used.

Unfortunately this experimental semi-moist pellet, made up on site, contained wet ingredients such as squid. This approach carries an inevitable risk of disease introduction to broodstocks, and in the future the development of better dry diets will be important.

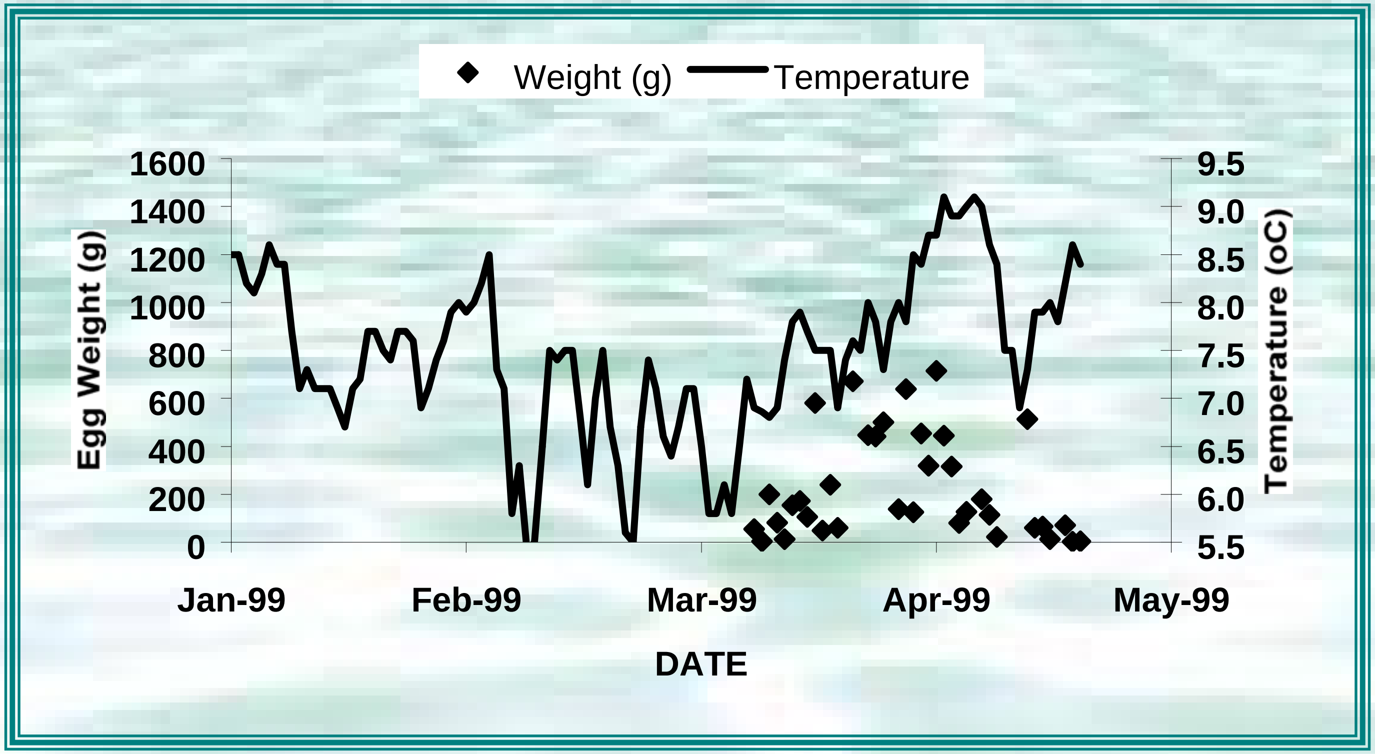
Extract from the Seafish Cod Report - Broodstock Feeding Trial

DIET	Start-Finish	Total No. Collections	Total Eggs (g)	Average "Batch" size (g)*	Average Percent Floating*	Average % Fertilized*	Total Viable Eggs (g)
Trouw Pellet	11/3/99-23/4/99	36	8,172	227.6 ± 217.6	54.9 ± 26.0	37.6 ± 41.6	1,912
Moist Diet	11/3/99-23/4/99	32	8,244	257.6 ± 278.9	63.0 ± 22.2	71.8 ± 36.2	4,319

* Values are mean ± standard deviation.

Hatchery - Broodstock 4

Cod spawn naturally within their broodstock tanks, the eggs are fertilised and pass out of the tank with the flowing water - there is no requirement for hand-stripping. Eggs are retained in a 100 Micron mesh located within a 2 m3 tank at the main tank outflow, and collected every day by staff. The figure below illustrates how many eggs were collected over the spawning season for one stock at Ardtoe. More recent experience suggests these figures can be greatly improved.



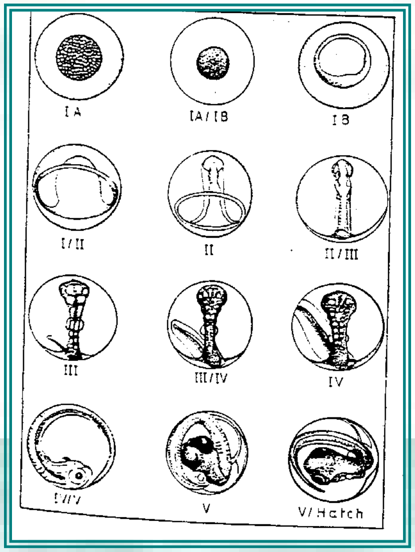
Hatchery - Egg incubation

Collected eggs are sterilised in a bucket containing 10 L of 4000 ppm Kickstart solution for 40 seconds (a proprietary sterilising solution, containing an equilibrium mix of acetic acid, peracetic acid and water)

After sterilisation, the eggs are stocked into incubators. Up to 2 kg (*approx.* 1 million) of eggs can be stocked in 70 L cylindro-conical white ‘Paxton’ tanks. Water inflow (2 L·min^{-1}) comes from a narrow inlet at the bottom of the tank. A central standpipe surrounded by a wider cylindrical 250 µm nylon mesh is used as the outflow. Gentle aeration is provided *via* an air-collar around the base of the cylindrical mesh. Illumination is kept at a low level (*ca.* 10 lux) except during brief periods of husbandry. Most mortality occurs during the first 48 hours *post*-stocking (possibly due to collection damage). Dead eggs can be removed by first switching off both aeration and water inflow. After *approx.* 10 minutes the dead eggs sank to the bottom, where they can be removed by siphoning. Mortality thereafter is negligible.

Hatchery - Egg Staging

All larval batches used in egg incubation are examined for developmental stage according to criteria described by Makhotin *et al.* (1984) and Russell (1976). The stages of embryonic development can be scored visually according to the twelve point scale of Thompson & Riley (1981) - See right

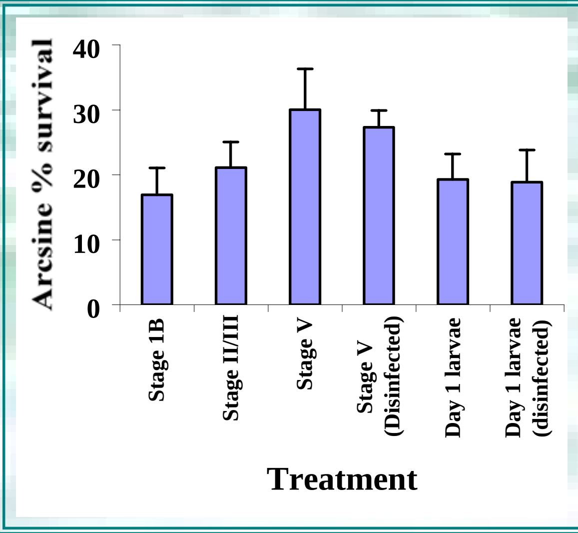


Hatching time at different temperatures can be predicted from work by Russell (1976) - see below

Average duration (days) to hatch of artificially fertilised cod eggs at different temperatures

Temperature	-1^{0C}	3^{0C}	4^{0C}	5^{0C}	6^{0C}	8^{0C}	10^{0C}	12^{0C}	14^{0C}
Days	42	23	20.5	17.5	15.5	12.75	10.5	9.67	8.5

Experience in trials suggests that movement to larval tanks at Stage V is probably preferred (see right)



Before transfer to rearing tanks, Stage V eggs are routinely disinfected and their

numbers estimated.

