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Editor: Ian Laing
CEFAS Weymouth Laboratory
Barrack Road
The Nothe
Weymouth
Dorset
DT4 8UB
Tel: 01305 206711 (Fax: 206601)
email: i.laing@cefas.co.uk

Assistant Editor: Denis Glasscock
CEFAS Lowestoft Laboratory
Pakefield Road
Lowestoft
Suffolk
NR33 0HT
Tel: 01502 524304 (Fax: 513865)
email: d.glasscock@cefas.co.uk

www.cefas.co.uk

CONTENTS Page

ARTICLES

KING SCALLOP CULTIVATION

Ian Laing
The Centre for Environment, Fisheries & Aquaculture Science, Weymouth, Dorset, UK.

Background

Commercial cultivation of king scallops (*Pecten maximus*) is one of the more recent developments in bivalve mollusc aquaculture in the UK. The aim of the work described here was to determine the performance and tolerance limits of scallops, especially juveniles, within a range of environmental conditions; in particular, factors that are important for site selection, such as sea water temperature and salinity, food availability and water flow rate.

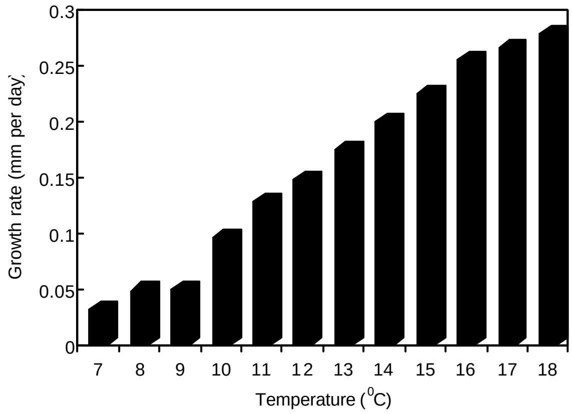
A 4-year study was funded by Defra through the Aquaculture LINK initiative with assistance from the following partners: University of Southampton Oceanography Department, Devon Sea Fisheries Committee, Loch Fyne Seafarms Ltd., Quest Holdings, Portland.

Approach

A combination of field trials and controlled laboratory experiments was carried out. Seed scallops (13-mm shell height) were planted at three field sites (Loch Fyne, Brixham and Portland Harbour), selected to give a range of environmental conditions. They were held in pearl nets initially, then transferred to lantern nets as they grew. Monthly measurements of growth and survival were made and water samples were collected weekly for analysis of salinity, chlorophyll and particulate material. Continuous temperature recorders were deployed. Laboratory experiments were carried out at the CEFAS Conwy laboratory and Southampton.

Main findings

Temperature - King scallops do not grow at all below 6.5°C. While measurable, growth is minimal between this temperature and 10°C. Studies measuring metabolic indicators of stress in scallops grown at a range of temperatures showed that this is the point above which the metabolism of the scallops changes from 'winter' to 'summer' mode. Growth rates increase with temperature above 10°C, and will continue to increase up to a maximum tested temperature of 23°C. However, at temperatures above 17-18°C the condition of the animals becomes lower, and there is evidence that this is



Mean growth rate (increase in shell height, mm per day) in relation to temperature (⁰C) at the field sites

because these higher temperatures are also stressful. It follows that the best sites for scallop cultivation are those where temperature is between 10°C and 17°C for the maximum length of time. Growth rate at field sites was strongly correlated with temperature.

Salinity - An ambient salinity of 28 psu or above is required for successful scallop cultivation. Scallops were usually able to tolerate short exposure (up to 6 hours per day for 3 days) to lower salinity (20 psu) although there was always a short-term reduction in growth rate and sometimes a high mortality at lower temperatures.

Food (Quantity) - It seems that sufficient food was available in the water at all field sites for maximum growth in relation to temperature, especially as scallops can filter faster when there is less food available, so as to maintain an adequate ration. Filtration rates were suppressed at very high food cell concentrations, suggesting that areas with regular dense algae blooms are not suitable.

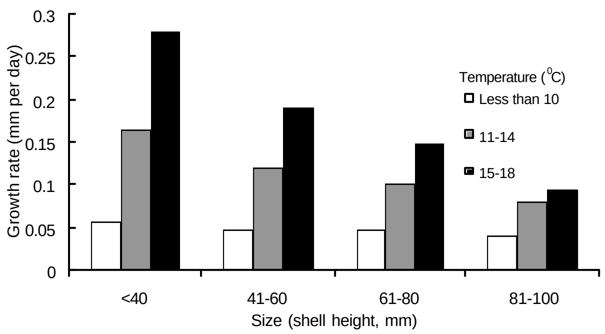
Food (Quality) - Filtration rate of scallops also varies with the type of algae available, being lower when species with a low nutritional value are present. Scallops are also less efficient at filtering smaller (2-5 µm) algae cells. Food quality is much more difficult to assess from water samples. Performance of scallops at the field sites varied from that expected from the prevailing temperature, with a sufficient quantity of food available.

These differences were attributed to the quality (nutritional value) of the algae species present in the seawater.

Water flow rate - A current velocity of 0.4-1.8 knots (0.2-0.9 metres per second) is most suitable for suspended culture systems. One knot is optimal for seabed culture, although up to 2 knots can be tolerated.

Predicting performance

Other information on performance of cultivated king scallops was obtained during the course of the project. Seed at all UK sites reached a size (50-60 mm) at which they could be put out onto the seabed after 12-14 months. Survival at this stage was excellent (> 80%). Performance of wild-caught and hatchery-reared seed was similar. It was found that mortality increases significantly if the scallops are kept any longer in lantern nets. Differences in growth rate due to temperature become less with increasing size of the scallops. As they approach market size they grow at a similar rate at all seawater temperatures above 10°C.



Mean growth rate (increase in shell height, mm per day) in relation to size of scallops and temperature

Yield

The combined wet weight of the edible parts, i.e. the adductor muscle and gonad (yield), from market size scallops increases with shell size such that a 20% increase, from 110 to 130 mm, gives a 70% increase in yield, from 30 to 50 g wet weight. There is therefore a balance between the additional costs of keeping scallops for a longer time against the benefits of a superior and more marketable product. The proportion of the edible part of the scallop that is composed of roe varies throughout the year. In spring the scallops will be ripe, with the roe comprising, on average, about 50% by weight of the total yield. Spawning occurs from late June/early July onwards, and by late summer (August/ September) the roe will be, on average, just 10% of the yield. The size of the gonad is then restored gradually over winter, although the rate at which this happens will vary between individual scallops and between sites. It can be very slow at first, so that there may only be a small amount of roe in some scallops harvested for the Christmas market.

Costs

As part of the project an assessment was made of the resources required for rearing scallops from seeding to harvest, on a commercial scale, at a site on the south coast of England. Based on seeding 75,000 scallops per year, with 15% mortality and harvesting by diver collection, commencing after 3 years, the profit is 23% of costs. This is based on equipment purchase within the first 3 years, and so profit would be higher if based on depreciation costs over several years. Further information on the costs associated with scallop cultivation is available from Seafish (see below) who have carried out an economic modelling study. Results from this suggest that commercial operations are potentially viable, particularly as a diver collected scallop is a superior product to dredged scallops and can thus command a premium price.

Further information

A booklet with more detailed findings from the study is available, and copies can be obtained from the author or downloaded (as a pdf file) from the CEFAS web site (http://www.cefas.co.uk/publications/ scallop_cultivation.pdf).

Also, Seafish Aquaculture publishes a ‘hyper-book’ on CD-ROM that covers all aspects of scallop cultivation. For further information contact the Aquaculture Development Officer for your area (see ‘Information File’ for address).

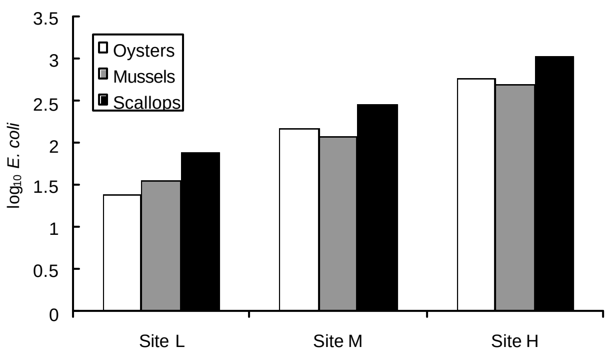
DEPURATION CONDITIONS FOR KING SCALLOPS (*PECTEN MAXIMUS*)

William J. Doré and Ian Laing,
The Centre for Environment, Fisheries & Aquaculture Science, Weymouth, Dorset, UK.

Introduction

King scallops cultivated in inshore waters will accumulate similar amounts of sewage-derived micro-organisms as other commercially cultivated bivalve shellfish (see figure). Some of these organisms can cause serious illnesses in human consumers. To minimise the health risks posed if shellfish are consumed raw or lightly cooked, shellfish harvesting areas are classified depending on *E. coli* levels in shellfish flesh. This classification then determines whether bivalve shellfish can be sold direct for consumption or must be purified (depurated) prior to sale.

As the availability of pristine waters for cultivation is limited in the UK it is necessary to determine appropriate conditions for effective depuration of scallops. Experiments funded by Fisheries II Division of Defra were carried out to achieve this.



Mean numbers (as logarithm to the base 10) of E. coli bacteria per 100 g of shellfish flesh at three experimental sites. The sites were chosen to represent a range of contamination levels; low, medium and high (designated L, M and H)

Approach

Hand-gathered king scallops were contaminated with *E. coli*, by relaying them in sewage impacted waters for a minimum of two weeks. These scallops were then purified for 42 to 48 hours in both laboratory systems and small-scale commercial depuration systems under varying conditions. Levels of *E. coli* were monitored before and after depuration to assess the effect of temperature, salinity, and shellfish loading arrangements and the use of artificial seawater on the depuration process. Self-righting trials were used as a simple assessment of the amount of stress imposed on the scallops due to transport, handling and the depuration procedures.

One of the CEFAS systems used for scallop depuration experiments

Depuration conditions

Initial trials indicated that it was possible to successfully depurate contaminated scallops to the required end product levels without any detrimental effects on the product quality. Standard equipment and techniques commonly used in the UK to depurate a range of shellfish species, in which they are purified for a minimum of 42 hours in UV-treated re-circulated seawater, can be used. Other conditions, specific to depuration of scallops, must be met. These are: -

Only natural seawater may be used - Although the use of artificial seawater during depuration is suitable for a wide range of bivalve mollusc species it is unacceptable for scallops. In the experiments, scallops failed to depurate properly and some mortality was observed. There was some indication that it was an unidentified constituent of the laboratory tap water used to prepare the artificial seawater that was responsible. Until more is known the use of artificial seawater cannot be sanctioned. This may be a constraint for cultivators, particularly if their depuration plant is inland, although collecting and transporting natural seawater is an alternative.

Salinity must be maintained at 30 psu or above; temperature must be maintained at 10°C or above - The salinity and temperature conditions under which scallops will depurate effectively are similar to the environmental optima for performance at on-growing sites. No upper temperature limits on depuration are set. This is because higher temperatures do not usually compromise the depuration process. However, excessively high temperatures may detrimentally effect scallop quality, as a marketable product. Results from this and other studies suggest that temperatures greater than 18°C should be avoided. The requirement for salinity of greater than 30 psu may be a constraint, depending on the location of the depuration plant, as estuarine water may frequently have lower salinity than this.

Purification must commence within 10 hours of harvesting - Scallops were held out of water at 15°C for 6, 10 and 22 h before being placed in depuration tanks. All scallops were successfully reduced to a satisfactory end product standard, although it appeared that 20 h emersion may be beginning to have a detrimental effect on the efficiency of depuration, compared with a 10 h period.

Scallops may be loaded up to a maximum of 2 layers high with the shell cup side down; scallops must be prevented from escaping from baskets during depuration and any method used must not interfere with their ability to open and filter; scallop to water ratios should not be any less than 1:12 (kg:litre) - It was possible to load up to sixty scallops in one of the standard plastic mesh baskets (72 mm long x 42 mm wide x 12 mm deep) used in the trials. Scallops have a considerable tendency to move and if left unconfined some will escape from the basket and deposit themselves on the base of the tank. This is unacceptable as much of the faecal material excreted by the scallops during the depuration cycle settles here. Placing plastic mesh over the baskets is a simple and effective method to prevent the scallops escaping. The recommended scallop to shellfish water ratio of 1:12 (kg:litre) was the maximum that could be achieved using the double layer arrangement described above in a typical commercial system. Other studies suggest that in any case scallops will not depurate effectively at higher stocking densities.

Self-righting (stress) trials

These experiments showed that the conditions used for holding and handling the scallops, including transportation to and from the field site and the laboratory, did not cause stress to the scallops. Conditions that supported effective depuration were not stressful, whereas scallops from conditions in which they did not depurate showed high levels of stress, sometimes accompanied by subsequent high mortality.

Further information

A report has been submitted to the Food Standards Agency (FSA) and they are considering the conditions. They will have to agree to the proposed conditions of approval in this report. Once this has been confirmed the CEFAS Weymouth laboratory will issue Conditions of Approval for individual systems. It should be possible to approve a system complying with these conditions as soon as anyone makes an application.

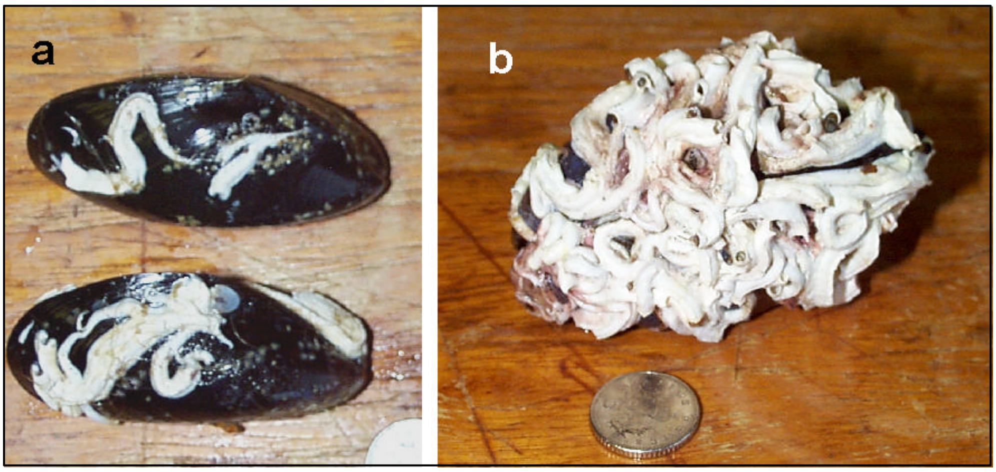
TUBEWORM FOULING ON SCOTTISH ROPE GROWN MUSSELS - MINIMISING THE IMPACT ON THE INDUSTRY

SAMS

Dirk A. Campbell and Maeve S. Kelly,
in conjunction with Loch Striven Mussels and Loch Beag Shellfish.
Scottish Association for Marine Science, Oban, Argyll, Scotland, UK, PA37 1QA.

Background

Suspended long line mussel cultures are susceptible to fouling since they are continually submerged and rendered vulnerable through routine cleaning and grading practices. Mussel fouling by tubeworm (*Pomatoceros* spp.) in particular, can be problematic, as the calcareous tubes >5mm are resistant to brushing. Mussels with more than 7% of the shell surface fouled are not considered Grade A quality, as the product is considered visually unattractive. Consequently, intense tubeworm settlement particularly threatens mussel industries, such as the Scottish rope grown industry, which maintain their competitive edge by trading in premium quality mussels only. Heavy settlements of tubeworm result in entire mussel stocks being discarded at an estimated cost to the industry of between £300,000 and £500,000 per annum. Established growers believe the problem to be worsening.

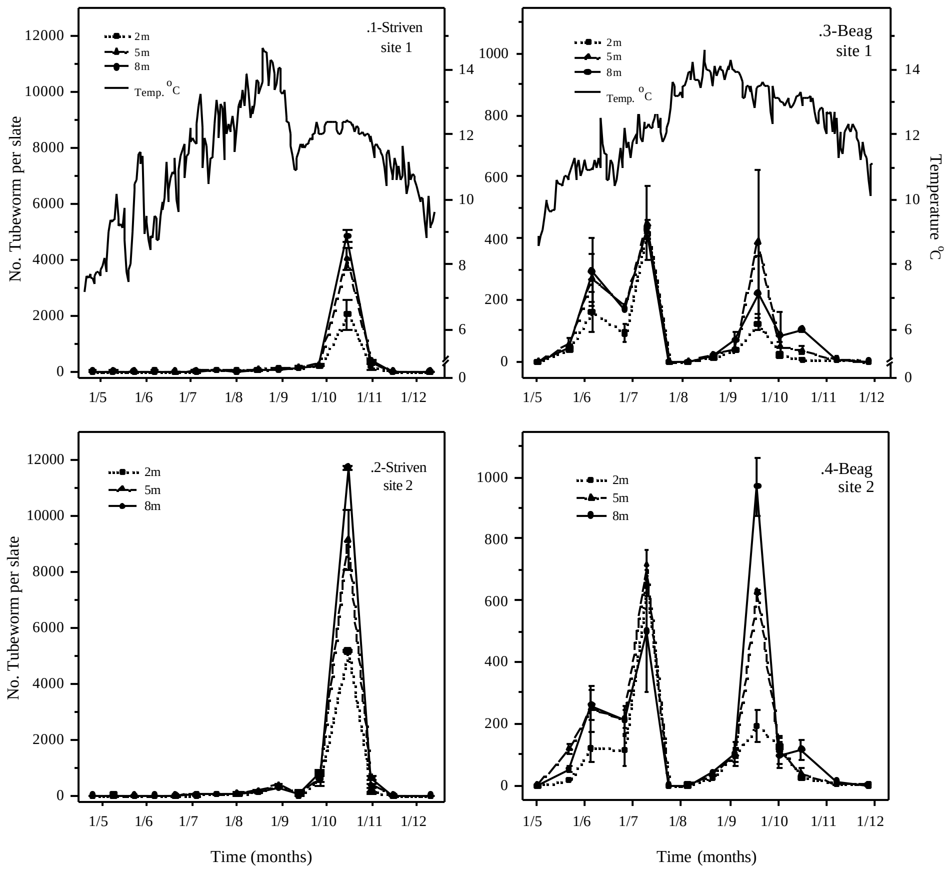


(a) Mussel shells fouled by the tubeworm Pomatoceros triqueter; (b) Extreme tubeworm fouling on a mussel shell - demonstrating their exceptional capacity for rapid colonisation

This project monitored variation in tubeworm settlement between lochs and over depth, and assessed the importance of mussel size, stocking density, culture depth and presence of adult tubeworm conspecifics, for management strategies to alleviate tubeworm fouling. In addition aerial exposure was evaluated as a method to control tubeworm growth on mussels.

Settlement

Tubeworm settlement was monitored (Apr – Dec 2001) using collector plates made from roofing slates, deployed at two sites in Loch Beag and Loch Striven. At fortnightly intervals replicate strings of slates, set at 3 different depths (2 m, 5 m and 8 m) were examined for recently settled tubeworm and replaced with a new set of slates.



Mean settlement counts of Pomatoceros spp. per slate at 2, 5, 8 m depth, at 2 sites 4 km apart within Loch Striven (Apr - Dec 2001) and 500m apart in Loch Beag (note difference in scale). Seawater temperature (°C) at 5m is also shown

The tubeworm species *P. triqueter* was the only species of tubeworm found on the mussels in the lochs, and was the most abundant of any species settling on collector plates. *P. triqueter* is generally considered as subtidal, inhabiting less turbid environments particularly adjoining deep water, all of which are characteristics of Scottish sea loch systems. Results showed:

- The occurrence of peak settlement was different for each loch, but was synchronous throughout sites and depths within the same loch. In both lochs settlement peaked after the highest water temperatures were recorded.
- At Loch Beag there were two discrete peaks in settlement, an order of magnitude lower than the single peak recorded in Loch Striven. In Loch Striven the highest number of individual *P. triqueter* per slate, over one fortnightly interval, was 11,700 individuals.
- There was a significant variation in settlement intensity between sites in the same loch (which in Loch Beag were only 500 m apart) and over depth. This suggests settlement intensity can be 'patchy' and influenced by local environmental parameters.

Field Trials

Prior to peak tubeworm settlement, rope-grown mussels were graded in to large clean mussels (no tubeworm upon the shell), large fouled (tubeworm upon the shell), and small clean mussels. Each class of mussels was re-tubed using cotton tubing and plastic 'pergolari' mesh, stocked at both high and low densities. The treatments were randomly suspended along the main line and examined for presence of tubeworm after peak tubeworm settlement had occurred. In addition, the fouling intensity on mussel stocks with varying treatment histories at the farm site was assessed. It was found that:

- Significantly more tubeworm settled on the larger mussels (mean shell length 60.8 mm) than on small mussels (mean shell length 33.5 mm.). The percentage of mussels with ≥1 tubeworm on the shell in small mussel classes ranged between 21.5% and 28.4 % compared to between 91% and 100 % on the large size classes.
- Tubeworm were found predominately on shell growth checks and on the umbo indicating settlement to have occurred on regions of relatively slower growth and/or at periods of disturbance and slow growth. Thus, faster shell growth rates in smaller mussels may prevent tubeworm attachment.
- In small mussels the initial stocking density and tubing system (cotton v.'s pergolari) had no effect on tubeworm settlement.
- Tubeworm settled in higher numbers on large mussels stocked at lower densities (2 kg/m) than on large mussels at a higher density (5kg/m). Therefore in areas of high tubeworm settlement mussel lines should continue to be stocked at optimum densities to ensure maximal rapid growth.
- Settlement was highest on large mussels with conspecific, adult tubeworm. Whenever practical, individuals with fouling should therefore be removed from mussels that are to be re-tubed for on growing.
- Mussels stocks that had not been graded had less tubeworm, indicating that mussels are more vulnerable to tubeworm settlement after a disturbance.
- The influence of depth on tubeworm settlement was not as distinct along mussel culture lines as on the collector slates. Consequently, adjusting culture line depth to control fouling may be ineffectual.

Tubeworm survivorship and aerial exposure

The survivorship of tubeworm (*P. triqueter*) on live mussel shells after periods of aerial exposure at two different temperatures was examined. Results showed that:

- 100% mortality of the tubeworm is achieved after 24 hrs (13C) and 36 hrs (7°C) of aerial exposure.
- While no mussels died as a result of exposure in this trial, as a result of the lengths of emersion time needed to kill all tubeworm, it may not be practical for growers to use aerial exposure as a method to control tubeworm growth on mussels to be re-tubed and harvested at a later date.
- To avoid increasing the standing stock of tubeworm in the vicinity of the farm growers could subject heavily fouled mussels for discard to a period of aerial exposure.

Conclusions

The discrete nature of peak *P. triqueter* settlement, allows mussel growers to routinely monitor tubeworm settlement and to avoid practises such as grading and returning mussels to the water in periods of intense tubeworm settlement. Tubeworm settlement can be monitored easily and cheaply, by using a simple spat collector made from roofing slates, suspended below 2 m to avoid any influence of freshwater. Each set of slates should be examined at least fortnightly, and then replaced by a clean set of slates. Recently settled tubeworms appear as characteristically shaped white flecks 1-3 mm long.

Recovery and examination of collector plates

Monitoring settlement should be conducted specifically for each mussel farm area. Growers should monitor settlement in conjunction with physical variables such as seawater temperature and salinity specific to individual sites, to reveal areas and conditions that consistently yield lower levels of tubeworm fouling. In addition, criteria for establishing new mussel farm sites should consider hydrographic characteristics that minimise tubeworm fouling.

Furthermore, mussel management strategies should minimise the time mussel stocks are in the water, particularly in the second growing season when individuals reach a critical size, becoming vulnerable to excessive tubeworm fouling. In contrast, an alternative approach to limiting tubeworm settlement might be to avoid grading in the second year, thereby leaving mussels undisturbed and allowing a mixed size-class stock to develop. Such a practise may suit smaller scale operations.

Further information

M.S. Kelly:
Tel: + 44 (0) 1631 559233 or
e-mail: mke@dml.ac.uk

'WET DREDGE' COCKLE HARVESTING – TRIALS IN THE RIBBLE ESTUARY

Bill Cook and Megan Davies
North Western and North Wales Sea Fisheries Committee, University of Lancaster, LA1 4YY

Introduction

In the North Western and North Wales Sea Fisheries Committee (NW&NWSFC) District, cockles are traditionally harvested by hand gathering methods such as jumboing and raking. In the past NW&NWSFC have also allowed mechanical harvesting, such as the use of vessel-based suction dredging, or gathering by tractor-towed devices. Tractor harvesting took place extensively in the early 1990s using harvesters known as 'dry dredges'. These could operate on the cockle beds when the tide was out, using rotating mesh drums to separate the catch from the sediment and undersized cockles. The use of these machines was quickly discontinued as they were extremely efficient, and the legislation was inadequate for the Committee to control the exploitation rate of cockles.

In December 2001, new trials began for 'wet dredge' cockle harvesters on the Ribble Estuary. The wet dredge is of a simple sledge-like design, which is towed behind a tractor. The dredge has an adjustable blade for removing the top layer of sediment that contains the cockles. The sediment and cockles move onto a flat grid where they are sprayed with a jet of water from a pump to separate the sediment from the cockles. The undersized cockles and the sediment are washed through the gaps of the sorting grid, leaving the harvestable cockles to be collected from the grid. The use of both a tractor and a water pump restricts the operation of the dredge to shallow water. This puts limitations on the efficiency of the dredge, which has to work the edge of an ebbing tide. The time spent on the bed is therefore limited, and the tractor cannot traverse the bed systematically, thereby protecting stocks from excessive exploitation. The trials continued until April 2002.

Monitoring

Monitoring of these trials has taken place, on average, once a fortnight. Many aspects have been looked at closely, and a summary of the main findings is given

The cockle dredge, with an operator raking the catch from the sorting grid

below. The stock of legal-sized cockles on the south Ribble Estuary was quite low last winter, and only one operator fished consistently throughout the winter, making the trial easy to monitor. However, in 2001 the Ribble had received one of the biggest spatfalls ever seen, and so there was a huge density of undersized cockles. In places these fingernail-sized cockles were found at 10,000 per m².

The dredge appeared to fish very effectively for the cockles, with no harvestable cockles being left in the dredge tracks, and very few undersized cockles in the catch. Numbers of undersized cockles were lower in the dredge tracks than in un-fished areas.

The damage rates for the catch and discards were recorded. Visible damage to the catch was reasonably low, but was more variable for the small, discarded cockles, averaging around 8% but in some cases exceeding 30%. Moreover, when the discards were brought back to aquaria, their survival was low compared to carefully hand-gathered control samples. Small cockles with no visible damage showed mortalities of up to 70% at the end of 2 weeks. We were not able to discover which part of the harvesting process was causing stress to the cockles, but hand-shaken Ribble cockles experienced higher mortalities than those from elsewhere, and it is likely that the exceptional densities resulted in weakened cockles that were more susceptible to stress.

The effects on other invertebrates were investigated using core sampling. The area showed very low species diversity, with only seven types of animals found, including the cockle. Of these, the cockle was by far the most numerous, with only a small bivalve, the baltic tellin, and a species of worm also appearing regularly in the samples. As with the small cockles, other invertebrates were found in lower numbers in the dredge tracks.

Birds feeding in the dredge track as soon as the tide has ebbed

In part of the trial area where wading birds were already present, large numbers of knot or dunlin were attracted by the dredging and were seen to be feeding actively, both in the dredge tracks and on adjacent areas. It is likely that they were taking small cockles brought to the surface by the dredge and distributed over a wider area by the receding tide.

Further information

A full report of the trial has been prepared, and copies are available from NW&NWSFC. It is hoped to resume the trials during early 2003, to observe the effects of the method on a cockle stock that does not have such unusual densities of first-year cockles.

BONAMIA RESISTANCE IN FLAT OYSTERS: A EUROPEAN UNION CRAFT STUDY

Andy Beaumont,[1] Maire Mulcahy,[2] Sarah Culloty[2], Michelle Cronin[2] and David Hugh-Jones [3]
[1]School of Ocean Sciences, University of Wales, Bangor, Gwynedd, LL59 5AB, UK
[2]Department of Zoology and Animal Ecology,
University College Cork, Lee Maltings, Prospect Row, Cork, Ireland
[3]Rossmore, Carrigtwohill, Cork, Ireland

Bonamia

A critical constraint on the culture of the European flat oyster, *Ostrea edulis*, is that heavy mortalities are suffered due to the parasite *Bonamia ostreae*. *Bonamia* is a microscopic parasite that infects the oyster blood cells. The disease was first detected in France in 1979 and has spread to The Netherlands, southern Britain and Ireland. However, it has not been detected in Scotland or Wales. The disease does not usually cause significant mortality before the oysters are mature enough to reproduce. Therefore oysters susceptible to the disease will pass on this trait to the next generation and any natural selection for resistant oysters will be, at best, a slow process.

A comparison of stocks

We focused on three stocks of potentially resistant oysters. One was developed by David Hugh-Jones (Rossmore oysters, Cork Harbour) by breeding from 4 year old survivors over several generations and the other two from Lake Grevelingen, Netherlands and Brittany, France where natural selection will have operated since the disease arrived 20 years ago. We wanted to investigate the performance of these populations of flat oysters when challenged by *Bonamia* in the field and compare them with other stocks taken from areas where *Bonamia* is not present. The programme ran from 1998 until the end of 2000.

Field trials

The field trials were located in Cork Harbour (Ireland), Lake Grevelingen (The Netherlands) and Brittany (SATMAR, France). At these sites, 700 (50-70g) oysters were laid out in 1998 from Bonamia–free areas (naive strains: Lough Foyle and Tralee, Ireland; Loch Kishorn and Mull, Scotland) and from *Bonamia*–endemic areas (Rossmore, Cork Harbour, Lake Grevelingen, The Netherlands and Brittany, France) (Figure 1). Due to high initial losses at Grevelingen, repeat samples of oysters from several sources were re-laid there in 1999.

Samples of 30 oysters were taken from each population on the three sites at 3-monthly intervals to measure weight and condition, to assess the presence, and the level of *Bonamia* infection by ventricular heart smears (Figure 2) and to assess mortality.

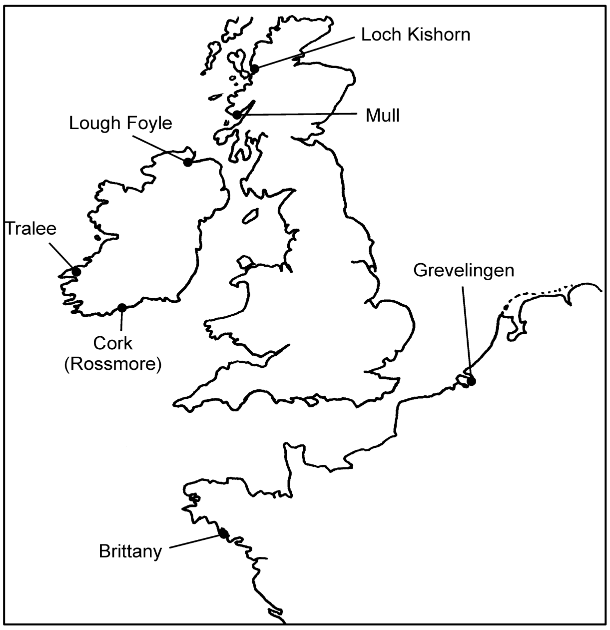


Figure 1. Sites where experimental challenge for Bonamia was carried out on samples of Ostrea edulis. Challenge sites: Cork (Rossmore stock), Grevelingen and Brittany. Additional challenged stocks from Ireland (Tralee and Lough Fyne) and from Scotland (Loch Kishorn and Mull)

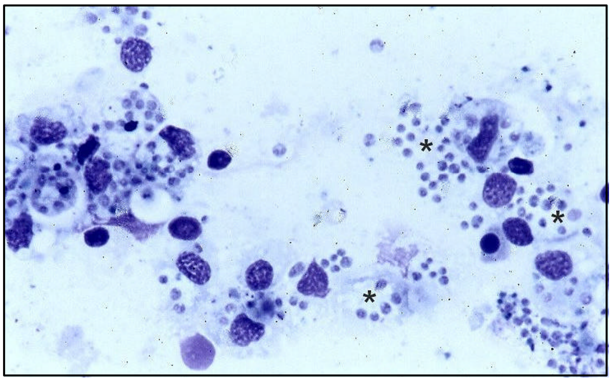


Figure 2. View under the microscope of a heart smear from an Ostrea edulis infected with Bonamia. Asterisks indicate the position of the parasites.
Photograph © Dr Sarah Culloty.

Table 1. Increase in weight, percentage of oysters infected and degree of infection in populations of transplanted oysters in the Bonamia - challenge field trials. Classes 1 to 4 represent light (1) to heavy (4) infections seen in heart smears. Data are taken from the last samples containing living oysters. Results for the first Grevelingen trial are not included

Field Site	Source population	%weight increase	% of oysters infected	Class 1	Class 2	Class 3	Class 4
Ireland (Cork Harbour)	Rossmore	40.3	50	70	26.7	0	3.3
	Loch Foyle	59.5	100	33.3	33.3	33.3	0
	Tralee	38.1	88.9	28.9	33.3	22.2	5.6
	Mull	23.8	50	50	50	0	0
	Loch Kishorn	33.3	100	-	-	-	-
Netherlands (Grevelingen)	Rossmore	106.1	20.0	90	10	0	0
	Tralee	89.2	100.0	11.7	32.4	32.4	23.5
	Loch Kishorn	64.5	92.9	35.6	39.4	25	0
	Grevelingen	86.8	93.1	100	0	0	0
France (Brittany)	Rossmore	37.7	28	80	8	8	0
	Loch Foyle	25.6	20	-	-	-	-
	Tralee	10.8	16.7	83.3	16.7	0	0
	Mull	-9.2	60	40	40	20	0
	Loch Kishorn	9.5	72.8	27.2	27.3	45.5	0
	Brittany	10.9	14.3	-	-	-	-

Performance

Some details of our results are given in Table 1.