Hatchery - Egg Transfer to First Feeding

In order to collect eggs from the incubators, brine is added until the salinity is 35.5 ppt. Air and water flow is switched off, and viable eggs can be jugged from the water surface and transferred into a fine mesh hand net immersed in water. The eggs are then disinfected and decanted into a 12 L acrylic container filled with 8 L of seawater. The water volume in the container is then made up to 10 L. Dead eggs and larvae (precociously hatched larvae would be killed by the disinfection, so that tanks would only be stocked with eggs. This ensured a narrow window for the start of first-feeding) are allowed to sink to the bottom, and are siphoned off. The water volume is then made back up to 10 L.

Egg numbers are then estimated volumetrically. Since the eggs float on the surface of the water, they are gently mixed and spread equally throughout the water column. A 50 ml sample is taken and is itself diluted to 1 L. The sample of eggs is gently mixed, and three sub-samples of 50 ml each are taken. The sub-samples are poured through a rigid 250 µm nylon mesh which catches the eggs and allows each sub-sample to be counted. The mean of the three sub-samples is estimated, and the number of eggs in the original 50 ml sample is calculated:

$$\text{Sample egg no.} = \text{sub-sample mean} \times 1000/50$$

where 1000 equals the volume the original sample was made up to, and 50 equals the sub-sample volume (both in ml). The total number of eggs in the acrylic container can then be calculated:

$$\text{Total egg no.} = \text{sample egg no.} \times 10\,000/50$$

where 10 000 equals the volume in the acrylic container, and 50 equals the original sample volume (both in ml). Volumes and dilution factors can be varied according to the discretion of the worker, and the egg density in the acrylic tank. Following estimation of egg numbers in a known volume (10 L), the rearing tanks can be stocked to the required density. Ensuring that the eggs are again well mixed in the water column, estimated quantities of eggs can be transferred to the rearing tanks by gently jugging known volumes of water from the acrylic container (*e.g*: if there is 500 000 eggs in 10 L, then jugging 2 L into a rearing tank would stock the tank with 100 000 eggs).

There is a considerable amount of larval rearing detail contained within the accompanying Seafish Report – which is provided here in Adobe Acrobat .pdf format.

You can find this report as a .pdf document "COD FARMING" inside the main Hyperbook folder. Click "exit" to leave this show, if you want to see the report now

For more detailed information on live food production, press the button

Algae Production

Algal Culture Methods

There are two basic methods for culturing algae. One is called a "Batch culture" the other is called a "Continuous culture".

Batch Culture

In this method algal cells are allowed to grow and reproduce in a closed container. They have a finite amount of nutrient, and when that is exhausted, their growth stops and eventually they die. These types of cultures typically last for about one week. After that, if you wish to continue the culture you must "sub-culture" by adding some cells from the old culture into a flask containing fresh growth medium. This type of culture is undertaken in 2.5 & 10L glass flasks – and in polythene bags ranging from 100 to 250 L

Continuous Culture

This method of culturing algae differs from the batch culture method in that fresh medium is added to the culture at a constant rate and old media (and some of the algae cells) is removed at the same rate. The culture therefore never runs out of nutrients. Hygiene and prevention of contamination is essential, and such systems rarely run indefinitely. On a small scale they can be run in 20L plastic carboys – with a percentage harvest once per day (often about 20%). Larger commercial systems are now on sale.

Rotifer Production

General

Rotifers (scientific name = *Brachionus*) are brackish water crustaceans commonly used as a starter feed for marine fish larvae. They are considered to have a higher nutritive value than *Artemia.* One of the most commonly used species is *Brachionus plicatilus* with a mean size of 250-260 µm. However, there are different strains of this species which differ in size (larger strains of 300-350 µm and smaller ones of 150-200 µm) and growth rate.

Rotifers can reproduce asexually in favourable conditions by laying one or two large eggs that hatch into females which in turn produces more females. This parthenogenetic reproduction is the basis of mass culture techniques.

Culture techniques

Rotifers are mostly produced in batch cultures and fed initially on marine microalgae such as *Chlorella* or *Nannochloropsis* and then supplemented and/or enriched with bakers yeast or special yeast-based preparations. In this way the composition of the rotifers can better meet the HUFA and vitamin C requirements of many marine fish species. Extra enrichment with emulsified or micro particulate products is also possible. In a standard batch culture systems using some of these specially developed products, rotifers can be produced at 3000-4000 per ml. Generally, this cannot be achieved with normal yeasts or algae. Unexplained collapses of batch cultures can occur. This is a major problem in commercial scale systems. New continuous culture techniques in recirculation systems offer a more consistent supply of high quality rotifers at densities ten times higher than in batch cultures. This is achieved by maintaining better water quality in the system with protein skimmers, ozone treatment and biological filtration. In experimental recirculation systems, densities of 3000 rotifers per ml were sustained. It was estimated that up to 2 billion rotifers can be produced per day at a cost of 54,000 Euros, compared to 94,400 Euros for producing the same number in a conventional batch system.

Disinfection of rotifers is still a bottleneck. However, bacteria levels in high density continuous cultures tend to be lower and more stable than in batch cultures. Another bonus is that rotifers produced in continuous cultures are larger than in batch systems.

Rotifers can be harvested with a 75 µm mesh net and rinsed thoroughly with fresh sea water before feeding to fish larvae.

Return to main section

Click for Artemia

Artemia Production - 1

General

Artemia salina, or brine shrimp, are the most widely used live prey in marine larviculture. The nauplii are hatched from dry cysts most of which are collected from the shores or harvested from the waters of salt lakes, or as a by-product of salt production. The market supply of *Artemia* has fluctuated a great deal in recent years. The Great Salt Lake in Utah, USA was the sole source of *Artemia* cysts for many years, supplying >90% of the world requirement. In 1997, the El Nino effect resulted in excessive rainfall and snow melt in the catchment area. This reduced the salinity of the lake, causing a disruption to cyst supply that led to a world shortage. Several new sources have had to be found, mainly in Russia and China.

Over the years the demand for *Artemia* cysts has increased with the development of fish cultivation. However, their availabilty from year to year has become less reliable and the quality of cysts, in terms of hatching success (>80%), individual dry weight and energy content, can vary with geographical source and between strains. Differences in culture methods, harvesting methods, handling and hatching success can all affect the nauplii, in terms of their size and weight (mg of hatched nauplii per gram of cysts) and their nutritional value and energy content. The maximum time that cysts can be stored before hatching success is compromised is no more than a year. Consequently, price has increased significantly, particularly for the best quality cysts.