The main points to emerge from this study were firstly that almost all the remaining oysters transplanted from *Bonamia*-free areas had died by the end of the study while many of the original Rossmore and Grevelingen oysters survived. Secondly, in general the growth of oysters was best at Grevelingen and worst in France, but with Scottish populations generally performing poorly at all sites. Nevertheless there was a lot of variation; the Lough Foyle oysters grew well at the Cork Harbour site, while the Rossmore oysters grew best at the French site, and in the second Lake Grevelingen trial.

Thirdly, the patterns of infection over time were complex. Some populations showed low infection early in the trials but became heavily infected or totally wiped out by the disease well before the end of the trial. Overall, however, the Rossmore oysters were generally less infected, sometimes significantly less, than all other strains on their own site with many surviving to the end of the trial. Similarly, in general, the Rossmore oysters performed well at other sites although there was considerable variation between strains at all sites.

Resistant oysters

One of the difficulties with this type of study is that the relationship between prevalence of *Bonamia* infection, its intensity and the percentage mortality of the oysters is a complicated one. This is because mortality can never, with certainty, be attributed to the parasite. We can say, however, that heavy mortalities in naive strains of oysters held in Cork harbour generally occurred three to six months after heavy infections of *Bonamia* were first recorded and elsewhere mortalities in naive strains tended to be associated with high prevalence of infection. Therefore it seems very likely that most of the mortalities were a direct consequence of *Bonamia* infection.

Rossmore oysters have been selectively bred from surviving adult oysters, over a period of fourteen years, and we can conclude that they show some significant tolerance to *Bonamia* infection. When they are challenged by this parasite in the field they do not suffer the high prevalence or intensity of infection and the high cumulative mortalities exhibited by the naive strains of oyster. But oysters from Grevelingen and France which have been subjected to years of natural challenge from the parasite appear to show little, if any, resistance in our trials. This reinforces the view that natural resistance to *Bonamia* may take a long time to develop in the wild. Limited response to several generations of artificial selection for *Bonamia* resistance in oysters has been shown in France by IFREMER scientists and we show here that controlled breeding from older oysters which have survived *Bonamia* challenge can produce stocks which are at least partially resistant to the parasite.

Partners

The lead Partners in this project from industry were Dennis Gowland of North Bay Shellfish Ltd, and David Hugh-Jones of Vokes Ltd., other industrial partners being Satmar S.A. (Dr Yves Le Borgne), Roem Van Yerseke (J. Huisman & Jan Bol), Bjerga Oysters Ltd (John S. Bjerga) Menai Oysters (Shaun Krijnen) and Dr Aad Smaal (RIVO-DLO).

Further information

Dr Sarah Culloty and Professor Maire Mulcahy,
Department of Zoology and Animal Ecology,
University College Cork, Lee Maltings,
Prospect Row, Cork, Ireland.
email: s.culloty@ucc.ie; mmulcahy@ucc.ie

DO GENES OR THE ENVIRONMENT CONTROL GROWTH OF FLAT OYSTER SEED? RESULTS FROM A EUROPEAN UNION CRAFT STUDY

Andy Beaumont [1] and Dennis Gowland [2]
[1]School of Ocean Sciences, University of Wales, Bangor, Gwynedd, LL59 5AB
[2]Benesther Shellfish, Orkney, Scotland

Background

As part of a study on the growth of stocks of the European flat oyster, *Ostrea edulis*, and their resistance to the parasite *Bonamia ostreae* we produced seed *O. edulis* from different source populations in an Orkney hatchery and undertook transplantations of these seed oysters to various grow-out sites. Where full reciprocal transplantation was possible, we wanted to establish whether any differences observed in growth rate were due to some genetic quality of the source oysters or to the environment of the site.

The study

During 1998 and 1999, three separate batches of seed oyster were produced at the John Eccles hatchery in Orkney from Orkney broodstock, and one batch each from Eriboll and Ailort stocks. Unfortunately a severe storm in Orkney during June 2000 caused the complete loss of a number of batches of seed oysters, including some derived from a Norwegian broodstock. Nevertheless, Orkney and Eriboll seed oysters were successfully transferred to five grow-out sites in Scotland - Loch Ailort, Loch Eriboll, Ulva, Mull and Orkney - and in Wales at the Menai Oysters site in the Menai Strait. In addition we were able to set up one full reciprocal translocation between Ailort and Eriboll stocks.

Seed oyster growth was measured at regular intervals over periods of more than a year. Growth performance was scored as a percentage daily weight gain (DWG) of the overall weight gain during the study period. Continuous recordings of temperatures on the sites were made using data loggers inside the oyster bags.

Findings

Details of oyster growth and temperature are given in Table 1 where the sites are ranked from the fastest to the slowest growing averaged across the three Orkney batches and the Eriboll batch of seed.

It is clear that growth was by far the greatest in the Menai Strait and this correlates well with the highest average temperature and the greatest number of days with temperature above 15ºC. Mull was the best Scottish site and, although showing generally slower growth than Mull, there was little to choose between Ailort and Ulva. Consistently low growth was observed on the Eriboll and Orkney sites. As has been demonstrated before, when all else is equal, temperature is the main factor influencing oyster growth. Not a surprising conclusion, perhaps, but this data set also confirms that it did not matter whether the seed was derived from the Eriboll or Orkney stocks, both gave exactly the same ranking from best to worst grow-out sites. This lack of broodstock influence on growth rates was further confirmed in the full reciprocal transplantation carried out between Eriboll and Ailort stocks (Table 2).

It can be seen from Table 2 that in spite of a longer average daily immersion time at Eriboll the higher average temperature (recorded as degree days) at Ailort has produced significantly faster growth on that site regardless of the source of seed. This is one of very few scientifically controlled reciprocal transplantations carried out on bivalve molluscan growth and it demonstrates the value of this approach in clarifying how much the genetics of a stock might influence its commercial performance. In this case, it is clear that

Table 1. Ranking of sites in relation to average growth performance of hatchery- produced seed oysters from Orkney and Eriboll broodstocks. DWG = percentage daily weight gain. Temperature factor is the total day degrees over the growing period at a site divided by that for Orkney (the coolest site). Temperature >15 = number of days with temperature exceeding 15°C. Immersion time = average daily immersion time in hours

Site	Mean DWG	Temperature factor	Temperature >15	Immersion time
Menai Strait	0.910	1.21	206	18.43
Mull	0.795	1.12	18	17.69
Ulva	0.761	1.14	72	18.79
Ailort	0.753	1.10	4	16.53
Eriboll	0.544	1.04	4	17.72
Orkney	0.545	1.00	14	18.24

Table 2. Growth of seed oysters from Eriboll and Ailort broodstocks in a reciprocal transplantation between these two Scottish sites. DWG = percentage daily weight gain. Day degrees = number of days x degrees centigrade during study period. Immersion time = average daily immersion time in hours

Broodstock source	Site	Weight increase (g)	DWG	Day degrees	Immersion time
Eriboll	Eriboll	0.70	0.074	1898	17.72
Eriboll	Ailort	2.30	0.215	2105	16.53
Ailort	Eriboll	0.40	0.079	1898	17.72
Ailort	Ailort	1.55	0.259	2105	16.53

genetics has very little effect on early growth rates. However, later growth, mortality, disease resistance, and reproductive capacity are also very important commercial traits, and further trials over extended periods are required to explore the role of genetics and the environment for these.

An important element in the growth trials was the need to ensure that the environment and husbandry on the various sites were similar. This was achieved by one of us (Dennis Gowland) visiting all the growers at the various sites, checking for similarity of location on the shore and providing advice and training on the methods to be used for sampling. We are indebted to the growers involved, and to Doug Mcleod from the Association of Scottish Shellfish Growers, for their support and co-operation because, without this, the scientific validity of the results could easily have been compromised.

Further information

Andy Beaumont, School of Ocean Sciences,
University of Wales, Bangor, Gwynedd, LL59 5AB,
email: a.r.beaumont@bangor.ac.uk

HOW MUCH GENETIC VARIATION IS THERE IN NORTHERN EUROPEAN POPULATIONS OF THE FLAT OYSTER? RESULTS FROM A EUROPEAN UNION CRAFT STUDY

Andy Beaumont and Halina Sobolewska
School of Ocean Sciences, University of Wales, Bangor, Gwynedd, LL59 5AB

Genetic markers

Genetic markers have been used in many fish and shellfish species to look for potential divisions of the species into localised genetically distinct stocks or populations. We carried out genetic analysis as part of a field-based study on the growth of stocks of the European flat oyster, *Ostrea edulis*, and its resistance to the parasite *Bonamia ostreae*. There is a particular interest in looking at flat oyster stocks because there have been extensive transfers between regions over many centuries. Earlier allozyme (protein) genetic work on oysters has revealed little detectable genetic differentiation in European stocks of *O. edulis*. We wanted to examine genetic variability and population structuring at the DNA level using modern genetic markers called microsatellite loci which are more sensitive than allozymes. In addition, samples of oysters which had survived *B. ostreae* challenge in the field trials were screened at these markers in order to identify any microsatellite variants (alleles) which might be linked in any way with *B. ostreae* resistance.

We isolated and identified fourteen microsatellite loci and developed four of these, which were highly variable, for our analysis of 12 oyster populations. The other loci remain to be fully developed for further use.

Loss of alleles in hatchery stock

The first important result, which can be seen in the Table, is the observation that the numbers of alleles at all four loci in the Loch Kishorn sample and the Orkney sample are significantly reduced compared with all or most of the other populations. The Loch Kishorn sample came from a shellfish farm which had been stocked with oyster seed from a UK hatchery. The Orkney oysters were also originally derived from a hatchery but had passed through four hatchery generations in Orkney. Because hatcheries cannot normally use very large numbers of broodstock adults this loss of genetic variability is inevitable, but it is interesting to note that even in the Loch Kishorn sample there were still more than seven alleles indicating that hatchery procedure was good and probably many more than 7 broodstock individuals contributed to that batch of oysters.

Although numbers of alleles were reduced in hatchery stocks, levels of heterozygosity (the proportion of oysters which were heterozygous at the four loci) were not reduced (see Table). These results are similar to earlier findings for the Pacific oyster, *Crassostrea gigas* where numbers of alleles at allozyme loci were significantly reduced, but heterozygosity was retained in hatchery bred stocks compared with wild, or naturalised populations.

Mean number of alleles per locus and mean heterozygosity per locus at four microsatellite loci in samples of O. edulis from sites in Scotland, Norway, Ireland, France and The Netherlands.
N = sample size.
**** = original source of sample was from a UK hatchery***

Country	Site	N	Mean number of alleles per locus	Mean heterozygosity per locus
Norway	Finnoyfjord	30	15.0	0.817
Scotland	Loch Eriboll	29	14.8	0.921
Scotland	Mull	34	17.8	0.846
Scotland	West Loch Tarbert	40	17.3	0.874
Scotland	LochAilort	27	17.5	0.815
Scotland	Orkney *	29	10.8	0.740
Scotland	Loch Kishorn *	39	7.5	0.824
Ireland	Lough Foyle	52	17.3	0.939
Ireland	Strangford Lough	30	19.3	0.817
Ireland	Rossmore (Cork)	90	19.3	0.839
France	SATMAR (Brittany)	35	17.8	0.771
Netherlands	Grevelingen	46	18.8	0.791

How closely related are the stocks?

All four loci have been scored for 10 of the 12 populations studied and the proportions of the various alleles in each population have been used to calculate Nei's pair-wise genetic distance (D): an index which provides a measure of the degree of differentiation between populations. Closely related populations have values close to zero with more distantly related populations having higher values. Populations which share the same alleles at similar proportions at all their loci are predicted to be exchanging genes regularly. In the particular case of flat oysters, this will be through larval dispersal, or alternatively through dispersal by man. The relatedness between the populations is displayed in a dendrogram (see Figure below). The Norwegian population is clearly separate from the rest, and the Loch Kishorn and Orkney samples are different to most others. In the case of Loch Kishorn and Orkney, this probably reflects the loss of alleles that has occurred as a result of hatchery production. The most closely related cluster of populations includes the France, Rossmore, Strangford Lough and Mull samples.

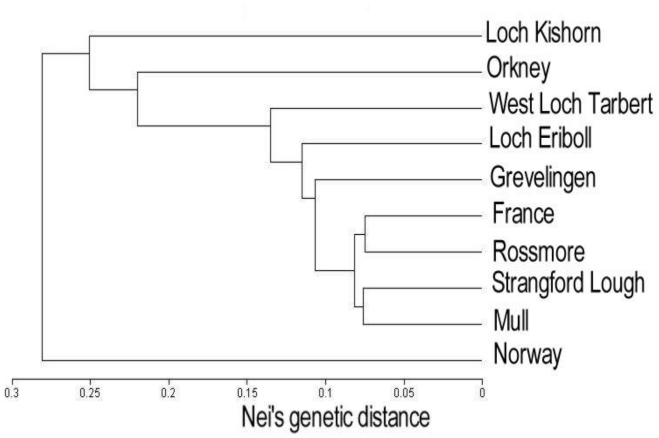
These microsatellite data reinforce the story provided by earlier genetic studies that there has been considerable gene flow between most northern European populations of *O. edulis*. Genetic mixing of populations through larval interchange, but more probably through human interventions during the last 2000 years, has maintained a basic genetic similarity of European *O. edulis* populations. There are therefore unlikely to be any unique stocks of the flat oysters although stocks in Norway are most different from the others we looked at.

No genetic link detected with Bonamia resistance

We were not able to check a large sample size of oysters that survived the *B. ostreae* challenge. However, an initial screening comparing the surviving Rossmore oysters against their initial genetics at various sites showed no indications that any particular allele or genotype was present at a much higher or much lower frequency amongst the survivors. Oyster deaths seemed entirely random with respect to these genetic markers so there is no evidence for any linkage between alleles at these loci and resistance to *B. ostreae*. Of course we are only sampling a minute fraction of the oyster DNA, so it is not surprising to find no link, but it is valuable to explore such possibilities whenever the data allow.

Further information

Andy Beaumont, School of Ocean Sciences,
University of Wales, Bangor, Gwynedd, LL59 5AB,
email: a.r.beaumont@bangor.ac.uk



Dendrogram of relatedness between 10 populations of flat oysters.
Nei's genetic distance (D) is based on variation at 4 microsatellite loci

CHRONIC MORTALITY IN A BIVALVE MOLLUSC HATCHERY: A CASE STUDY

Rose-Marie Le Deuff and Louise Richens
Centre for Environment, Fisheries and Aquaculture Sciences, Weymouth, U.K

The problem

Following the report of chronic high mortality of larval pacific oyster (*Crassostrea gigas*), Manila clam (*Tapes philippinarum*) and carpet shell clam or palourde (*Tapes decussatus*) in a European hatchery, investigations were carried out at both Weymouth and Burnham-on-Crouch CEFAS laboratories in 2000 and 2001. Mortality was experienced in 90% of spawned batches of clams, each of around 100 million larvae. Peak mortality of pacific oyster larvae was between five and six days old, whereas the larvae of the Manila and carpet shell clams died pre-settlement, typically at ten to thirteen days post hatching.

During these investigations, state-of-the art techniques were used to look for a possible toxicity of the hatchery water and also for the presence of potential infectious pathogens (e.g.: bacteria, virus, parasite).

Water quality

Various samples of water from the hatchery were evaluated using an oyster (*Crassostrea gigas*) larvae bioassay called Toxicity Identification Evaluation (TIE). In this assay, the growth of larvae in the sample water is compared to growth in reference seawater. This growth is then measured by image analysis and results compiled by a sophisticated computer program.

The TIE method represents the current state-of-the-art technique for evaluating the toxicity of seawater for living organisms, such as larval molluscs. However in this study, this method did not identify any toxicants.

Bacterial pathogens

Bacterial agents, mostly *Vibrio* species, can be associated with high mortality of larval bivalve molluscs. The threshold for clinical infection is usually considered as 10,000 predominant bacteria per larvae. However, the role of sub-clinical levels of bacteria cannot be overlooked, as some strains of *Vibrio* are known to produce toxins. Classical microbiology methods have therefore been used to assess the bacterial content of the samples taken in the hatchery. Larvae and water samples corresponding to batches presenting high and normal mortality rates were collected in the hatchery and inoculated onto seawater and TCBS agar. Total bacterial content was enumerated and significant colony types were isolated and identified. The virulence of isolated strains was investigated by performing larval challenge assays.

Various significant bacteria have been isolated from the samples presenting high mortality rates (Table 1).

Table 1. Average number of organisms per larvae in samples presenting high mortality rates

Bivalve Species	Vibrio spp. (10 strains)	Pseudo-alteromonas	Vibrio splendidus Type 1
Carpet shell clam	109	905	-
Manila clam	30	-	601
Pacific oyster	-	395	764

Although *Vibrio splendidus* has been identified, larval challenge assays using non-fed larvae do not indicate this to be any more or less pathogenic than other *Vibrio* spp. isolated from the hatchery. Conversely isolates of *Pseudoalteromonas* sp. do not demonstrate toxic effect even at 100,000 CFU/ml. However, larvae challenged with three *Vibrio* spp. isolated from clams gave high mortality rates when they were fed with algae supplied by the hatchery. In these last challenges, mortality rates were 70% above control after 48h and could reach up to 100% six days post-challenge.

Viral pathogens

Bivalve mollusc productions can be significantly affected by viral pathogens, e.g.: the pacific oyster herpesvirus (Ostreid herpesvirus-1 or OsHV-1). This virus was first described in larval pacific oysters in 1991, at the same time in France and New Zealand. Since then, the OsHV-1 has been associated with chronic high mortality of larval and spat bivalve molluscs of various species grown in European hatcheries (e.g.: pacific oyster, European oyster, Manila clam, European clam, scallops) and in wild spat oysters. The only other known virus associated with significant mortality of larval molluscs is the Oyster Velar Virus Disease (OVVD) although it has only been described in pacific oyster larvae bred in North American hatcheries. OsHV-1 and OVVD can not be diagnosed using classic tissue culture methods but their associated histopathology is typical and can be confirmed by transmission electron microscopy (TEM). As these methods allow direct observation of tissues, they are also an effective way to screen for new viruses or parasites. In addition, a PCR procedure (Polymerase Chain Reaction, a molecular biology method of amplification that allows detecting very low amounts of specific DNA sequences, for example virus DNA) has been developed for the diagnosis of OsHV-1.

Althought this hatchery had one known historical outbreak of OsHV-1 in larval pacific oysters, the histopathology, TEM and PCR screenings did not reveal the presence of OsHV-1, OVVD or any other virus in the samples collected in 2000 and 2001.

Other investigations

An important number of spherical bodies were observed in the stomachs of larvae of all species presenting high mortality rates (Figure 1). These spherical bodies were present in five out of the six batches analysed by histology. Histopathology revealed dilation of the stomach, which indicates poor digestion of the spherical bodies resulting in gut impaction. No significant tissue necrosis was apparent but an abnormal deposit of dense material, mainly localised in the velum, in carpet shell clams (Figure 2) was observed. These deposits could be interpreted as an abnormal production of melanin but they could also correspond to the 'dense bodies' described by Elston in 1980 in relation with a 'DLO' (see below). Further ultrastructural description of the spherical bodies (i.e.: description of the fine cellular structures as seen by electron microscopy) revealed similarities with the genus *Chlorella*, a pigmented algae (Figure 3). The ultrastructure of this agent was compared to the algal species grown on-site. Although sharing common features with some of them, it is not related to the species given to feed the larvae.

Structures similar to the spherical bodies described above have previously been reported in the literature as 'Dermocystidium-like organisms' (DLO). They were associated with a disease called '*digestive tract impaction of oysters'*. It was reported in 1978, in larval pacific oysters in an USA hatchery over a three years period. It was also detected at three other sites and in wild stocks in Washington State, USA, but the significance of the disease remains unknown. A further article on the ultrastructural description was published in 1980. Major histopathology signs associated with this DLO consisted of dilation of the stomach, necrosis of the stomach epithelium, erosion of the velum and the presence of dense bodies in the cytoplasm of some velum cells. These signs would explain the loss of appetite and reduction of swimming activity resulting in high mortality rates in most of affected batches. According to this author, this '*Dermocystidium*-like organism' appears morphologically related to *Hyalochlorella marina*, a colourless algae, and to *Dermocystidium* spp. from salmon dermal cysts. This author also stresses that there is no relationship between these organisms and the adult oyster pathogen and notifiable disease, *Perkinsus marinus* (or *Dermocystidium marinum*).

The organism observed in our study seems to share a similar mechanism of 'pathogenicity' to the larval molluscs. However, in this more recent case, chloroplasts have been observed in the organism. It is therefore a pigmented algae, different from the one described as DLO in the USA. For convenience, we suggest the temporary name of '*Chlorella*-like organism' or CLO, until this organism is fully identified.

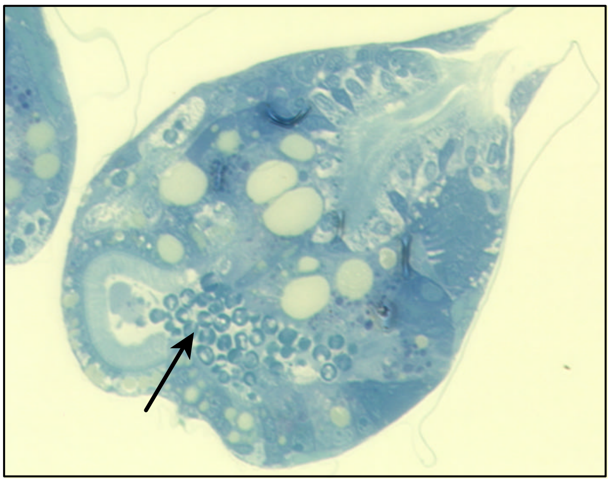


Figure 1. Presence of numerous spherical bodies in the dilated stomach of an oyster larva (arrow)

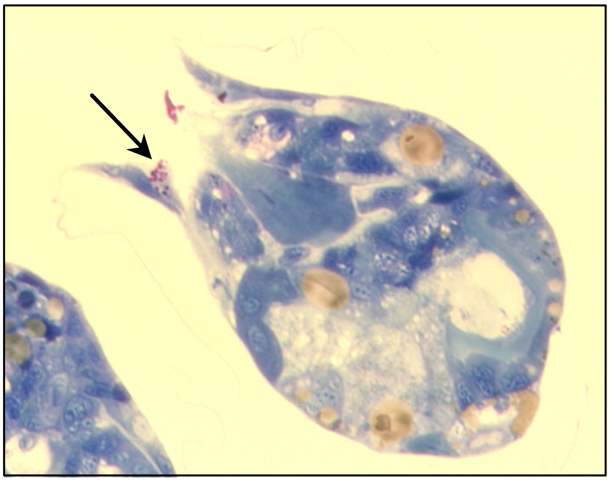


Figure 2. Dense bodies can be observed in the velum of this clam larva (arrow)

Figure 3. Ultrastructure of the CLO. C: chloroplast, N: nucleus, V: vacuoles, M: mitochondira. Bar = 1µm

Conclusion

Bacterial and viral aetiologies have been investigated, as well as the possibility of water toxicity. There was no conclusive evidence to suggest that any one of these agents was the sole cause of the mortality events. The *Chlorella*-like organism (CLO) appeared to be the most likely aetiology associated with the high mortality rates observed in the hatchery. However, we cannot yet conclude whether there is another related problem. No virus could be observed on-site, but a certain number of potentially pathogenic bacterial agents were identified. When larvae were challenged in a 'no food' environment, there was no evidence that these bacteria were capable of inducing larval mortality. However high mortality rates were induced when the challenged larvae were given food supplied by the hatchery. It is therefore possible that the CLO weakens the young larvae, then triggers a cascade of events that may include a bacterial infection or the effects of poor water quality.

In the light of these observations, means to control the disease on-site could include the use of water filtration and/or UV irradiation. Recent studies showed that these measures proved effective in the prevention of parasitic infections by *Haplosporidium nelsoni* (MSX) and *Perkinsus marinus*. There was no evidence to suggest that food algae strains used at the hatchery were contaminated with the CLO, but their replacement could also be considered. In addition, although our observations suggest that the source of contamination is likely to be the water or the food given to the larvae, appropriate disinfection of equipment and use of separate equipment for each batch of larvae held on-site, would help to manage the condition.

Acknowledgements

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We should also acknowledge colleagues from IFREMER laboratories in Brest (Dr J.-L. Nicolas) and La Tremblade (Dr T. Renault and Dr F. Leroux) for their help and expert advice. The input of Dr D. Alderman, Mr P.D. Martin, Ms A.E. Bayley, Ms K.S. Bateman and Dr J.E. Thain (CEFAS) has also been invaluable. This study would also not have been possible without the valuable contribution of private shellfish hatcheries.

AMERICAN LOBSTERS - OVER HERE?

Ian Laing,
CEFAS Weymouth Laboratory, The Nothe, Weymouth, Dorset

The American lobster

The American lobster, *Homarus americanus*, is native to coastal regions of the Northwest Atlantic from Labrador to North Carolina, at depths out to 700 m. Coastal lobsters are concentrated in rocky areas where shelter is readily available, although occasional high densities occur in mud substrates suitable for burrowing. Offshore populations are most abundant in the vicinity of submarine canyons along the continental shelf edge. Tagging experiments in coastal waters suggest that small lobsters undertake rather limited movement, although larger individuals may travel extensively. Offshore lobsters show well-defined migrations during the spring, regularly travelling 80 km (50 miles) and by as much as 300 km (186 miles).

The American lobster is fished commercially in North America; annual landings are about 80,000 tonnes.

Is there a problem in Europe?

Large quantities of live American lobsters, *Homarus americanus*, are imported from the American and Canadian east coasts into Europe for human consumption. In the UK the trade amounts to some 1,200 tonnes, with the bulk coming from Canada. For this reason these lobsters are often referred to as 'Canadian lobsters'. The quantity imported is similar to the landings of native lobsters in this country.

Some European States are becoming concerned about the escape and establishment of American lobster populations in their waters, together with the possible interaction of the American lobster with the local native species. Laboratory studies have shown that males of the American lobster can reproduce with females of the European lobster. The hybrids have high survival and growth rates. There is the potential for genetic impact on the native species as female hybrids can reproduce. There is also a risk that the American lobster can transfer parasites and diseases to the European lobster, most notably Gaffkaemia. This condition sometimes referred to as 'Red Tail Disease' is caused by the bacterium *Aerococcus viridans*. It is usually transmitted through puncture wounds or lesions. Lobsters impounded in tanks are most at risk, particularly if subjected to other stresses. Heavily infected specimens may have slightly reddish discoloration visible through the integument of the underside of the abdomen.

Infection often causes death. Modern husbandry methods of holding lobsters, including claw banding and holding the animals at low temperatures, have reduced the risk of the development and spread of this disease.

American lobsters in the UK

Reports of American lobsters appearing in fishermen's catches are made from time to time. Earlier this year a lobster caught off the south coast of England was sent to the CEFAS Weymouth Laboratory, where identification was confirmed and a blood sample was tested for Gaffkaemia. The result was negative. More recently a particularly large American lobster, reportedly 500-cm in total length, was caught in the English Channel. This lobster, which attracted the attention of the national press, was subsequently dubbed with the name 'Rocky'. It is now held, in quarantine, on public display at the Blue Reef Aquarium in Portsmouth. It is thought that Rocky may have been cast overboard from a passing cruise liner. Nevertheless, a straw poll of lobster merchants suggests that finding American lobsters in UK waters is still a relatively rare occurrence.

No routine monitoring for Gaffkaemia is carried out in England and Wales, although following a Gaffkaemia outbreak in a lobster-holding site in 1990, a sample of European lobsters caught in the adjacent coastal area in North Wales was tested, but no evidence of Gaffkaemia infection was found. Wild-caught European lobsters are exported from Scotland to Norway and annual testing of these for Gaffkaemia is carried out at four sites, two in Orkney, two on the east coast. Results from all tests have been negative.

Anyone wishing to keep ('deposit') live American lobsters in storage tanks that are within one mile of tidal waters in the UK must first obtain a licence. The licensing scheme is administered in England and Wales by the Fish Health Inspectorate at the CEFAS Weymouth Laboratory and in Scotland by the Fisheries Research Services at the Marine Labroatory, Aberdeen.

However, there is no need to apply for a licence for lobsters that are being held solely for consumption on the premises. This is provided that none of the water in which the lobsters have been held and no lobster waste is discharged into any tidal waters.

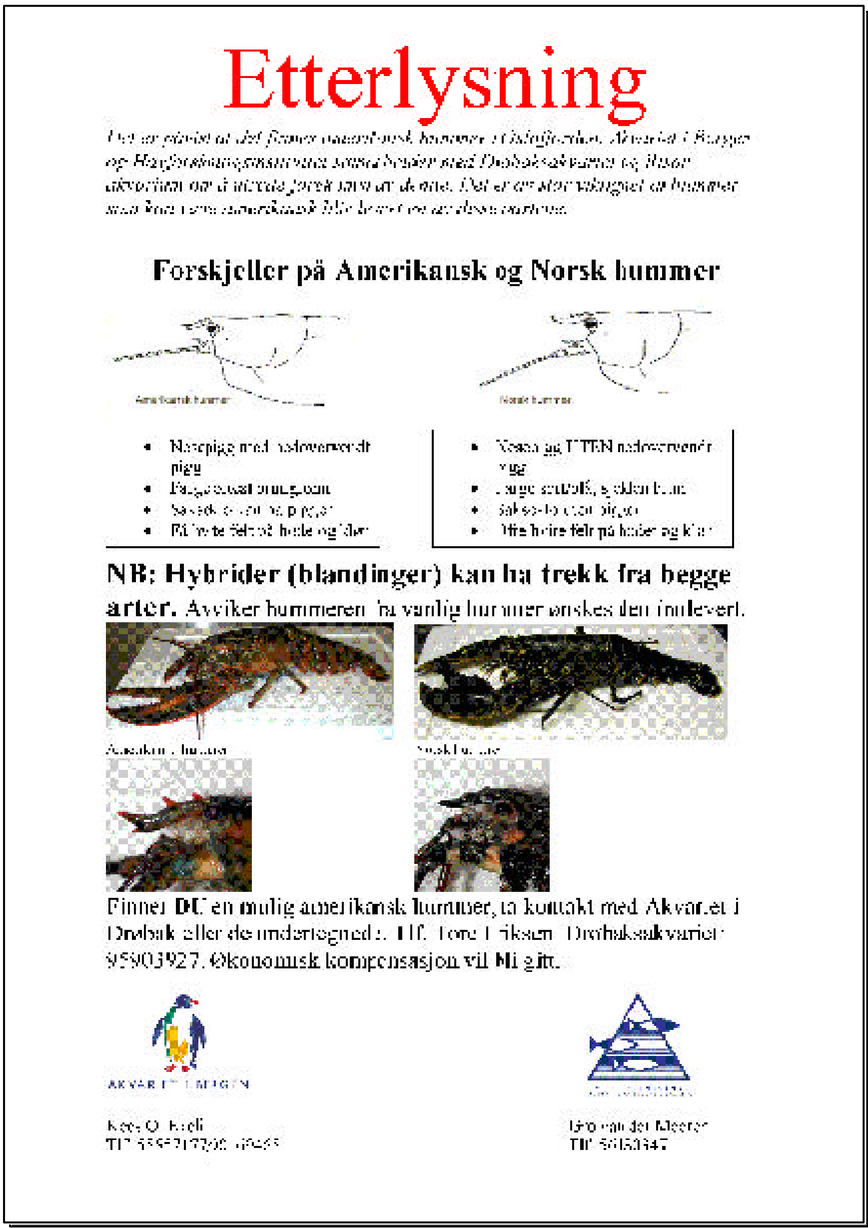
Licences to deposit American lobsters will have conditions attached to them, mainly to ensure that quarantine conditions are applied, including disinfecting the holding water prior to release.

It is illegal to release American lobsters into the sea in the UK.

Close-up of the rostrum of the American lobster caught off the Sussex coast. Note the well-developed spine on the lower rostrum margin, which is a distinguishing feature

Research in Norway

American lobsters were first detected in Norway in November 1999. A public awareness campaign directed through the fishermen's organisations and a network between Norwegian aquariums for collecting suspected specimens was then launched. Posters (see illustration overleaf) were prepared and distributed to raise awareness of the problem. Since then American lobsters have been found at several collecting stations in southern Norway. During 2000, 24 specimens were collected, of which eight specimens were confirmed as *H. americanus*. The reports of suspected *H. americanus* have been limited, but those found have occurred as clusters around larger cities with airports. This is good circumstantial evidence that the lobsters were released. The laws and by-laws for preventing such introductions should in theory be effective against such introductions, but are difficult to enforce. Additional studies for mapping of genetic make-up and a project on mating success were undertaken in 2001.



Norwegian publicity poster

European wide concerns

One source of illegally introduced lobsters is holidaymakers returning from North America. They are able to buy live lobsters prior to their departure and can bring them back in packs as hand luggage. Some of these lobsters may subsequently be released.

There are currently concerns throughout Europe that illegally released American lobsters may establish populations and interbreed with natives, thereby affecting the stock. In Sweden, imported American lobsters are sometimes, although illegally, held in cages on the west coast. There are severe risks that the lobsters can accidentally escape from these cages. There are accounts of lobsters that do not resemble the European lobster being observed in the wild in Sweden.

What to do if you find an American lobster

Any reports of suspect lobsters in the UK should be sent to the Fish Health Inspectorate at the CEFAS Weymouth Laboratory (for England and Wales) or the Fisheries Research Services at the Marine Labroatory, Aberdeen (in Scotland). Addresses are at the back of this issue of Shellfish News.