Methodology

When selecting which strain of *Artemia* to use, the size of nauplii that the larvae can ingest is a very important factor to consider. Also, hatching efficiency (nauplii per gram of cysts), hatching percentage and time taken to hatch are other important characteristics.

Many types of containers are suitable for hatching *Artemia* cysts. These include conical-based cylinders with water circulation that keeps the cysts in suspension, funnel-shaped containers aerated from the base and plastic bags. Natural sea water, at 25-30 oC and pH 8-9, is used as the culture medium and a high dissolved oxygen level is required. Continuous illumination is recommended.

To increase the hatching rate, decapsulation (i.e. the removal of the outer hard shell = chorion) and disinfection of *Artemia* cysts to reduce the bacteria load are advisable before the cysts are introduced into the culture vessel. *Artemia* nauplii can be heavily contaminated with bacteria, mainly *Vibrio* spp, resulting in their transfer to larval rearing systems with the live feed.

Decapsulation is achieved by hydrating the cysts (in fresh or sea water <35 parts per thousand at 25 oC for 1-2 h) followed by short exposure to a hypochlorite solution. Then the cysts need to be washed and the chlorine residues removed. For hatching, a density of <10 gram of cysts per litre of water is recommended.

Within 24 h the nauplii will have hatched. Harvesting is done by siphoning through a 125 µm mesh. The harvested nauplii retained on the mesh should be washed thoroughly before feeding to the larvae. If necessary, they can be stored at 1 - 4 oC in aerated containers for up to 48 h with minimum enegy loss.

Return to main section

Click for Artemia 2

Artemia Production - 2

GeneralQuality of nauplii

Newly-hatched nauplii, at the instar I stage have a high energy content are the most suitable for feeding to marine fish larvae. Within 24 h of hatching at 25 the nauplii go through a moult stage when the calorific value can decrease by 20%.

Bioencapsulation of *Artemia* (also known as enrichment or boosting with selected HUFAs and vitamins for 24 hours after hatching) has significantly improved the culture of marine fish larvae in terms of survival, growth, success at metamorphosis and overall larval quality (reduced malformations, improved pigmentation, increased resistance to stress and disease). Various enrichment emulsions are available, differing in their fatty acid composition. Traditional EPA-rich formulations have been replaced by those with high levels of DHA and arachadonic acid. Vitamin C has also been incorporated into boosters to increase levels of ascorbic acid. Techniques for cyst decapsulation, high-density nauplius hatching and enrichment, washing and harvesting on a large scale have been standardised and automated.

Nauplius to adult

Artemia can also be cultured from nauplii to the pre-adult stage in intensive or extensive systems.

In intensive systems, hatched nauplii are introduced at a density of 10,000 per litre. It is a filter feeder, filtering continuously so feeds (e.g. algae, yeasts, microparticulate diets) must be dosed continuously or at pre-set times to maintain an optimum food concentration. Solid wastes must be removed from the rearing vessel. Water temperature, salinity, pH and dissolved oxygen levels are similar to those described for hatching cysts. After 2 weeks, the *Artemia* will have grown to 8mm, with a yield of 5 g (wet weight) per cubic metre of culture medium. Higher yields have been produced in through-flow systems.

Return to main section

Click for Copepods

Copepods

General

One of the advantages of using copepods is their higher nutritional value compared to *Artemia* and rotifers. Also, they are usually smaller than the other live feeds making them more suitable for some marine fish larvae. Some copepod species have a nauplius stage that is 50-75 µm in length. Several copepod species are being tested for their nutritional value and ease of culture. They include harpacticoid copepods, e.g. *Tisbe,* and calanoids, e.g. *Calanus* and *Pseudocalanus*.

The different life stages of copepods can provide much improved nutrition of fish larvae, resulting in better survival, pigmentation and feeding morphology of the larvae. As yet, industry take-up of this nutritional advantage has been limited. Harvesting copepods from the sea is possible in some coastal regions but availability is seasonal and it carries the risk of disease transmission and parasite introduction. Culture methods include semi-extensive ponds and more intensive systems but as yet, commercial scale systems for the reliable and economic production of copepods, and in particular intensive culture systems, are not well established. Candidate species for commercial culture of marine fish larvae will need to have the following characteristics – small size, a short generation time, tolerance to high densities in culture, tolerance to changes in temperature and salinity.

Culture methods

Although calanoid copepod culture is feasible, the high volume systems for culture in captivity are perceived to be too expensive and unreliable for most intensive hatcheries in the UK. Through research into calanoid copepod culture in Australia, an automatically controlled 500-litre recirculation system was developed that produced 450,000 nauplii per day for over 400 days. It was predicted that in locations where flow-through systems could be used in preference to re-circulation systems then production could be increased.

Intensive culture of harpacticoid copepods appears to offer good prospects in the UK for large-scale production. They can be held in captivity at high densities. There are a number of protocols for laboratory-scale production. Research being carried out at SFIA Ardtoe is addressing methods for the intensive cultivation of *Tisbe holothuriae.*

Broodstock of the copepod *Tisbe* have also been held in mesh-bottomed trays floating in larval culture systems. When the eggs carried by the female copepods hatch, the nauplii simply fall through the mesh into the culture water. A production of 132,000 nauplii per day from a 200 ml tray has been recorded.

The copepods are fed on cultured marine microalgae species, particularly those with higher levels of essential HUFAs. Alternatively, nutrient rich water in ponds or lagoons can be used for growing algae as a natural food source for the copepods.

Return to main section

Hatchery - Weaning

Weaning is very well covered in the Seafish Report, and you should read this section carefully when considering this phase of cod rearing. Fundamentally, weaning is not a majot problem with any marine species provided:

- The larvae are inherently healthy and robust when weaning commences
- The weaning does not start before the larvae are physiologically able to digest the inert diet
- Tank systems allow for good hygiene
- There is a sufficient "overlap" of weaning diet at and live food

Feeding Schedule for Trouw Nutra Marine weaning diet

SIZE GRADE	DIET CODE	CRUMB SIZE (mm)
Under 3mm grid	00 plus 01 + Artemia	0.3-0.6 plus 0.6-1.1
3mm-4mm	01 + Artemia	0.6-1.1
4mm-5mm	01 plus 02	0.6-1.1 plus 1.1-1.5
5mm-6mm	02	1.1-1.5
6mm-7mm	02 + 03	1.5-2.3

Hatchery - Nursery

Once the small cod are fully weaned, it only remains for the hatcheries to grow them as speedily and safely as possible up to a size at which they can leave the hatchery. This will depend upon individual company policies and the requirements of customers, but 5g cod are perfectly hardy animals, quite capable of being transported in much the same way as juvenile turbot. Allowing for some culling of runts and the occasional mortality due to aggression, nursery throughputs should now be > 85%.

There are two major factors to consider around this stage of cod hatchery:

- Aggression and cannibalism is always a potential problem for small cod. Good attention to feeding-to-satiation, plus a rigorous grading regime, should minimise these problems. Frequent grading between 1 and 10g is recommended.
- Cod juveniles (weaning/nursery) may prove to be susceptible to infection by IPN virus (Infectious pancreatic necrosis) or vibriosis. Sterilisation of incoming hatchery seawater, and attempts to reduce any other sources of infection, are essential. Note that the IPN virus is particularly hardy, and high doses of sterilants such as UV or ozone are required. There is no evidence yet of vertical transmission of the virus (from the parents), but this possibility can not be ruled out. The use of early vaccination may prove to be a useful tool in large scale cod rearing in the future.