RESEARCH ON VIRUSES IN BIVALVE SHELLFISH

David Lees, CEFAS Weymouth laboratory, The Nothe, Weymouth, Dorset DT4 8UB

Introduction

Infectious human disease acquired from the consumption of bivalve molluscan shellfish (such as oysters and mussels) is an internationally recognised problem and occurs because of the filter-feeding nature of these species. Human pathogens derived from sewage contamination of their growing waters are concentrated and retained. In the EU legal controls are stipulated by Directive 91/492 which specifies sanitary standards reliant on the traditional bacterial indicators of faecal contamination *(E.coli* and the faecal coliforms). However, in Europe and elsewhere shellfish associated outbreaks are predominantly caused by virus infections. Norwalk-like viruses (NLV), also called Small Round Structured viruses, causing gastro-enteritis (diarrhoea and vomiting) predominate with a smaller proportion of cases caused by Hepatitis A virus (HAV). Unfortunately the specified sanitary controls for shellfish, based on bacterial faecal pollution indicators, do not perform well for viruses. Thus many outbreaks of infectious viral disease have been associated with shellfish fully compliant with the legal bacteriological standards.

Within the UK these problems were highlighted in 1998 by the governments Advisory Committee on the Microbiological Safety of Foods (ACMSF) report on Foodborne Viral Infections. The Food Standards Agency has commissioned a programme of research in this area addressing the development of methods for detection of enteric viruses in shellfish, the evaluation of potential alternative faecal indicator organisms, and the improvement of commercial purification (depuration) procedures to better eliminate enteric viruses. This article summarises progress by CEFAS in these research areas.

Detection methods for enteric viruses in shellfish

CEFAS has pioneered the application of the polymerase chain reaction (PCR) to the detection of NLVs in shellfish. CEFAS has developed sample extraction procedures and, in collaboration with the Virus Reference Laboratory, Colindale, a sensitive nested RT-PCR procedure for NLVs. This methodology has demonstrated the presence of NLVs in shellfish associated with outbreaks of gastro-enteritis and in shellfish harvested from potentially contaminated growing areas. The nested PCR procedure generates good quality PCR amplicons which facilitates genome sequencing of positives enabling confidence in the accuracy of PCR results and also typing of the virus strain detected. The ability to sequence virus is a powerful tool for use in epidemiological investigations of shellfish associated outbreaks as the virus strain occurring in patients can be directly compared with that found in the implicated shellfish and, potentially, in the area from which they were harvested. However, a complication in the application of such molecular epidemiology techniques has been the finding that shellfish are very commonly contaminated with more than one strain of virus. Protocols have been established for cloning NLV positive amplicons prior to sequencing which enables characterisation of mixed strain populations. These methods have proved very useful. However, the techniques are expensive and more routine methods are also being investigated for confirmation of virus presence and strain identity. We are also investigating real-time PCR methods for NLVs which may help us quantify virus titres in shellfish. Initial results are very promising however this a technically difficult area.

The developed methods have been used to assess the feasibility of applying molecular techniques to the monitoring of NLV contamination in shellfish harvested areas. Initial results showed that in study areas historically associated with outbreaks many samples were positive for NLVs, particularly during the winter months. The findings correlated well both with known outbreaks from the study areas and with the winter seasonality of illness from shellfish associated outbreaks in the UK. Recently the studies have been extended to examine virus contamination in a range of commercial shellfish harvesting areas (category A, B, C, and prohibited). NLV detection has been found to be much more likely in areas identified as faecally polluted by routine faecal pollution indicator organisms. The correlation between faecal contamination, as judged by *E. coli* presence, and viral contamination is statistically highly significant and gives support to the current classification process. It is however clear that NLVs can be detected in areas graded as class B according to *E.coli* criteria. In such areas protection of the live bivalve consumer is very dependant on how well depuration performs for removal of viruses. Data for class A areas is very limited since there are relatively few areas with this classification. However, the data that is available suggests that viral contamination is an infrequent occurrence in areas where *E.coli* levels in shellfish are compliant with the grade A classification.

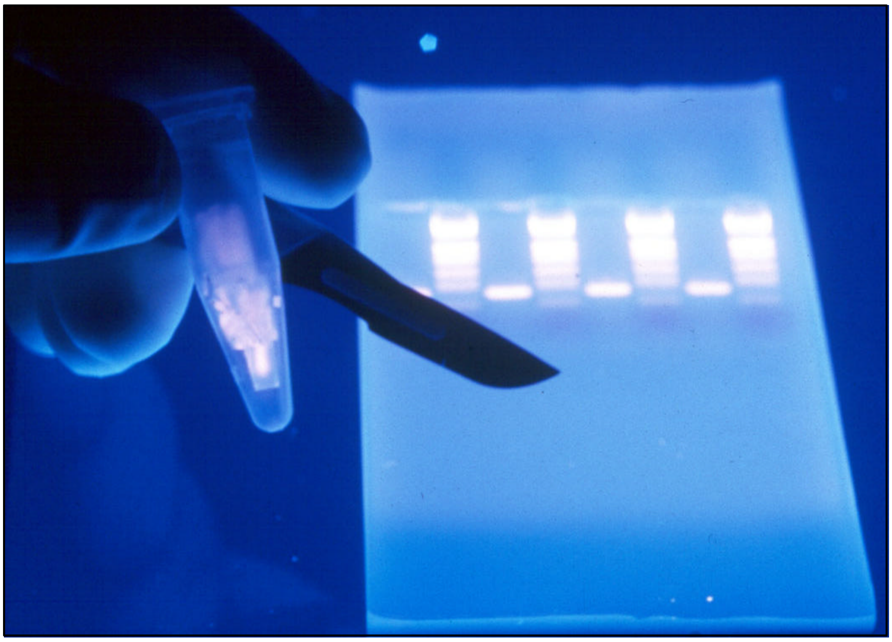
In the above studies sequence characterisation has shown a diversity of NLV strains contaminating shellfish harvesting areas. Some strains were isolated on only one occasion whereas others, such as Grimsby/Lordsdale strain, have been repeatedly isolated. This makes sense since Grimsby/Lordsdale has been the predominant NLV clinical strain circulating in the community during recent years. We have now sequenced in excess of 250 NLVs from shellfish samples and have established a diverse database of strains from environmental samples. In the large majority of cases it has been possible to give a positive identification for strains detected by comparison with sequence data for clinical strains. It is interesting to note that despite the existence of veterinary NLVs (calf and pig types) reactive with the PCR primers used, and the potential for shellfish harvesting areas to be contaminated by agricultural run-off, no veterinary strains have thus far been identified in shellfish. However, it has been found that shellfish are frequently contaminated with more than one strain of NLV. This could potentially have implications for the role of shellfish in the emergence of new NLV variants, through recombinants emerging as a consequence of mixed NLV infections in the gut. This possibility warrants further investigation.

These approaches have also been used for the development of similar tests for the detection of hepatitis A in shellfish. In the UK HAV is currently at a very low level in the community with no shellfish associated infections reported for a number of years. Consequently, it could be anticipated that HAV contamination of shellfish would be a comparatively rare event. We have now tested >100 shellfish samples for HAV and have had 2 positive results. The first was in a highly polluted (prohibited) harvesting area, the second (much weaker) positive result was in a commercial harvesting site downstream of the prohibited area. We were only able to obtain sequence data from the former sample and this was confirmed as wild type HAV. Interestingly these positive results occurred following media reports of a marked increase in HAV incidence in children in the geographical area contributing to the sewage impact these harvesting areas. It should be noted that this is the first laboratory demonstration of HAV contamination in shellfish in the UK. Should we face an outbreak of HAV associated with shellfish we are now in a better position to investigate samples in the laboratory.

So could PCR be used for routine monitoring of harvesting areas for virus contamination in a similar way to the controls for algal biotoxins? The problem for routine use is that although these methods have proved very successful in a research context shellfish remain a challenging sample matrix for PCR. The complexity and lack of standardisation of sample extraction protocols, and other aspects of the procedures, are currently inhibiting wider uptake of the methodology. Along with other partners in Europe current research by CEFAS is therefore aimed at the simplification, standardisation and validation of methods and the development of appropriate standards and quality assurance. The view from Europe is that progress in these areas could well lead to PCR monitoring of shellfish being more widely adopted as a way forward for combating the viral contamination problem.

Alternative ‘viral’ faecal pollution indicator organisms

It is now well established that shellfish associated with outbreaks of NLV gastro-enteritis are normally fully compliant with the *E. coli* standards required by Directive 91/492. In the UK a major factor influencing this is the relative ease of removal of *E. coli* during



Detection of Norwalk-like virus by PCR and gel electrophoresis

commercial processing (depuration) compared with the difficulty of eliminating enteric viruses. A major factor may be the significantly different size, genetic composition, and sensitivity to environmental degradation, of *E. coli* (a bacterial indicator) compared to enteric viruses. FRNA bacteriophage has been proposed as an alternative indicator organisms much more similar in size and properties to enteric viruses than is *E. coli*. CEFAS has examined the potential of FRNA bacteriophage, as a candidate 'viral' indicator, in commercial shellfish harvesting areas and in depurated shellfish sold ready for consumption.

Studies on the distribution of FRNA bacteriophage showed that this organism was widely prevalent in commercial shellfish harvesting areas in the UK with average levels approximately 3 fold greater than *E. coli*. Interestingly a strong seasonal effect was noted with levels of FRNA bacteriophage particularly elevated during winter months. This effect was not seen for *E.coli*. It is interesting to note that elevated levels of FRNA bacteriophage during the winter months concurs with the period of higher risk for shellfish associated viral gastro-enteritis (hence the term winter vomiting disease). It is possible that shellfish related biological factors could similarly contribute both to the observed higher levels of FRNA bacteriophage contaminant concentrations, and retention of viral pathogens, during the winter months. Significantly FRNA bacteriophage in shellfish from category B sites were regularly detected at levels which would not be easily removed by conventional depuration, the usual treatment used for such shellfish.

In a two-year study FRNA bacteriophage content in market ready oysters was compared with both *E. coli* and NLV contamination, with the pollution status of each site, and with the officially reported gastroenteric illness incidents associated with products from each site. The inadequacy of *E. coli* was confirmed during this study with all samples meeting the EU end-product standard of <230 *E. coli* per 100 g shellfish despite oysters from two of the sites being implicated in outbreaks of viral gastro-enteritis. By comparison the frequency and degree of FRNA bacteriophage contamination was highly associated with the consumer health risk from enteric viruses as judged by both the degree of harvesting area pollution, the NLV content of shellfish and the association of products with reported gastroenteric illness incidents. Furthermore detection of FRNA bacteriophage in marketed oysters showed a clear seasonal trend with levels markedly elevated during winter months. This is consistent with oyster associated gastro-enteritis in the UK which occurs predominantly during winter months. Thus FRNA bacteriophage content in market ready oysters reflected the high risk period for contamination with enteric viruses further suggesting their possible utility as a 'viral' indicator.

It should however be noted that, in addition to FRNA bacteriophage, other alternative viral indicators have been proposed. These include bacteriophage of the obligate anaerobe *Bacteroides fragilis*, somatic bacteriophage, faecal streptococci, human adenovirus, and human enteroviruses. We have just completed a comprehensive field evaluation of these various suggested alternative indicators validated through comparison with the occurrence of human enteric viruses, particularly NLVs, and HAV. This work has been conducted as part of a large European study with partners in the UK, Spain, Greece, and Sweden. The results confirm that FRNA bacteriophage shows the most promise for routine applications. Bacteriophage of *B. fragilis* has been found in insufficient quantities for it to be useful as an indicator. Titres of somatic bacteriophage appear highly variable and do not seem to correlate well with occurrence of enteric viral pathogens. Faecal streptococci behave in a very similar way to *E. coli* and the methodology is less well standardised. Interestingly, human adenovirus has been the most commonly isolated human enteric virus and a statistically significant relation with the presence of other viruses is emerging. Adenovirus could potentially be applied as a molecular index of viral contamination in shellfish. However, adenovirus detection, like NLV and HAV, depends on molecular techniques that are not at this time well suited for routine application. This study also demonstrated that methodologies for both NLVs and HAV can be successfully implemented in diverse laboratories throughout Europe.

In practice we have found that monitoring for both *E. coli* and FRNA bacteriophage in shellfish can be more informative than either indicator alone. High levels of FRNA bacteriophage, particularly in depurated shellfish, are a warning sign that the products are susceptible to viral contamination.

Removal of enteric viruses during shellfish depuration

Finally, CEFAS has investigated the removal of viruses from shellfish during the commercial depuration and relaying procedures. These studies have mainly been performed using FRNA bacteriophage as a model for enteric virus behaviour. The results show that depuration temperature, initial contamination load and duration of depuration are critical factors for successful removal of viral contamination. Furthermore it seems clear that currently used commercial depuration protocols would be unlikely to clear FRNA bacteriophage, and hence possibly enteric viruses, from shellfish harvested from category B areas during winter months. Significant further effort has been applied to the potential use of elevated temperature for enhancing viral removal in commercial scale depuration systems. It is now clear that elevated temperature, combined with extended purification times, can significantly improve viral clearance (as judged by FRNA bacteriophage) in commercial depuration systems. This effect appears independent of season and does not appear to significantly affect product quality.

The characteristics of FRNA bacteriophage removal during depuration are now well characterised and we have developed reliable predictive equations. A working hypothesis has been developed suggesting that depuration systems capable of removing FRNA bacteriophage during winter months should provide significantly enhanced levels of consumer protection against human enteric viruses. Unfortunately, field evaluations in commercial depuration plants, both in the UK and elsewhere in Europe, have shown that currently FRNA bacteriophage is not adequately removed from shellfish during commercial processing. Thus it is probable that currently commercial depuration systems across Europe are not providing adequate levels of consumer protection when processing shellfish contaminated with human enteric viruses.

This hypothesis depends on FRNA bacteriophage behaving in a similar fashion to human enteric viruses during depuration. We are certainly confident that FRNA bacteriophage is more representative of virus behaviour than is *E. coli*. Current work is utilising quantitative TaqMan PCR for NLVs to compare enteric virus clearance during depuration with FRNA bacteriophage. So far the results suggest that FRNA bacteriophage is indeed a good model for NLV removal during depuration.

All our results suggest that depuration plants geared up for FRNA bacteriophage removal would be much more likely to be effective against enteric viruses. This may prove to be a useful way forward for improving the effectiveness of commercial depuration systems.

Further information

Further information, including a bibliography of relevant CEFAS publications, can be obtained from the following websites; www.nrlcefas.org (for National Reference laboratory activities) and www.crlcefas.org (for Community Reference laboratory activities).

ADVICE FOR LABORATORIES UNDERTAKING MICROBIOLOGICAL TESTING OF LIVE BIVALVE MOLLUSCS

Committee of UK Microbiological Laboratories Undertaking Shellfish Testing: comprising representatives from CEFAS Weymouth Laboratory, Public Health Laboratory Service, FRS Marine Laboratory Aberdeen and Belfast City Hospital together with the Food Standards Agency.

Background

Public health controls on the commercial production of shellfish for human consumption within the European Union (EU) are determined by the Shellfish Hygiene Directive (91/492/EEC) as implemented within each Member State. The Food Standards Agency is the competent authority for these controls within the UK. Under the Directive, and associated UK Regulations, official control laboratories undertake microbiological testing of samples of such shellfish from harvesting area monitoring programmes and official sampling at purification and dispatch centres. They may also test official samples taken at final sale. Operators of purification and dispatch centres are required to undertake their own testing and this may be expedited in laboratories within the centres or by other laboratories. Those laboratories outside of a centre must be acceptable to the responsible food authority.

Stipulated/recommended methods

The Shellfish Hygiene Directive specifies the use of a 5-tube 3-dilution most probable number (MPN) procedure for the enumeration of *Escherichia coli* and/or faecal coliforms. The Directive allows the use of other methods that do not correspond to such a format for the purposes of end-product testing, as long as they have been shown to be of equivalent accuracy. The option for such alternatives is not included in the criteria for demarcation of classes B and C. In the UK, official testing for the purposes of harvesting area classification is based on enumeration of *E. coli* rather than faecal coliforms. The recommended methods for *E. coli* and *Salmonella* are described in the appendix to Donovan *et al*. (1998), [Modification of the standard UK method for the enumeration of *Escherichia coli* in live bivalve molluscs. *Communicable Disease and Public Health* **1,** 188-196]. The method given for *E. coli* conforms to the requirements of the Directive and must be used for all testing for the purposes of classification of shellfish harvesting areas in the UK.

Recovery of target organisms is undertaken in minerals modified glutamate broth (MMGB) with confirmation by detection of β-glucuronidase on BCIG agar. A number of other methods that have been used for *E. coli* determination in shellfish are either less effective at recovering cells stressed in the marine environment or have nominal detection limits that are higher than the upper limit specified for class A/the end-product standard in the Shellfish Hygiene Directive. The method used must be capable of distinguishing between class A and class B categories at its lower limit of detection (and thus also be capable of demonstrating conformity with the end-product standard).

Condition of sample

Samples of shellfish should be cleaned after collection to ensure the removal of mud in order to prevent mud ingestion by the shellfish during transport to the laboratory. Samples that are muddy on arrival at the laboratory may be rejected as unsuitable for testing, as the result may be void. Shellfish received immersed, or partly immersed, in water may also be rejected. If they are received in either condition a comment should be made on the report.