Hatchery - Overview 1

A *summary* of the current challenges and opportunities facing cod hatcheries would include:

Broodstock Numbers: This issue is probably not a major impediment to the industry at this stage.
Yolk Sac Rearing and Transfer to First Feeding: This phase is not problematic - eggs are transferred pre-hatch, directly to larval rearing tanks, and the yolk sac phase is short.
Larval Rearing: Good attention to hygiene and live food enrichments is important
Fish Quality: Those cod which survive the hatchery phase are of good quality in terms of later ongrowing. There is not much evidence of large scale deformities such as *lordosis* or *scoliosis* - but the industry should be aware of these issues.
Handling and Husbandry Systems: Many hatchery operators may find that tank hygiene during the larval rearing phase is a difficult husbandry challenge. There is a need to clean debris from the tank bottoms regularly, but the use of a manual siphon system is both time consuming and overly intrusive to the larvae in the water column of the tank. Efforts are underway to develop a more automated system for this task.
Susceptibility to Disease: Cod appear to have a non-specific immune system which becomes highly competent once they reach a size of >2g. However, at the weaning and early nursery phase there might be incidents of serious disease outbreaks. Studies are underway on the potential for maternal vaccination and early vaccination during the live food stages.
Aggression and Behaviour: Cod larvae are clearly aggressive and cannibalistic, and care is needed in this part of the early rearing cycle

Hatchery to Ongrowing Transition

The cumulative time taken to produce 2-5g weaned juvenile cod in the hatchery is somewhere between 3 and 4 months. This compares with around 4 months to produce juvenile turbot of a similar size.

Traditionally, marine fin fish hatcheries have to focus on the difficult live food and larval rearing stages in order to achieve success. The final hatchery-nursery phase from weaning up to 2- 5g is relatively undemanding from a biological standpoint - but it does occupy considerable physical space within the hatchery. It also occupies staff time, and critically it interferes with “pulse” production principles (where a hatchery operates on a distinct “all-in, all-out” seasonal pattern of production).

For these reasons, marine fin fish hatcheries need to get fish off site as early as possible.

For species such as turbot, where ongrowing production takes place in land-based systems, this is not a problem. The ongrowing farm would have a dedicated “nursery” or “pre-ongrowing” system - small tanks, usually under cover. Juvenile flatfish tend to remain at their most vulnerable to diseases (e.g. Vibrio, IPN) or behavioural problems up to a size of about 100g. At that point, they are relatively hardy, and can be placed into any “main” ongrowing system. The problem for cage ongrowing of cod is that there is no “nursery” option on the ongrowing site.

Nursery Ongrowing 1

The "middle phase" which *may* emerge for cod production in Scotland is the so-called "nursery phase". Fish would be typically taken from the hatchery and placed in another separate land-based unit, to be grown from 2-5 g to 50g or even bigger. Such units would represent a "cost centre", and should either be built *alongside* hatchery units, or alongside a large cage operation shore base. In both cases there is the opportunity to share overheads and manpower.

However, there are two points of view on this issue - some operators believe that cod juveniles can be stocked directly in sea cages at post hatchery sizes. The very successful bass and bream industry in the Mediterranean takes this approach, with fish of 1-2g being placed directly into cages.

The main considerations are:

- **Small cod appear to be prone to vibriosis, and this could be exacerbated by conditions in cages**
    - ***Although good vaccines are now available***
- **A land-based nursery can offer the prospect of temperature control and stable environments, whereas conditions for placing small cod directly into cages may be less favourable at some times of the year (temperature and water conditions)**
- **Land-based nurseries may give faster growth - so providing a "head start" to the overall production cycle**
- **Land-based nurseries will be expensive to build and operate**

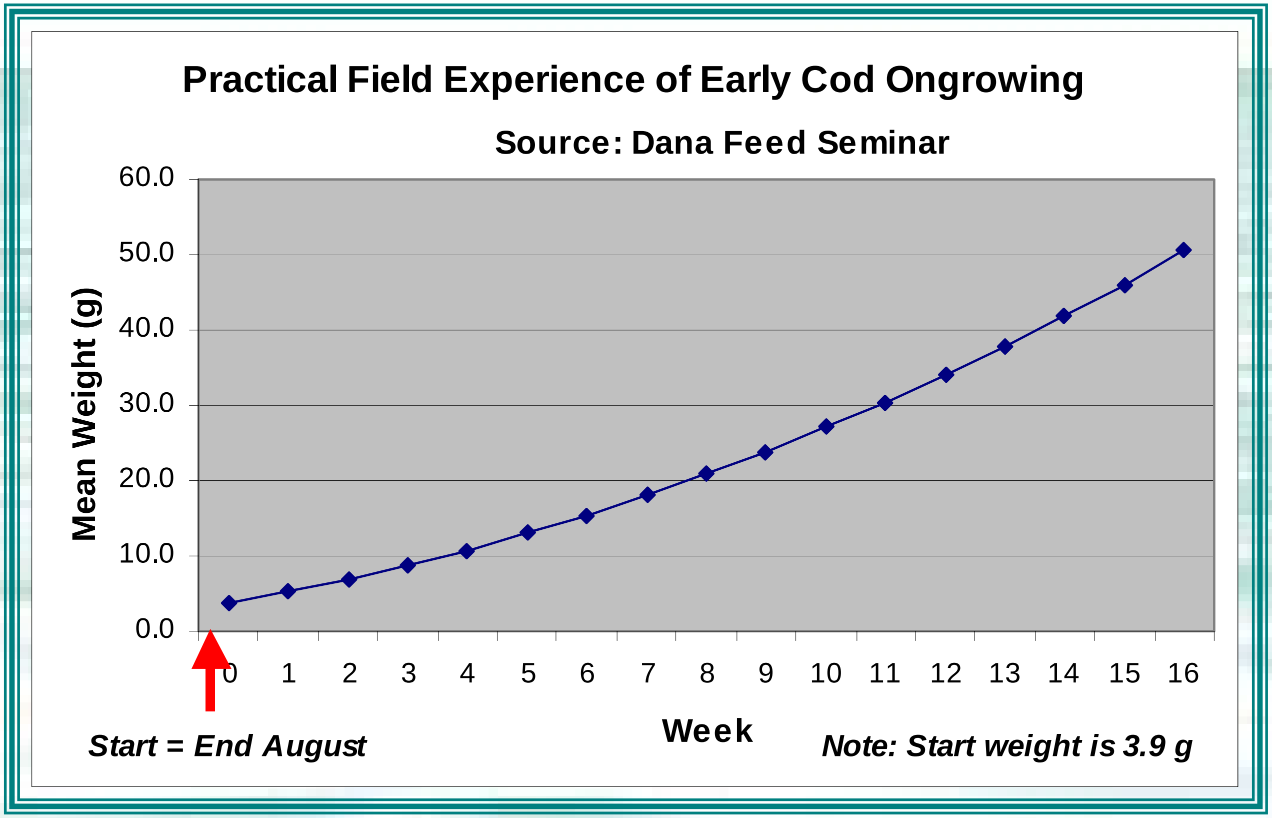
Nursery Ongrowing 2

The expectation of growth rate can be numerically calculated, and can relate to several parameters. However, temperature of the rearing water is probably the main deciding factor.

The question of cage *v* tank nursery seems to be less relevant than some people might expect.

In a recent field experiment in Scotland, a sibling batch of small cod was divided and grown in both a cage and land-based tanks.

The resulting growth curve is shown right - and note that there is only one curve, since both populations performed in an almost identical manner.



Nursery Ongrowing 3

Cod nursery units (if required) are primarily an issue of technical design and operation - and so they are discussed in the TECHNOLOGIES section of this Hyperbook.

From a production process standpoint, there are 3 principle options:

- **Simple ambient temperature flow-through systems**
- **Temperature control by way of heat reclamation**
- **Temperature control by way of recirculation systems**

Other than achieving different rates of growth, the cod biology and husbandry is relatively consistent. The following parameters are important:

- **Feed (see SUPPLIERS) should be offered properly**
- **Feed conversion target should be in the region of 1.2:1 dry:wet**
- **Care must be taken to avoid disease - particularly vibriosis**
- **Grading should be undertaken when necessary**
- **Stocking densities can be high - in the region of 10 kg/m3**

Ongrowing in Cages 1

Cod ongrowing floating sea cages is essentially the same as salmon ongrowing in cages, with the following key differences:

- **A “standard” cage requires some surface light shading**
- **This can be achieved by stretching agricultural shade-netting over part of the surface**
- **Great care should be taken to protect against vibriosis - and this may be particularly relevant when the seawater temperature is less than 10 Deg C**
- **Cod cages may require slightly more sheltered sites than those needed for salmon**

Experimental cod cages in Scotland

Ongrowing in Cages 2

Cod growth rate in sea cages will depend upon the ambient temperature range in the location chosen, but also upon good husbandry and feeding practices. The duration of the growth cycle will depend upon the company's harvesting strategy. Overall cage utilisation will depend upon stocking densities. There is also the choice of working with single or multiple "year class" sites. This Hyperbook can not provide you with all the answers in this new and developing field, but you may find the following pages useful.

Growth Rate **expectation in Scottish conditions:**

- The *target* would be 2.5- 3 kg after 24 months in the sea
- This would need to equate to an average Specific Growth Rate constant (SGRC) of 14+

For discussion about growth measurement, press here

It should be noted that the SGRC of juvenile cod (to 50g) in the field trial was only 8.9, although it is likely that this average improves overall when cod become larger. For example, cod in land-based tank trials were reported to have grown from 15g to 2.1 kg in some 18 months in the West of Scotland - an SGRC of >15.

Specific Growth Rate Equations and Constants

The growth rate of any fish is determined by a number of factors, such as food supply, suitable water chemistry, gender etc. However, if all these other factors are at or near optimum, the key factor is water temperature. Different species of fish have different “preferred” temperatures (which may vary slightly with fish size).

Growth rate can be numerically studied in two principal ways: the Specific Growth Rate (SGR) and the “GF3”. This Hyperbook uses the SGR methodology, with SGR being defined as percentage change in body weight per day. SGR changes as fish get bigger, and of course it also varies with temperature.

The method utilises the equation:

$$SGR = (Constant \times Weight^{-0.5})/100$$

This is basically a way of “smoothing out” the effects of fish sizes over a time period. Unlike GF3, this method does not take account of factors such as temperature, diet etc. In practice there would be a range of different SGR “constants” (SGRC) during the life of a cod growing under ambient conditions in Scotland.

Ongrowing in Cages 3

Other considerations about cod cage ongrowing:

- **Feeding - follow the feed suppliers guidelines, but be prepared to experiment with feeding rates and frequencies**
- **Intelligent feedback loop automatic feeders will probably be very useful for cod farming**
- **Stocking densities have not yet been fine-tuned for cod - but as a rule of thumb one should probably be thinking of 25 kg/m3 as a maximum for larger fish**
- **Stock observation and mort. removal is essential, but difficult if water clarity is not good - consider using divers or ROV-technology**
- **Cod appear sensitive to light - and in any event, the use of controlled light may be important for maturation. More work is required in this area**
- **Stock handling and net changing procedures will have to be similar to salmon farming**
- **Cod appear quite hardy (in disease terms) so far, but care should be taken with vibriosis in the early stages of ongrowing**

THE PRODUCTION PROCESS

Environmental Aspects of Cod Cultivation - 1

Any form of aquaculture shares a natural resource (water) with a number of other users and stakeholders. The effect of aquaculture on the aqueous environment differs depending upon the species and the farming system:

- **Shellfish are thought to be "benign" because they do not use artificial feeding, and thus do not add nitrogen, phosphorous or new solid material into the environment. On the other hand, they actually remove nitrogen from the marine environment, and carrying capacity for their production in some countries is limited by this very factor. They also do produce solid waste (faeces and pseudo-faeces) which deposits on the sea bed in their vicinity in a way which would not happen in a "natural" environment. In addition, current shellfish production technologies have some visual impact on the foreshore and general coastal waters.**
- **Fin fish farming does involve the addition of artificial feed - and this results in both solid and dissolved waste material (faeces and nutrients such as nitrogen and phosphorous). Furthermore, there may be the use of antifoulant chemicals in sea cage farms, and chemo-therapeutants in all types of fish production:**
  - **In cage farming there is little or no way to prevent these by-products of the process from entering the general aqueous environment**
  - **In traditional land-based farming there are some prospects for screening effluents for some waste materials (at a cost), but since flow rates are very high there is little prospect of much more "treatment" at any reasonable cost**
  - **In modern high-tech "recirculation systems" there are much lower flow rates, and therefore more prospects for water treatment. However these systems are expensive to install and operate, and are unlikely to form the mainstream of aquaculture prospects for Scotland in the future (although their use in land-based "nurseries" for halibut, cod and haddock may be practical)**

In truth the physical "footprint" of all aquaculture in Scotland is very low - about 0.2 % of the entire coastal waters. Nitrogen input from the industry in year 2000 is calculated to be around 6,500 tonnes - a tiny percentage of the nitrogen running into the sea from towns, farms and forestry. Combining these inputs with the natural nitrogen flux into and out of our coastal waters, some scientists have estimated that aquaculture contributes only a tiny fraction of the total.

Environmental Aspects of Cod Cultivation - 2

Cod is a fin fish, much like salmon, and many of the environmental considerations are the same. The main differences or points to note include:

- **Estimates of environmental input of nitrogen for cod farms have not yet been formally reported, but this work is underway**
- **Cod cage farms will probably finally be of a similar scale to modern large salmon farms - 1000 tonnes per annum, for example.**
- **Visual impact at the surface will remain very similar to salmon farms**
- **Anti-foulant treatments for nets will probably be similar to salmon farming**
- **Cod do not “host” the salmon sea louse - and thus are not part of the sea lice/riparian owners debate. There will thus be no requirement to treat cod with anti-lice medications**
- **Hatcheries and land-based nurseries will be able to screen effluents for solid waste, and will be amenable to “end of pipe” discharge consent controls**
- **Any application of recirculation technology (if it proves to be viable in other regards) will mean even more discharge treatment - but one form of nitrogen or another will still be the final nutrient input of relevance to the marine environment**

Environmental impact - real or perceived - of aquaculture is a very complex subject. This Hyperbook can not go into any more detail than that shown above at the present time.