Sub-sample size

The following sub-sample sizes are recommended for inclusion in the homogenisation step: Oysters and clams, 10 - 15; Mussels, 15 - 30; Cockles, 30 - 50. The weight of shellfish flesh and liquor must be at least 50 g for the *E. coli* method. For other species, sufficient shellfish should be opened to achieve this minimum weight of flesh and liquor, with the proviso that a minimum of six animals should be used for very large species such as *Mya*. In general, the more shellfish that are included in the initial homogenate, the less the final result will be influenced by the inherent animal-to-animal variation in *E. coli* concentration.

Homogenisation methods

Peristaltic homogeniser (stomacher)
If sufficient weight of shucked shellfish (>75 g) is subject to the primary homogenisation step then separate amounts can be removed for *E. coli* (50 g) and *Salmonella* (25 g) testing. The appropriate diluents can then be added (0.1% peptone for *E. coli*; buffered peptone water (BPW) for *Salmonella*) prior to secondary homogenisation, as specified in the method.

Blender
Use of a blender requires the addition of diluent to the weighed shellfish prior to homogenisation. In order to conform to the recommended methods, it is necessary to process the shellfish for the *E. coli* and *Salmonella* tests separately to ensure that the correct diluent for each test is used. In practice, the addition of shellfish plus 0.1% peptone (75 ml of 1 in 3 dilution) to an appropriate volume of buffered peptone water (175 ml), has not been shown to affect the performance of the *Salmonella* method adversely. Therefore, a single bulk homogenate may be prepared in 0.1% peptone and used for both methods.

Quality control

The recommended methods specify positive and negative control strains. Experience has shown that weakly β-glucuronidase positive strains may show as negative on some BCIG agars depending on the exact formulation of the medium. It is therefore further recommended that a weakly positive strain be included in the test procedure. NCTC 13216 is a suitable strain of *E. coli* for this purpose. Media conforming to the specification for BCIG in the UK standard method are available from at least two commercial suppliers and each uses a different name for the medium.

Interpretation of results

The most probable number (MPN) tables published in the standard method contain only category 1 and 2 values, that is only those values that have a high probability of being correct. Values that do not appear in the tables are not acceptable and should not be used. If the tube combination results in an unacceptable value then the entire test should be repeated on retained refrigerated molluscs or a further sample obtained. If an unacceptable value is obtained, report the result as void.

Examination for *Salmonella*

The method for detection of *Salmonella* described by Donovan, *et al*. (1998) will be retained pending publication of the new version of EN ISO 6579 Horizontal method for the detection of *Salmonella* species (currently in draft). The requirement for a second subculture of the RVS enrichment broth after 48 hours of incubation therefore still remains valid.

External quality assurance

It is recommended that laboratories undertaking testing of live bivalve molluscs for the purposes of the Shellfish Hygiene Directive participate in a relevant external quality assurance scheme. The Shellfish Scheme organised by the PHLS is currently the only scheme specifically designed for this purpose. Laboratories that also undertake examination for vibrios in such samples may wish to test the ad hoc *Vibrio* EQA samples distributed by the PHLS.

For further information contact the Scheme Co-ordinator:
Julie Russell, PHLS Food EQA Schemes,
Food Safety Microbiology Laboratory,
61 Colindale Avenue, London NW9 5HT UK.
Telephone: 0208 200 4400 ext. 4119,
Fax: 0208 200 8264

Accreditation

Laboratories in the UK that undertake testing of samples for the classification of shellfish harvesting areas, or end-product testing for official control purposes, must be accredited by the United Kingdom Accreditation Service (UKAS) for the specific shellfish methods. Laboratories that undertake testing for producers must be acceptable to the relevant food authority and it is recommended that such laboratories are also accredited for those specific tests.

National Reference Laboratory

Following a number of shellfish-related incidents in EU Member States, the European Council adopted a Decision (1999/313/EC) which established a framework for a network of Reference Laboratories for monitoring bacteriological and viral contamination of bivalve molluscs. The framework includes a Community Reference Laboratory (CRL) with a National Reference Laboratory (NRL) in each member state. CEFAS Weymouth has been designated as the UK NRL. The Council Decision defines the responsibilities of the NRL as:

1. Each national reference laboratory shall be responsible for:

(a) Co-ordinating the activities of the national laboratories responsible for viral and bacteriological analyses of bivalve molluscs in the relevant Member State.

(b) Assisting the competent authority in the Member State to organise a system for monitoring viral and bacteriological contamination of bivalve molluscs.

(c) Organising, on a regular basis, comparative tests between the various national laboratories responsible for the said analyses.

(d) Disseminating the information provided by the Community Reference Laboratory referred to in Article 3 to the competent authorities and national laboratories responsible for the said analyses.

2. The national laboratories shall collaborate with the Community Reference Laboratory referred to in Article 3.

While these responsibilities relate to official control laboratories, information is also disseminated as far as possible to other laboratories undertaking testing for the shellfish industry under Directive 91/492/EEC in order to keep them abreast of developments and recommendations. Further information can be found on the UK NRL web site at www.nrlcefas.org.

POLICY MATTERS

STRATEGY FOR EUROPEAN AQUACULTURE

The European Commission has issued a strategy for the sustainable development of European aquaculture which may be accessed from the Internet at

http://www.europa.eu.int/comm/fisheries/reform/proposals_en.htm

The strategy is part of a series of proposals issued by the Commission as part of discussions on the reform of the Common Fisheries Policy. The document which was published on the 19th September 2002, sets out a strategy based on the Commission's vision over the next 10 years for the development of a stable aquaculture industry which is able to guarantee long term secure employment and development in rural areas, providing alternatives to the fishing industry, both in terms of products and employment.

Fisheries Departments will be consulting stakeholders on the proposals.

ANNOUNCEMENTS

DO YOU KNOW THIS SHELL?

The picture opposite is of a scallop shell, which was handed in to Dave Putt at the Defra Fishery Office in Brixham. Paul Bolton, skipper of the *Geeske*, fished the shell as a live scallop from off the Channel Islands in May this year.

It has very clear marks on the outside of the cupped shell that cannot be removed by light scratching. They appear to say ‘c 67’. The inside of the shell has dark brown pigmenting, but not in the region of these marks.

A few preliminary enquiries have failed to find any reference to a tagging programme using such a marking technique.

If you can identify this shell then please contact Dave Palmer at the CEFAS Lowestoft Laboratory.

UK MICROBIOLOGICAL LABORATORIES UNDERTAKING SHELLFISH TESTING

Resolutions of Fourth Meeting

A periodic meeting of laboratories undertaking microbiological testing of bivalve shellfish was held at Defra, Nobel House, London on April 16th 2002. The group comprised representatives from CEFAS Weymouth (the National Reference Laboratory), the Public Health Laboratory Service, the FRS Marine Laboratory Aberdeen and Belfast City Hospital.

The remit of the group is:

1. To provide, with reference to Council decision 1999/313, a UK technical forum for discussion of issues relating to microbiological testing of shellfish.
2. To agree, where possible, common methods and approaches relating to shellfish testing for use throughout the UK and their quality assurance.
3. To advise the central UK competent authority, and the devolved administrations, of the views of testing laboratories as outlined above.
4. To enable CEFAS Weymouth, as the UK National Reference Laboratory (NRL), to represent the views of UK testing laboratories in the European laboratory framework specified in Council decision 1999/313 and to co-ordinate with UK laboratories initiatives arising at the European level.

The group agreed the following resolutions:

1. The group undertook to prepare a discussion paper for ISO proposing an additional horizontal standard method for *E. coli*, to be a 5x3 MPN method as given in Donovan, et al, 1998. This action was decided upon due to concerns relating to the appropriateness for shellfish testing of current and draft ISO *E. coli* methods.
2. The group emphasized that it was necessary for sampling officers to comply with the sampling protocol issued by CEFAS. Particular concerns had been raised with regard to cleaning of shellfish after sampling and the avoidance of subsequent immersion in water.
3. Further to Resolution 3 of the meeting of April 2000, it was agreed that the group reaffirm its view to the FSA that the UK standard method be specified for all testing undertaken in the UK under Directive 91/492/EEC.
4. The group had re-examined possible changes to the *Salmonella* method and agreed that the current standard method as given in Donovan, *et al*., 1998, should be maintained pending the publication of the revised ISO standard. The method would be further reviewed at that point.

5. The group supported the proposed training provision and pilot ring trial distribution for F+bacteriophage to be undertaken by the NRL with funding from the FSA.

Further information

Julie Younger,
CEFAS Weymouth Laboratory,
The Nothe, Weymouth, Dorset, DT4 8UB
e-mail: fsq@cefas.co.uk

FIRST WORKSHOP OF NRLs FOR MONITORING BACTERIOLOGICAL AND VIRAL CONTAMINATION OF BIVALVE MOLLUSCS

A workshop of the European National Reference Laboratories (NRLs) for monitoring bacteriological and viral contamination of bivalve molluscs was held at CEFAS on May 14-16 2002. The workshop was hosted by DG Sanco of the European Commission, Brussels, and the attendees comprised representatives from CEFAS Weymouth (the European Community Reference Laboratory (CRL)), the European NRLs and the European Commission Food and Veterinary Office. The workshop produced a number of resolutions to be distributed in the public domain mainly through the CRL website (www.crlcefas.org). Further details of the activities of the network of laboratories can also be obtained on this website.

Resolutions

1. There was recognition by the NRLs of the progress in establishing the CRL/NRL network but there was need to develop and implement work programmes to ensure compliance with requirements of Council Decision 1999/313/EEC as soon as possible.
2. The NRLs agreed to build on the scientific and technical liaison between members of the reference laboratory network initiated at the workshop.
3. It was agreed that the method for shellfish examination as recommended by the CRL should be the reference method for *E. coli* in live bivalve molluscs. However it was identified that formal validation of this method would need to be carried out.
4. The NRLs agreed that the CRL *E. coli* method should be proposed to ISO/CEN, by the CRL, as a method to cover the requirements of a 5x3 MPN test satisfactory for live bivalve molluscs.
5. The NRLs agreed that rapid methods for the detection of *E. coli* in shellfish should be discussed at the next meeting (May 2003).
6. The NRLs agreed with the proposal in the draft microbiological criteria proposals that the faecal coliform standard is deleted and *E. coli* be used as the sole faecal indicator bacterium for live bivalve molluscs.
7. The NRLs supported the use of the CRL Collaborative Shellfish External Quality Assurance (EQA) Scheme as the primary means of comparative bacteriological testing between NRLs and also between National Laboratories within each member state.
8. Further to Resolution 7 the NRLs recommended a pilot EQA distribution to the reference laboratory network and it was agreed that this would be organised by the EQA scheme collaborators within six months of this meeting (by November 2002).
9. The NRLs agreed that specific ring trials would be undertaken in addition to EQA participation but that any such trials should be deferred until the EQA has been implemented for NRLs.
10. The NRLs endorsed the need for compliance with Article 4(g) in Council Decision 1999/313/EEC in that the reference laboratories should have an appropriate system of quality assurance.
11. The NRLs agreed that a working group should be established to produce a guidance document for the microbiological monitoring of shellfish harvesting areas.
12. Further to the preparation of the guidance document the NRLs recommended that certain criteria relating to the microbiological monitoring of shellfish harvesting areas inter alia, sample size, sample frequency, conditions of transport, should be specified in the relevant Community legislation.
13. Those laboratories that do not currently have the ability to carry out analysis of shellfish for FRNA bacteriophage undertook to seek training and advice from the CRL and/or other competent NRLs within a period of one year of this meeting (May 2003).
14. It was agreed that there would be a target for NRLs who do not currently have the ability to carry out analysis of shellfish for FRNA bacteriophage to achieve competence within a period of one year of this meeting (May 2003).
15. It was agreed that a pilot ring trial for FRNA bacteriophage would be organised by the CRL, within eight months of this meeting, for those NRLs able to undertake this analysis (by January 2003).

16. Those laboratories that do not currently have the ability to carry out analysis of shellfish for viruses undertook to seek training and advice from the CRL and/or other competent NRLs within a period of one year of this meeting (May 2003).
17. It was agreed that there would be a target for NRLs who do not currently have the ability to carry out analysis of shellfish for viruses to achieve competence within a period of two years of this meeting (May 2004).
18. It was agreed that a pilot ring trial for Hepatitis A virus would be organised by the CRL, within six months of this meeting, for those NRLs able to undertake this analysis (by November 2002).
19. It was agreed that a pilot ring trial for Norwalk-like virus would be organised by the CRL, within one year of this meeting, for those NRLs able to undertake this analysis (by May 2003).
20. There was general agreement by NRLs that the process performance criterion for depuration using FRNA bacteriophage as given in the draft microbiological criteria document dated 26 March 2002 was acceptable.

It was agreed that future workshops of the laboratory network should be held on an annual basis and that the next meeting would be on May 6-8 2003.

THE FISH HEALTH INSPECTORATE & YOU

STANDARDS OF SERVICE – CITIZEN'S CHARTER PERFORMANCE RESULTS

by Debbie Murphy, CEFAS Weymouth Laboratory, Barrack Road, The Nothe, Weymouth, Dorset DT4 8UB

Introduction

The Fish Health Inspectorate (FHI) aims to provide an efficient, quality service. Our standards of service have always been high and we are constantly looking for ways to improve them. Under the terms of the Citizen's Charter we are required to publish an annual summary of the results of our performance against the standards set. The results are reported in the Defra publications 'Trout News' and 'Shellfish News', which are sent free to all registered fish and shellfish farmers. A copy of the results is sent separately to all fish and shellfish import licence holders and can be found on our web site www.efishbusiness.com. Additional copies of our new Charter can be obtained from the FHI or on the CEFAS web site www.cefas.co.uk.

The FHI has agreed to answer all calls to the administrative team (01305 206673/4) promptly. Since the publication of our new charter document we have accepted the Defra standard within 10 rings (20 second period). This is monitored regularly by logging all calls received on a chosen day. We fully met this standard.

Our web site dedicated to the movement and keeping of fish – www.efishbusiness.com has been available for over a year, an increasing number of callers have been directed to this site to fulfil their requirements e.g. to obtain forms, students researching projects.

The following report shows the performance achieved against our target of 100%, for the period 1st April 2001 to 31st March 2002.

	Achieved in 2001-02
Correspondence	
The Inspectorate's target is to reply to all letters, e-mails, faxes and complaints, within 10 working days of receipt.	**93.8%**
Import licence applications	
The Inspectorate has undertaken to issue import licences within 10 working days of receipt.	**99.7%**

Deposit licence applications

The FHI issue crayfish, lobster and mollusc deposit licences, these are not currently covered by our Citizen's Charter Statement, but it is currently our aim to issue them within 10 working days'.	**100%**

Movement document applications

The Inspectorate has agreed to respond to all requests for movement documents, provided 5 working days' notice is given.	**100%**

Fish and shellfish farm registrations

Registration visits The Inspectorate has undertaken to visit all potential farmers Within 20 working days of receipt of their application.	**70.6%**
Registration administration The Inspectorate aim to complete the administrative action within a further 10 days from the date of the visit.	**93.1%**

Notifiable diseases

Respond immediately to a notification of suspicion of infectious salmon anaemia (ISA), infectious haematopoietic necrosis (IHN), viral haemorrhagic septicaemia (VHS), gyrodactylosis caused by G. salaris, bonamiosis, marteiliosis, haplosporidiosis, iridovirosis, mikrocytosis and perkinsosis.	**100%**
Respond to other notifiable diseases within 2 working days.	**100%**

Reporting of test results and visit summaries

The FHI must report all negative test results within 5 working days of the full results becoming available and give a verbal report within 1 working day where a notifiable disease is found. We have agreed to provide a follow up letter within 10 working days to advise the farmers in writing of any points raised during the visit.	**78.2%**

Overall results

The overall compliance rate with our set targets.	**89.9%**

The total amount of correspondence received and recorded by the Inspectorate was 2022. Our performance fully met or approached our targets in most areas. We will continue to strive to achieve all our standards in 2002/2003.

Customer care helpline

The purpose of our work is to prevent the introduction and spread of disease into and within England and Wales. This involves implementing European Union Fish Health Directives and administering and enforcing national legislation. In carrying out this work our main aim is to ensure that you receive a high quality, cost effective service so that your compliance costs are kept to a minimum. The best way for us to measure our performance is to receive feedback from people who require our service. To help us achieve this we have set up a Customer Care Helpline on 01305 206673/4 where all complaints will be recorded and, thoroughly and impartially investigated. Our helpline staff can assist the customer to formulate the complaint and will explain in full our complaints procedure. They will also aim to send a reply within 10 working days and to ascertain whether the customer is satisfied with the outcome.

THE SCOTTISH EXECUTIVEAQUACULTURE STRATEGY

Consultation

On the 26 June 2001, the Scottish Executive announced its intention to embark on a wide-ranging consultation to establish a long-term strategic framework for aquaculture. Following a series of meetings with key stakeholder organisations a Ministerial Working Group was formed and has been working to develop proposals and to prepare a draft strategy. A further consultation period will follow the publication of the draft strategic document, due in late autumn 2002.

Further information

Further information may be obtained on the Scottish Executive Aquaculture newsletter at http://www.scotland.gov.uk/publications/issue.asp?id=1.