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 cod production, in:

Hatchery - Broodstock 1

A “typical” cod broodstock tank might be:

- 4m in diameter - or larger
- 1m deep water (at least)
- Temperature controlled - at least near spawning
- Photoperiod controlled - therefore in a partitioned building or with its own light-proof cover
- Capable of being partially drained quickly in order to allow staff access in waders
- Secured in terms of broodstock fish “jumping” out of the water
- Secured by the general alarm system, for water level, flow rate, oxygen etc
- Provided with an egg collector arrangement

A 10 m diameter circular tank broodstock, with its own light-proof cover

Hatchery - Broodstock 2

A good egg collection system is essential:

Hatchery - Egg Incubation

Cod egg incubation lasts for about 8-10 days, and requires:

- Conical-shaped upwelling incubation vessels - kept largely in the dark. 70L “Paxtons” are commonly used
- 1 Micron filtered and UV sterilised seawater at full salinity and a stable temperature (if possible) of 10 Deg C
- Accurate flow-controls
- Record-keeping protocols and facilities
- Normal hatchery equipment:
  - Hand nets
  - Siphon
  - Jugs and beakers
  - Chemicals for egg sterilisation (“kick-start”)

Typical 70 L “Paxton” conical vessels, suitable for cod egg incubation

Hatchery - Yolk Sac Incubation

Cod eggs are transferred directly to larval rearing tanks pre-hatch, and the yolk sac phase for cod is then of short duration:

Day 1 cod larvae - note the yolk sac

Hatchery - Larval Rearing

Cod larval rearing (live feeding) lasts for about 45-65 days, and requires:

- **Plastic rearing tanks of 1000L or larger**
- **Equipped with:**
  - **Low level lighting**
  - **Temperature controlled filtered seawater flow (c. 10 Deg C)**
  - **Mesh screen outlets**
  - **Aeration**
- **Normal hatchery tools, monitoring systems and record-keeping protocols**

Typical small 1000 L polyethylene cod larval rearing tanks

Hatchery - Weaning

Cod weaning takes place in the main larval rearing tank. One of the key issues as cod reach weaning age and beyond is GRADING. Bar graders can be purchased, and are relatively easy to use.

Bar graders in action

Hatchery - Nursery

Cod nursery in the hatchery requires:

- Flat-bottomed fibreglass, polyethylene or butyl-lined tanks (2 - 3 m diameter, by 0.8 - 1m deep)
- Provision of temperature-controlled water flow (12-14 Deg C)
- Equipped with:
  - Medium level lighting
  - Mesh screen outlets
  - Aeration
- Normal hatchery tools, monitoring systems and record-keeping protocols
- Automatic feeders may be used - but regular hand-feeding and cleaning is probably preferable

Nursery cod

Nursery Facilities - 1

A stand-alone land-based cod nursery is effectively a small ongrowing farm. Typical tank sizes would tend to be 4-5m diameter, and the design should be as simple as possible.

An example of a simple tank layout - with the addition of some sun-screen covers, this would be a near-perfect cod ambient temperature nursery unit - but if a temperature controlled nursery was required … see next page

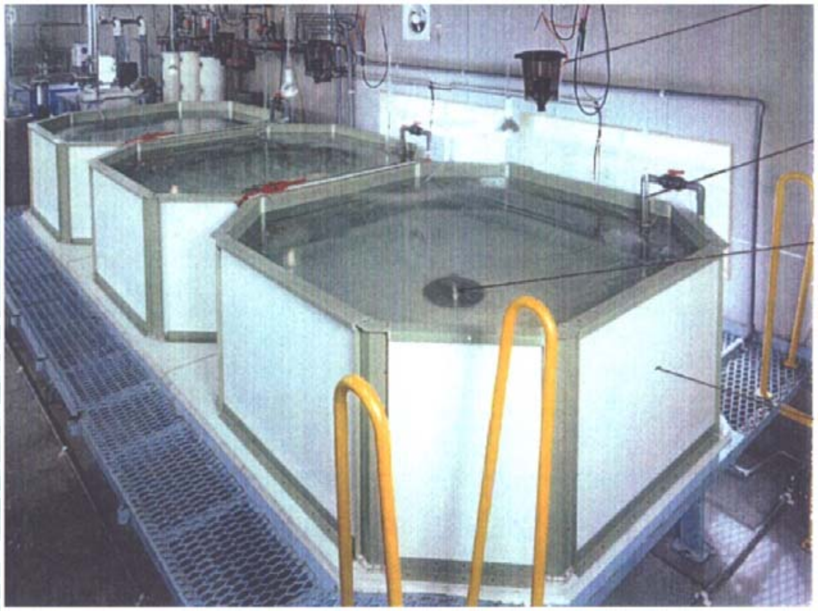
Nursery Facilities - 2

A temperature-controlled cod nursery would provide faster growth and therefore throughput - and so allow more “crops” per unit time. The disadvantage would be higher construction and operating costs. Some sort of thermal insulation would be required, whether for a recirculation system or a heat-reclamation system. This could be achieved in a rigid building, or in individually-covered tanks & treatment units.

An example of a simple individually insulated fish tank, with a water recirculation system within a shed in the background - note the shed would be capable of housing treatment units for several tanks

Nursery Facilities - 3

There are several companies which will offer high-tech recirculation units, housed in insulated buildings and working on the highest standards of water quality.



An example of a very high-tech recirculation system - this was actually designed for small Japanese flounder, but the principle would be much the same as that on offer to would-be purchasers of cod nursery recirculation systems

Sea Cage Ongrowing- 1

Cod Cage Guidelines

There is not yet sufficient cod cage growing information in the public domain for this Hyperbook to discuss the technologies any further.

In practice, all of the techniques and equipment which is used in salmon farming will be utilised for growing cod.

SITE SELECTION

Introduction

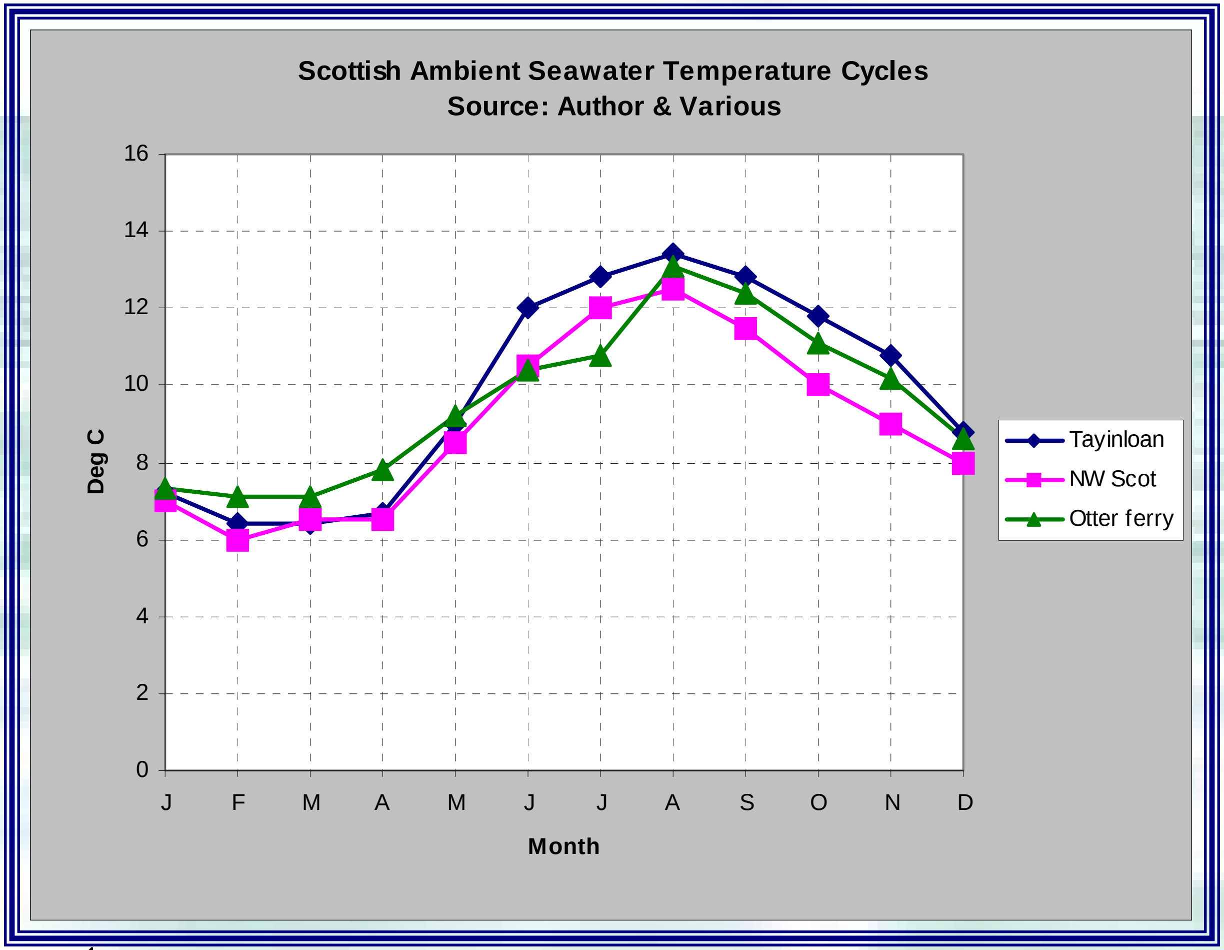
This section of the Hyperbook will consider how locations for cod cultivation projects might or should be chosen. Good site selection is critical to the success of any aquaculture venture, and there are some obvious considerations:

- Choosing a location with the wrong ambient seawater temperature for the species may mean that they grow too slowly - or may even suffer mortality in the extremes of winter or summer
- Sites near industrial facilities, with the risk of water pollution incidents, should be avoided
- Sites without reasonable access (whether sea sites or land-based) for staff and supplies are clearly impractical - although the cost of providing access can always be considered in the outline business plan
- Sites have to be “feasible” from the point of view of the regulatory and planning authorities who have statutory obligations in the area - but this issue is discussed in the Legal and Administrative section

SITE SELECTION

Seawater Temperature Profile - 1

Cod in ongrowing farms can probably survive in areas where the temperature varies between 2-3 Deg C in the winter and 17-18 Deg C in the summer. However, for best growth rate over most size ranges of cod, it is probably better for the temperature to remain above 8 Deg C and below 15 Deg C.



The figure shows the ambient seawater temperature cycle for some aquaculture locations in Scotland - and they are clearly <u>almost</u> ideal for Atlantic cod

Seawater Temperature Profile - 2

Cod Hatcheries may also be dependent upon a good temperature regime, but the main elements here are:

- Cool temperature profiles if possible
- Stable daily temperatures (i.e. deep oceanic water locations)
- Alternatively, hatcheries should be seeking areas where there is saline ground water

A saline borehole

Cod Nurseries require temperature profiles similar to ongrowing sites, or perhaps even a little warmer. However, by using some recirculation or water reuse and heat reclamation technology in the winter months, a wide range of locations could be accommodated.

Cod appear to grow faster in land-based farms than in cages under similar temperature conditions, so potential cage sites should really seek to be in the best possible area from the point of view of temperature regime.

Topography

Land-based sites are inherently expensive to construct and to operate, compared with cage sites. This is less critical to the economics of hatcheries (and they are usually small units), but it is of major importance to nurseries and ongrowing farms. Issues to consider are:

- The land area should be relatively flat and therefore cheap to develop
- The site area should be as low-lying as possible in relation to the mean sea level - as a guideline, sites lying about 6-8m above mean high water spring tide are probably near the upper limit for water pumping costs
- The site should be as close to the sea as possible
- Areas where the tidal range is low are better - which also usually means areas where the horizontal distance of the sea from the foreshore is not too extreme at low water. Typical acceptable tidal range would be 2.5-3.5 m.
- Pumping seawater from sandy areas creates water quality problems, particularly in rough weather. Sites should be located on rocky foreshores, or near rocky promontories.
- Sites should facilitate the maximum separation between the location of the water intakes and the drainage water outlet - and the former should be located on the “up” side of the prevailing coastal currents
- Access has already been mentioned. There are probably many “ideal” land based sites around the UK, but if they lie more than a few hundred metres from an existing road access, they will be expensive to develop
  - (Consider also existing power lines, telephones, freshwater etc)

SITE SELECTION

Sea Cage Sites

Cage sites for cod *may* require to be more sheltered than for salmon. Good road access for the shorebase is essential.

Introduction

This section of the Hyperbook will consider the nature of the regulatory framework within which cod cultivation takes place. Regulations and the legislation which underpins them (“statutory instruments” or “SI’s”) are a matter for individual jurisdictions, and this Hyperbook will focus upon the situation in Scotland.

It is important to stress that the regulatory framework and the European and national legal instruments are changing and evolving all the time, and that this Hyperbook is being written at a time of great flux in this regard. Consequently readers should make significant use of the internet links within this section in order to obtain up to date information. This section will provide a “picture” of some of the issues which would-be aquaculturists ought to consider, but there is no substitute for current investigation in this area.

The other point to consider is that regulation of the industry is intended to ensure that it co-exists with the environment and other stakeholders in a sustainable way - good regulation is good for aquaculture.

Main issues - 1

A focus on the main regulatory bodies would be the most useful approach. These are most easily identified during the process of application for a new aquaculture site (and in particular a cage site at sea). Once an application has been granted, and fish farming operations commence, the number of regulators with a significant ongoing operational concern reduces further.

For an 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
- The Scottish Environmental Protection Agency (SEPA). Considers issues including site location, proximity of other fish farms, water quality, authorisations of medicinal and other discharges and the hydrographic conditions prior to issuing a discharge consent. A maximum permissible biomass of fish on site is stipulated, together with limitations on discharges from the site
- Local Authorities. Considers applications and issues opinions to the Crown (and will eventually be the lead body in this regard). Also provide planning permission for any on-shore facilities
- Scottish Executive Environment and Rural Affairs Department (SEERAD). All marine fish farms must be registered with SEERAD, and the department is particularly concerned with its statutory obligations with respect to control of diseases and parasites, as well as having an interest on the impact of the project on the inshore marine environment
- Scottish Executive Development Department (SEDD). Considers the siting of all fish farms from a marine safety and navigation point of view
- Scottish Executive Inquiry Reporters Unit (SEIRU). Provides a further route for reconsideration of an application which is initially refused
- Health and Safety Executive. Concerned with health and safety

Main issues - 2

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

- Scottish Natural Heritage (SNH). Have an interest in the natural environment
- SEERAD. As above
- SEPA. 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

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)

Useful Internet Links

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

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

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.