NATION-WIDE SEARCH BEGINS FOR ELUSIVE NATIVE OYSTER

A comprehensive survey of Scotland's native oysters is set to go ahead this year, in an effort to understand how to protect the species. Scottish Natural Heritage (SNH) will commission a study of coastal areas around Scotland to investigate the current population of native oysters, which appear to have declined significantly in Scottish waters during the 20th century. The survey, which was announced during Scottish Biodiversity Week, will aim to provide a clearer picture of the abundance, distribution and reproductive biology of native oysters in Scotland and help to develop appropriate advice for conservation management.

The native or flat oyster (*Ostrea edulis*), once a common delicacy on restaurant menus, is these days a rarity, since supplies have declined substantially in UK waters in recent decades. Most oysters now served up in Scotland are farmed, and the species favoured for farming throughout Europe is the pacific oyster. The native oyster once supported a significant fishery in the Firth of Forth but although dead shells are commonly seen, no live animals have been found in recent surveys. Scientists are unclear as to how much the species has suffered elsewhere, although they are aware of scattered populations found in sea lochs on the West coast of Scotland, which probably represent a UK stronghold. However, there has been concern in the last two years about the level of illegal fishing experienced at a number of isolated oyster populations in Argyll.

David Donnan, Maritime Advisory Officer at SNH said "This survey gives us the opportunity to find out what is happening to the oyster population in Scotland and what we can do to help it recover. If oysters are sustainably managed they can be an important economic resource for Scotland as well as a flourishing part of the ecosystem."

Stock abundance of the native oyster was probably greatest in the 18th and 19th centuries, when there were large offshore oyster grounds in the southern North Sea and the Channel, producing up to 100 times more than today's 100-200 tonnes. The main UK stocks are now located in the rivers and flats bordering the Thames Estuary, the Solent, River Fal, the West coast of Scotland and Lough Foyle.

Over-fishing of native oyster stocks was one aspect known to contribute to the decline of native oysters, but pollution, lack of stock management and disease may also be important factors. The species is rapidly fished out because it is relatively long-lived and reproduces sporadically, so recovery from over-exploitation can take a very long time. Native oysters are an UK Biodiversity Action Plan species and this survey is a significant step in taking the action plan forward in Scotland.

The survey is part of SNH's drive to boost biodiversity in Scotland and was announced to celebrate this year's Scottish Biodiversity Week, which was held between 31st August – 8th September. The nine days of events and activities were organised by environmental and community groups, government agencies and individuals with the aim to raise awareness about Scotland's rich variety of animals, plants, fungi, microbes and the habitats in which they live. This is the second year the week has run and this year it coincided with the World Summit on Sustainable Development in Johannesburg.

Further information

Dr David W Donnan,
Maritime Group, Scottish Natural Heritage,
2 Anderson Place, Edinburgh EH6 5NP.
Tel: 0131 446 2438,
email: David.Donnan@snh.gov.uk

SEAFISH PRODUCES HYPERBOOKS TO ASSIST AQUACULTURE DEVELOPMENT

Seafish has been developing a series of Hyperbooks that provide the most up-to-date information on the cultivation of a selected range of marine fish and shellfish species. They are available on CD-ROM and make use of ‘web browser’ style hyperlinks and multimedia features. The project was made possible through a FIFG grant awarded by the Scottish Executive’s Environment and Rural Affairs Department.

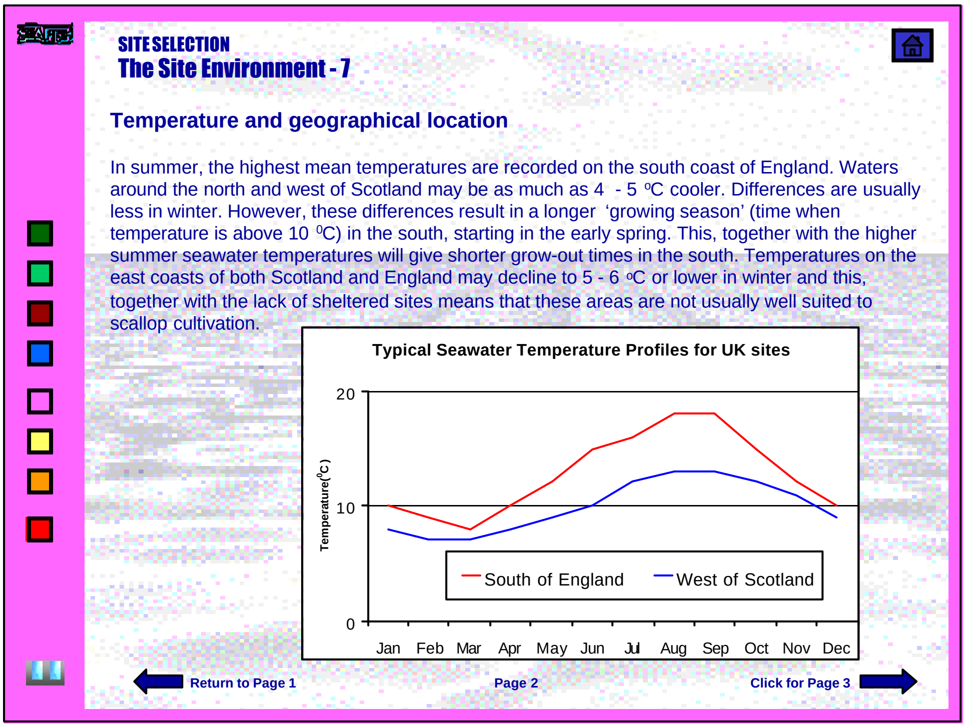
Hyperbooks have been produced for rope grown and seabed cultured mussels, Pacific oysters and native flat oysters, scallops, Manila clams and native clams (palourdes).

Each Hyperbook contains a financial planning package, and supporting sections that provide practical information on a range of aspects that can affect the success of any aquaculture business. The technical and biological requirements are described for each species, along with the requirements for good site selection, recent marketing information, environmental considerations, legislative and regulatory aspects, equipment suppliers and a list of websites where additional helpful information can be found. A short video on shellfish cultivation can be run within the package.

Seafish’s two Aquaculture Development Officers collated most of the information with considerable assistance from some of the established shellfish producers and with reference to published information.

The Hyperbooks will be a useful tool not only to the respective sectors of the shellfish cultivation industry but also to their regulators, finance providers and other advisors.

For more information, contact the Seafish Aquaculture Development Team.



A page from the scallop hyperbook

NEW BOOKS

1. Molluscan Shellfish Farming

***Brian Spencer** – Conwy, UK*

The cultivation of shellfish is a multi-million dollar industry worldwide with cultured species now making up a significant proportion of the world's supply of shellfish and the total aquaculture output. This important book carries on the prestigious tradition of Buckland Series books, providing cutting edge information on the subject from a recognised world expert.

Chapters are devoted to the general biology of bivalves, their predators, hatcheries and each of the major cultured groups: Clams, Oysters, Mussels, Scallops and Abalone. An important chapter on processing live bivalves for consumption is also included. This fantastic publication should find a place on the shelves of all those involved in any type of bivalve cultivation.

Table of Contents: Introduction; Bivalve cultivation in the UK; structuring influences; General biology of bivalves with respect to cultivation; Hatchery culture of bivalve larvae and juveniles; Cultivation of hatchery-reared oysters in the sea; Clam cultivation; Oyster cultivation; Mussel cultivation; Scallop cultivation; Abalone cultivation; Bivalve predators and their control; Criteria for selecting a site for bivalve cultivation; Processing live bivalves for consumption; Glossary of terms; Index.

This hardback book (ISBN 085238291X) has 296 pages with 125 illustrations. The normal price is £59.50 (+p&p) but it is available to readers of Shellfish News for only £47.50 (+p&p). To order your copy simply contact Blackwell Publishing Direct Orders. c/o Marston Book Services on Tel: + 44 (0) 1235 465500, Fax: + 44 (0) 1235 465556, Email: direct.order@marston.co.uk and quote 'Spencer Special Offer'.

2. Bivalve Molluscs: Biology, Ecology & Culture

***Dr Elizabeth Gosling** –*
University of Dublin Trinity College, Dublin

Bivalve Molluscs: Biology, Ecology and Culture brings together information on the biology, ecology and conservation, cultivation, fishery and management of the molluscs that are commonly available (mussels, oysters, scallops and clams). Extensively illustrated, the text is presented in a clear, concise and easy-to-read style and includes up-to-date references and suggestions for further reading. Written by an author of international repute with more than 15 years experience teaching shellfish biology to undergraduate students.

This comprehensive text will be an essential reference for students of aquaculture, and all those employed in the cultivation of molluscs.

Table of Contents: 1. An Introduction to Bivalves; 2. Morphology of Bivalves; 3. Ecology of Bivalves; 4. How Bivalves Feed; 5. Reproduction, Settlement and Recruitment; 6. Growth and Factors Affecting Growth; 7. Circulation, Respiration, Excretion and Osmoregulation; 8. Fisheries and Management of Natural Populations; 9. Bivalve Culture; 10. Genetics in Aquaculture; 11. Diseases and Parasites; 12. Public Health.

This hardback book, to be published in December 2002, has 288 pages with many illustrations. The normal price is £69.50 (+p&p) but it is available to readers of Shellfish News for only £55.50 (+p&p). To order your copy simply contact Blackwell Publishing Direct Orders. c/o Marston Book Services on Tel: + 44 (0) 1235 465500, Fax: + 44 (0) 1235 465556, Email: direct.order@marston.co.uk and quote 'Gosling Special Offer'.

NEWS FROM THE TRADE ASSOCIATIONS

SHELLFISH ASSOCIATION OF GREAT BRITAIN (SAGB)

European Shortages Boost Bivalve Prices

A shortage of cockles and mussels in Holland and France has pushed prices for these shellfish to record high levels. This is likely to be followed by strengthening import demand for oysters into France, as the west coast has suffered a second year in succession with very poor spatfall of pacific oysters. The French industry normally expects to be able to survive with one poor year in four, but two years in succession is exceptional. French growers also continue to be badly hit by 'summer mortality' of pacific oysters. At a recent meeting of European mollusc producers in Bordeaux, Dr. Henri Grizel of IFREMER said this is not a disease, but did admit that micro-organisms such as rickettsias may be implicated. The way that summer mortality has spread around Europe certainly has the appearance of that of a disease, and so the Shellfish Association of Great Britain continues to advise its members not to import seed oysters from counties which have a record of summer mortality. These include France, Ireland and Holland.

The reasons for the current shortages are different for each species. Cockle supplies have been badly hit by UK bed closures caused by DSP and most commonly by 'atypical DSP', a term coined to describe an unidentified substance which kills mice when cockle extract is injected into them for the routine DSP toxin test.

Mussel supplies have been reduced in Holland because of shortage of seed over the past two years, as so much seed is now prohibited from being exploited, being reserved for seabirds. The French mussel fishery off Barfleur has already been fished and closed in September. In some years the fishery has supplied much of French demand for lower quality rough-dredged mussels. Demand for mussels is also continuing to rise, so new sources are needed.

Oyster prices have declined over the past twenty years, so if the French shortage does result in an increase next year it may prove to be a benefit for UK growers. In recent years Irish oysters have supplied much of the UK market, but this has also helped to depress prices. The Irish industry now has close links with French shellfish merchants, so it is likely that more Irish oysters will be supplied to France next year to meet the shortage. The UK oyster industry has not grown much in recent years, apart from a small number of new operations, such as on the Yealm Estuary in Devon, and in the Wash near Boston. The European shortage of oysters may now give a spur for expansion. A further likely result of this unprecedented failure of wild spatfall is that the French industry may begin making itself less dependent on natural settlement of wild spat and make more use of hatchery seed oysters.

At least expanding and improving the efficiency of bivalve aquaculture can solve these shortages of supply.

Spat collector tiles in Arcachon: little set this year

The situation bears no resemblance to the 'doom-and-gloom' scenario of wet-fish landings in European waters. In fact most shellfish stocks around the UK are in remarkably good shape. This is largely because technical conservation measures succeed for shellfish in a way that they do not for finfish. The return of undersized individuals and berried lobsters from passive pot fisheries is done with almost no mortality, unlike the huge losses of discards in the wet-fisheries. Technical conservation measures have succeeded until now but effort pressure is building rapidly on crustacean stocks, so effort capping through potting licences is now urgently needed before stocks become endangered.

A combination of efficient and sustainable aquaculture for oysters, mussels and clams and well managed wild fisheries for scallops, cockles and for the crustaceans can ensure supplies of shellfish and meet increasing demand.

Further information

The Shellfish Association of Great Britain,
Fishmonger's Hall, London Bridge, London, EC4R 9EL
Tel: 020 7283 8305 Fax: 020 7929 1389
email: SAGB@shellfish.org.uk

ASSOCIATION OF SCOTTISH SHELLFISH GROWERS (ASSG)

VIEWS FROM THE ASSG

Readers will recall that I am a strong supporter of and enthusiastic advocate for the development of infrastructure for the shellfish aquaculture industry through the creation of consortia. This is in order to integrate and encourage collaboration between the efforts of the various public bodies that support our development efforts, as well as to optimise access to limited public funds.

Readers will also be aware that such synergetic efforts in Scotland are as rare as oyster teeth!

A return visit

I was forcefully reminded of his sad state of affairs when I recently visited one of the premier oyster cultivation areas on the French Mediterranean coast, the lagoon at

Leucate. On my previous visits I had admired the co-operation between the oyster growers as they are all located at the 'Centre Conchylicole', although each operator is fiercely independent and each enjoys a dedicated landing site and their individual wholesale/ retail outlet for marketing purposes. Nevertheless, it had been a trip to a dirt and gravel parking area, which must have been less than conducive to tempting customers, even the oyster-loving French, particularly on days when the Tranmontagne is blowing!

On my most recent visit, however, the entire dustbowl area had been transformed. There was a smart car park with lighting, young trees at strategic positions, a hall for meetings, presentations, etc, and even a well located cell 'phone mast to improve communications between the base units and the on-growing sites. I was pleased to discover that this make–over had been the result of a consortium, bringing together industry (40%), the Commune, the Region and the European Commission (60%), for a total investment of just under Euro3 Million, as explained on a site map.

Visits earlier in the year to Galicia had confirmed similar collaborative ventures involving local authorities in order to facilitate industry's efforts to commercialise its products.

The situation in Scotland

So where are the joint facilities for our industry in Scotland? Why do we appear to find it so difficult to promote co-operation between public bodies in such a productive fashion? I hope that we can optimise our 'bangs for our FIFG bucks' through similar constructive groupings. This will improve the image and efficiency of the shellfish sector in selling both itself and its products to the consumer, as profitability must be enhanced if we are to generate the surpluses essential to finance our future expansion. Indeed, the concept of improving the amount of 'joined-up thinking and doing' should enjoy a place in the emerging draft of a 'framework of strategic principles for aquaculture'. This has been discussed at length throughout the summer months by representatives from all interested parties at meetings of the 'Ministerial Working Group on Aquaculture' and its sub-groups. The final outcome of this process should be ready for public consultation by December.

We tend to feel that we suffer an unfairly excessive plague of problems here in Scotland. We feel that our industry is confronted with a plethora of disadvantages – weather, distance from suppliers and markets, ferry or bridge charges added to transportation costs, perceived deterioration in water quality, biotoxin events, eider ducks, an over-enthusiastic 'food police', and so on. In addition there are the larger scale, strategic issues such as competition for space, ICZM, oil tanker spills and the potential for 'exotic' introductions through ballast water discharges.

While concern over these issues is certainly a debatable point of view, there are other producing areas who mirror these drawbacks and face equivalent negative aspects, but have managed to expand faster and to a larger scale than ourselves. This is perhaps another aspect of the critical question that we sought to have analysed some years ago (remember the ill-fated 'Nautilus Report'?), what are the constraints that have prevented Scottish production of cultivated shellfish from expanding at rates enjoyed elsewhere.

The PEI experience

In mid-September I enjoyed a fairly close up look at one of these 'parallel universes', namely Prince Edward Island (PEI) in the Gulf of St Lawrence of eastern Canada. This is the heartland of Canadian mussel production, despite suffering from similar drawbacks to those that afflict our Scottish producers. They are selling fresh product from an island location to distant markets. They are far from equipment suppliers. There are mussel consuming 'seaducks' (various species), and they are dogged with the reputation as the first example of an ASP biotoxin event (with fatalities), and with continued repeats of the intoxication (the latest being an unprecedented Spring event last April). There are the inevitable water quality issues associated with urban waste water discharges and agricultural run-off, while tankers, freighters and passenger ships regularly cruise to and past the island, with a great potential for both pollution and exotic introductions.

In fact PEI has some additional problems to the Scottish difficulties, including a winter season when the mussel farms are covered with a metre of ice and a summer season when water temperatures rise to the level where mussels drop off the ropes! Furthermore, the island suffers from the negative effects of a number of accidental exotic introductions, with ballast water discharges in the Gulf suspected as the main culprit.