Main Issues - 3

This Hyperbook can not go into all the issues surrounding aquaculture regulation in great detail, and you are urged to do your own research. However, at the time of preparation of this Hyperbook, the "hot topics" facing the cod sector were:

- Locational guidelines for aquaculture in Scotland - where new sites might be developed
- Environmental impact of cod farming - as part of overall carrying capacity and discharge consent debates, but in the context of uncertainty about the science which pertains to "new species" such as cod
- Fish health regulations with respect to IPN and VHS - based on outdated EC Directive 91/67 EEC
- Discharge consents for medicines - but particularly the use of FORMALIN as a traditional anti-parasite treatment for marine species

In the longer term, in conjunction with all fin fish species, attention is/was being paid to:

- Coastal zone management and the development of local framework plans for coastal water users
- Welfare issues (debated at the Council of Europe) relating to all aquaculture - but potentially delivering numeric restrictions to operating parameters such as stocking density
- Disposal of waste - mortalities on site are "hazardous waste" and require special treatment

Use of Divers

When divers are engaged in any work around a fin-fish cultivation site 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). Generally, this will be that for 'Commercial diving projects inland/inshore', but others may be applicable under specific circumstances. Compliance with the regulations 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 any form of diving related to fin-fish cultivation. Infringements frequently result in prosecution and those who contract-in divers are equally liable in these circumstances.

SUPPLIERS

Introduction

This section of the Hyperbook covers suppliers to the industry who might be able to support cod 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 (hatcheries, feeds)
- Hardware suppliers (equipment)
- Services suppliers (advisors, utilities, financial)

Biological Suppliers

Cod Hatcheries

- Otter Ferry Seafish Ltd. Tel: 01700 821226 Email: seafish@otterferry.com
- Aquascot Ltd. Tel: 01369 820360
- Macrihanish. Tel: 01586 810287
- Orkney Marine Hatcheries: 01856 741216

Live Feed Suppliers

- CCAP (Cambridge collection of algae and protozoa). Tel: 01[illegible] 362244
- INVE (Artemia and enrichments): Tel: 00 32 52259070 Web:
- Biomarine/Aquafauna (Artemia [illegible]d enrichments). Tel: 00 1 3109735257 Web:
- (Instant Algae) Reeds Web:
- Catvis (Artemia, larval diets). Web:
- Argent (Algal nutrients etc). Web:

Dry Feed Sup[illegible]iers

- Trouw UK
- Ewos UK
- Biomar UK
- Danafeed

Medicines

For advice on medicines, you should contact your own veterinary advisor.

Alternatively, try:

Institute of Aquaculture, Stirling: Tel: 01786 467878

Web:

Hardware Suppliers

General Aquaculture Equipment

- Dryden Aqua
- C&H Plastics
- Red Rooster
- Tropical Marine Centre
- FOR A GOOD TOTAL LIST OF SUPPLIERS, SEE:

• Cages & Associated

- Irish Seafood contacts
- W&J Knox (nets)
- Fish Farming Online contacts
- Fusion Marine
- Alexander Noble & Sons (boats) Ayrshire Tel: 01465 712223

• Land Based Nursery

- Brice Baker & Co (tanks) Tel: 01480 216618
- Flygt (submersible pumps)
- Air Products (oxygen generators)
- Aerzen (roots-type air blowers)
- Everyvalve Equipment Ltd (valves, pipework) Tel: 01707 642018 Web:

Services Suppliers

Insurance

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

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

Trade Associations

British Marine Finfish Association. Dr J S Buchanan (Tel: 0131 440 2116; e-mail: jim.buchanan@onyxnet.co.uk). Richard J Slaski (email: RichardSlaski@aol.com)

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

Services Suppliers - Continued

Information, technical advice etc

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

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

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

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

North Atlantic Fisheries College, Port Arthur, Scalloway. 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

Services Suppliers - Continued

- 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

Services Suppliers - Continued

Government Departments

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

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

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

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

Development agencies

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

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

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

For Northern Ireland:

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

For Wales:

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

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

BUSINESS PLANNING

Introduction

This section of the Hyperbook covers the development of business plans to support cod cultivation. The section will provide an overview of business planning, but mainly introduces the Cod Economic Models - a series of 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.

General Principles

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

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

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

The core Economic Models for Cod Cultivation are contained within your COD HYPERBOOK Folder. Access the READ ME FIRST file once again, just to remind yourself how to use these models.

Just press “Esc” on your keyboard at any time if you want to leave this Hyperbook show

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Cod Cocktail

340g (12oz) cod fillets, fresh or defrosted, skinned and cubed
5 x 15ml spoon (5 tablespoons) mayonnaise
1 x 15ml spoon (1 tablespoon) tomato puree
1 x 15ml spoon (1 tablespoon) sherry
0.5 x 5ml spoon (one half teaspoon) sugar
dash Worcestershire sauce
dash lime juice
salt and black pepper
115g (4oz) mixed lettuce leaves
paprika, to garnish

Microwave Power: 800 Watt

Poach the fish in 300ml (10 fl oz) water for 5-6 minutes or place in a suitable dish with 1-2 x 15ml spoon (1-2 tablespoons) water, cover and cook on HIGH for 2-3 minutes. Drain the fish and allow to cool. Chill in a refrigerator until required.

Mix together the mayonnaise, tomato puree, sherry, sugar, Worcestershire sauce and lime juice, season.

Line individual dishes with the lettuce; add the fish and spoon over the cocktail sauce. Garnish with paprika.

Serve with bread as a starter.

Serves 4

NUTRITIONAL VALUES PER PORTION (APPROX) 222 Kilocalories; 16g Protein; 15g Fat; 3g Carbohydrate; 0g Fibre.

See a
picture

Cod Cocktail

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Cheesy Citrus Cod

2 x 170g (6oz) chunky cod or haddock fillets, fresh or defrosted
1 x 15ml spoon (1 tablespoon) olive oil
salt and black pepper
rind of half an orange
55g (2oz) low fat soft cheese

Sauce
4 x 15ml spoon (4 tablespoons) half fat crème fraiche
rind and juice of half an orange
salt and black pepper
2 x 15ml spoon (2 tablespoons) fresh chopped chives

Preheat the grill

Place the fillets onto a greased grill pan and brush with the olive oil. Season and cook for 2-3 minutes under a moderate heat.

In a small bowl mix together orange rind and low fat soft cheese. Spread over the fish fillets.

Return to the grill and continue to cook for a further 4-5 minutes.

To make the sauce: place the crème fraiche and orange rind and juice into a pan. Heat gently for 3-4 minutes, season and add the chopped chives.

Serve the fish and sauce with mashed potatoes and broccoli.

Serves 2

See a
picture

Cheesy Citrus Cod

Back to Markets Section

Warm Spiced Cod Nicoise

4 x 170g (6oz) thick cod fillets, skinned, fresh or defrosted, thickly sliced
340g (12oz) new potatoes, thick sliced
sea salt
170g (6oz) fine green beans, halved
170g (6oz) cherry tomatoes
1 red onion, cut into wedges
30g (1oz) butter, melted
1 x 5ml spoon (1 teaspoon) crushed chillies
4 x 15ml spoon (4 tablespoons) low fat Caesar dressing
1 x 15ml spoon (1 tablespoon) fresh chopped chives

Cook the potatoes in boiling salted water for 8 minutes, add the fine green beans and cook for a further 2 minutes. Drain and spoon into a bowl. Add the tomatoes and red onion.

Brush the fish with a little melted butter, sprinkle with the sea salt and crushed chillies. Cook under a hot grill for 4-5 minutes.

Add a little water to the Caesar dressing. Add three quarters of the dressing to the vegetable and toss to coat.

Serve the vegetables topped with the fish and drizzle over the remaining dressing. Garnish with the chives.

Serves 4

See a picture

Warm Spiced Cod Nicoise