The clubbed tunicate, an 'aquatic invader' from Korea, causes considerable problems with fouling

Examples are *Codium fragile tomentosoides* (a Japanese alga), *Carcinus maenas* (European green crab) and *Styela clara* or clubbed tunicate, an "aquatic invader" from Korea. The latter is now so prevalent throughout the eastern inshore waters as a fouling organism that it is 'public enemy Number One' as far as mussel growers are concerned!

Despite all these disadvantages, PEI produces annually around 20,000 tons of mussels, using long-line techniques, and 4,000 tons of oysters (*Crassostrea virginica*), using tray culture methods, a significant industry for the island economy (population 130,000) that has been developed over the past twenty years or so. Although the ecosystem has reached what the industry believe must be close to its sustainable biological carrying capacity (assessed by a decline in growth rate when additional long-lines are introduced), this scale of production makes a appreciable contribution to maintaining the important seafood sector. This forms part of the attraction (along with the pleasant climate and 'Anne of Green Gables'!) for the thousands of tourists who visit the island each year.

Long-line mussel cultivation in Prince Edward Island

The obvious relative under-performance by the industry here in Scotland requires, in the view of the ASSG, a serious and credible review. An in-depth analysis by sector specialists who would be able to identify, from knowledge, insight and experience, the 'choke points' on our development in the Highlands and Islands of Scotland and identify remedial policies and support mechanisms is needed. One difference in PEI, for example, is the relatively low rents, at C$8/acre/year (equivalent to £3), thereby reducing the financial diversion our producers suffer, with payments to the Crown Estate rather than to productive investment.

International Workshop and Conference

Meanwhile, back in Scotland, the ASSG's annual 'International Workshop and Conference' (held mid-October in Oban) this year focused on 'Candidates for Cultivation' (workshop sessions on new and exotic alternatives for the shellfish sector, including sea urchins, abalone, clams, sea horses and freshwater crayfish) and 'Improving Returns from Cultivation'. The latter was an assessment of how to increase profitability from shellfish farming in Scottish waters.

The Workshop was chaired by SNH, an early example of the closer collaboration between ASSG and SNH foreshadowed by the signing of the 'Joint statement of Intent' at last Spring's AGM. The Conference was chaired by Dr Sue Utting of SFIA, with the Keynote address delivered by Dr John Bonardelli, a Canadian consultant currently working in Norway. The Conference session opened with the formal signing and 'launch' of a 'concordat' between the ASSG and WWF Scotland, another example of this Association building bridges to like-minded organisations.

Further information

Doug McLeod, ASSG.
Tel/Fax: 01471 844324;
email: DouglasMcLeod@aol.com;
Mobile: 07831 383826

SHELLFISH PRODUCTION

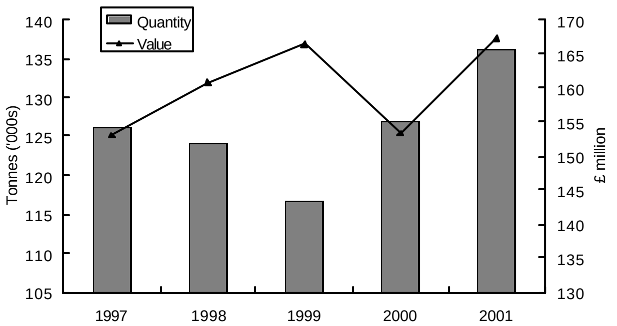
SHELLFISH PRODUCTION IN THE UK IN 2001

The figures available are presented in three categories. Readers should be aware that there is some overlap in the statistics. For example, figures for farmed production of some species may or may not also be included in the Fishery Order figures. This is indicated where information is available. The data are nevertheless valuable for giving an overall impression of activity within and value of the industry, and for comparisons between years. More detailed analyses of the figures may be obtained from the sources quoted.

1. Shellfish landings

Source: Defra, UK Sea Fisheries Statistics 2001, HMSO, London.

About 136,000 tonnes of shellfish were landed in the UK in 2001, representing an increase of just over 6% compared with the previous year. This is in addition to the increase of about 9% from 1999 to 2000. The total catch of fish, including shellfish, landed by the UK fleet in 2001 was 738,000 tonnes, representing a one per cent decrease from the previous year. Shellfish landings were worth over £167 million, which is over 9% higher than in 2000, but returns a value for the industry similar to that in 1999. Total (fish and shellfish) value of landings increased by 4% to £574 million in 2001, from £550 million in 2000. Weight and value of shellfish landings in the UK over the last 5 years are shown on the figure.

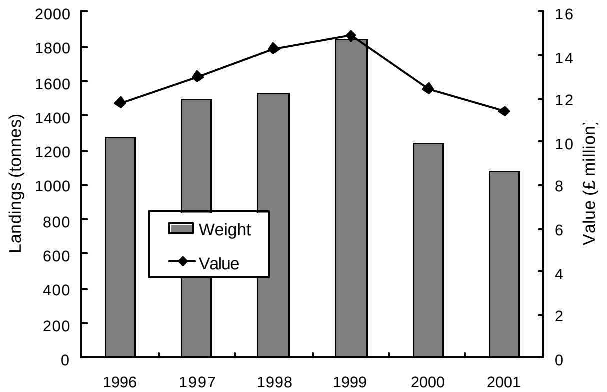


Weight and value of shellfish landings in the UK (1997-2001)

There were major increases in landings of queens, shrimp and mussels in 2001. Landings of queens and shrimp increased by 60% over the previous year and mussel landings doubled. Note that the majority of the mussel landings are from cultivated fisheries, which also appear in the farmed shellfish production figures. The increased landings of these three species accounted for an increase of £6.3 million in the total value of the catch.

The balance of the total increase of £14 million for 2001 was largely due to a 12% increase in the unit price obtained for Nephrops, compared with the previous year. This reverses the trend in 2000, which saw prices fall by 10%, compared with 1999.

Nephrops make up the largest single component of the total catch, at 21%, and account for 41% of the total value. Crabs (18% by weight, 17% by value) are the next most important species. Cockles make up 14% of the catch but contribute only 2% to the total value, whereas scallops, which also make up 14% of the catch, account for 18% of the total value. Lobsters are the most valuable species on a per weight basis, with a price per tonne of about £10,600. They contribute 7% to the total value of the catch, although landings have declined from 1,800 tonnes in 1999 to just over 1,000 tonnes in 2001.



An increase in the price for lobsters has helped to maintain the value of the catch against falling landings in recent years

Total Shellfish landings in the UK in 2001

Type	Tonnes	Value (£s)	Unit Value (£ per tonne)
Cockles	19,047	3,831,668	201
Crabs	24,959	27,830,265	1,115
Lobsters	1,078	11,436,049	10,610
Mussels	14,905	4,835,150	324
Nephrops	28,404	68,432,646	2,409
Periwinkles	759	791,183	1,042
Queen Scallops	8,660	3,666,597	423
Scallops	19,515	29,853,381	1,530
Shrimps	2,554	3,565,939	1,396
Squid	1,391	3,903,295	2,806
Other Shellfish	14,886	9,177,275	
Total Shellfish	**136,162**	**167,323,448**	

The ‘Other Shellfish’ category in the table includes oysters and clams, as well as some high value species, for example, Crawfish, English Prawns, Razor Fish and Squat Lobsters, for which there is no separate information available.

2. Farmed Shellfish Production

A summary table of farmed shellfish production in the UK in 2001 is given below. The total value of the shellfish produced for the table was an estimated £11.1 million, from over 18,500 tonnes. The table does not include production or value of native oysters from the Solent Several and Regulated grounds. These appear in the Fishery Order table in Section 3, below. These oysters are ‘cultivated’ in the sense that the grounds are managed, including the relaying of cultch. The figures also do not include hatchery/nursery seed production, for on-growing, much of which is exported.

Overall production and value of farmed shellfish production for the table in 2001 was broadly similar to that in 2000. Lower production of mussels in England was balanced by increases in Wales and Scotland and, to a lesser extent, Northern Ireland.

A. England and Wales

P. Dunn and I. Laing, CEFAS Weymouth Laboratory, Barrack Road, The Nothe, Weymouth, Dorset, DT4 8UB.

The accompanying tables shows the statistics collected by the Inspectorate during their disease inspection visits to shellfish farms and the summary is presented in the context of previous years to demonstrate trends.

In 2001 there were 114 registered farm sites belonging to 89 businesses in England, an increase of two farm sites compared with 2000. In Wales there were 9 farms belonging to 8 businesses, the same as in 2000. There were 12 sites, all in England, with no recorded production. This is one less than in 2000.

Farmed production of native oysters and manila clams in 2001 increased slightly compared to that in 2000. Levels of production of these species continue to run at the highest that they have been in the last 10 years. There was a 28% drop in pacific oyster production and farmed cockle production also decreased, compared with 2000. A small quantity of palourdes were produced in 2001, and a few tonnes of hard shell clams were fished at one farm site, following four years with no recorded production.

Production (tonnes) of farmed shellfish in the UK in 2001

	Scotland	England	Wales	Northern Ireland	UK Total
Pacific oyster	279	209	16	322	826
Native (flat) oyster	8	117	0	20	145
Scallops	28	0	-	-	28
Queens	47	-	-	-	47
Mussels	2,988	4,799	8,568	977	17,332
Clams	-	34	-	2	36
Cockles	-	105	-	-	105
Estimated Value (£ million)	4.0	2.5	3.0	1.6	11.1

Farmed shellfish (table) production in England and Wales 1996-2001 (in tonnes)

	Native oysters	Pacific oysters	Mussels	Manila clams	Hard clams	Palourdes	Cockles
1996	111.4	584	7,618	11.5	0.3	0	0
1997	68	401	11,684	32	0	0	0
1998	106	330	9,295	19	0	12	43
1999	93	386	8,009	17	0	12	43
2000	115	313	11,224	25	0	3	147
2001	127	225	13,367	29	4	1	105

Farmed juvenile (seed) shellfish production in England and Wales 1996-2001 in thousands (1000s)

	Native oysters	Pacific oysters	Manila clams	Palourdes	Hard clams	Scallops
1996	1,610	66,020	13,150	2,800	0	50
1997	1,810	127,591	19,571	0	0	50
1998	2,200	110,035	20,000	4,010	0	50
1999	2,270	125,500	20,000	4,000	0	0
2000	2,000	63,230	19,200	2,100	0	0
2001	600	318,211	50,000	30,000	62,000	0

Total shellfish production, by weight, continues to be dominated by mussels. The majority of mussels are produced in Wales (64%) and East Anglia (29%), with the remainder coming mainly from south-west England. Most (69%) native oyster farming takes place in the Essex estuaries, whereas pacific oysters are mainly farmed in the south-west of England, with 56% of production coming from this area.

Hatchery seed production of palourdes and manila clams was considerably higher than in previous years. Hard shell clams were produced for the first time since 1993, when just 78,000 were reared. The majority (over 90%) of clam seed was exported. Seed production of pacific oysters also increased, being more than double the highest total of the previous five years and 5 times the production in 2000. Conversely, production of native oyster seed was lower than in any of the previous five years and less than one third of the production in 2000. Lack of hatchery-produced king scallop seed continues to be a concern for the industry although some new initiatives are seeking to address this problem.

In addition to mollusc seed production, The National Lobster Hatchery in Padstow, Cornwall reared and released about 1,000 juvenile lobsters in 2001. This was carried out during September and October at sites off both the north and south Cornish coast.

B. Scotland

Source: "Scottish Shellfish Farm Production Survey 2001" (ISBN : 1363-5867), available from Fisheries Research Services, Marine Laboratory, PO Box 101, Victoria Road, Aberdeen, AB9 8DB (Editors D.J. Pendrey & D.I. Fraser).

Introduction

This report is based on an annual survey questionnaire of all registered Scottish shellfish farming companies. The co-operation of the shellfish farming industry is gratefully acknowledged.

Movement and production forms were sent to 185 companies registered as active before the survey. One hundred and eighty four returns were received, the company that did not respond made no contribution to production in 2000. Shellfish production from two companies, unregistered prior to 2001, are included in the figures. Production returns are recorded from 173 companies. During 2001 sixteen companies de-registered, and returns showed that a further eleven companies ceased trading during the year. One 'wild' mussel fishery registered as a shellfish farm has been excluded from this report.

Activity

The survey shows that 97 companies (56%) produced shellfish for sale, both for the table and for on-growing. The remaining 76 continued in operation, but had no sales during 2001. The number of active companies continued to decrease from a peak of 229 in 1990, to 173 at the end of 2001. These companies farmed 261 active sites, of which 173 (66%), placed shellfish on the market.

The industry employed 137 full-time and 235 part-time workers during 2001, an overall increase of 2% over the previous year.

The number of companies registered as active decreased by 3 during 2001, and the number of active sites increased by 6%. This trend reflects the development of new sites, particularly for mussel production. Many unproductive sites held stock not yet ready for market, others were fallow, and some were positioned in remote areas where the cost-effective production and marketing of shellfish proved difficult.

Many companies cultivate more than one species on site, a practice made possible by similar cultivation techniques. For example, scallops are grown together with queens; Pacific oysters with native oysters and mussels with pacific oysters. The number of companies producing more than 100 tonnes of mussels has increased from 7 to 12 since 2000. Those 12 companies produced 67% of the total mussel production in Scotland. The number of companies producing pacific oysters did not alter significantly in 2001, nor did the scale of production among companies. The seven companies producing over 100,000 pacific oysters produced 82% of the total pacific oyster production in Scotland.

Production
Total production was dominated by mussels (2,988 tonnes) and 3.5 million pacific oysters (279 tonnes). Small volumes of queens (47 tonnes), scallops (28 tonnes) and native oysters (8 tonnes) were also produced.

Pacific oyster production increased by 13% as markets were maintained and demand remained high. Over 80% of pacific oysters were produced in the Strathclyde region. Native oyster production increased by 102%. This accounts for a small percentage of total oyster production, targeting a niche market. Mussel production increased significantly by 49%, as markets were developed, and prices remained high. The greatest increase in production for mussels by region was in Shetland by more than 100%. The mussel production for Shetland was 822 tonnes, 28% of the Scottish total production. Strathclyde region remained the largest producer of mussels, accounting for over 45% of Scottish production. Queen production decreased by 43% through a variation in natural settlement. Production of farmed scallops decreased as a result of environmental influences, which caused area closures and prevented sales for human consumption. Nine Several Orders have been granted for scallop fisheries, seven for commercial companies and two for research and development of which one has recently been withdrawn.

Reports from industry indicated a strong market for scallops and queens throughout the year. Prices of farmed shellfish fluctuated throughout the year, however, the value at first sale of the species cultivated was estimated. The price of pacific oysters varied between 15 and 25 pence per shell; native oysters 50 pence per shell; scallops and queens 50-60 and five pence per shell respectively; and mussels between £800-£1,300 per tonne.

Environmental and health issues
Approved Zone status for the notifiable diseases Bonamia and Marteilia was maintained in 2001 (under EC Directive 91/67) after testing confirmed the absence of these diseases in Scottish waters. Samples were taken from 10 sites holding native oysters, a species known to be susceptible to these shellfish diseases. Approved Zone status continued to offer benefits to both wild and farmed native oyster stocks in Scottish waters. EC Council Directive 95/70 maintains that minimum Community measures for the control of certain diseases affecting bivalve molluscs are in place. A third of all shellfish sites are visited annually by the Fish Health Inspectorate under the Directive. On these visits, facilities, stock health, movement records and registration details are checked. It is the responsibility of farmers to inform the Department of any abnormal, unexplained mortalities on their sites.

Summary
The 2001 survey has shown that:

- Mussels and Pacific oysters are the main species produced in terms of value and tonnage.
- There was an increase in the number of producing sites.
- The number of active sites producing shellfish for table sales rose from 53% to 66%.
- Production of mussels and Pacific oysters increased substantially.
- Manpower increased by 2%.
- There was a substantial increase in the production of native oysters, although scale of production remains low.
- There was a decrease in production of scallops and queens.
- Environmental influences affected scallop sales during the year.
- Approved Zone status for the diseases Bonamia and Marteilia was maintained during the year.
- The industry continues to be dominated by small producers, although there is a trend towards large companies contributing significantly to the annual production of all species.

The market for all species appeared to be buoyant, and prices remained stable throughout the year. It is predicted that production will continue to increase steadily over the next few years, although environmental influences may continue to impact on production of scallops.

C. Northern Ireland

Mr David Martin
DARDNI, Fisheries Division, Annexe 5, Castle Grounds, Stormont Estate, Belfast, BT4 3PW.

Shellfish production statistics for Northern Ireland in 2001 are included in the summary table, above. The industry currently employs 40 full time and 51 part time personnel. Production of all the major species (pacific oysters, native oysters and mussels) was similar to that in 2000. There was an increase in production of other species, mainly clams, from 2 tonnes to 12.6 tonnes. The estimated total value of production increased by 14% compared with 2000.

3. Shellfish Production from Several and Regulated Fisheries

Source: Annual Returns

In England and Wales there are currently 16 Several Fisheries, 7 Regulated Fisheries and 2 Hybrid Order Fisheries. Hybrid Orders are Regulating Orders where the grantee has the power to assign Several plots within the fishery. Scotland has 9 Several Fisheries, primarily for scallops and one Regulated Fishery, covering most shellfish species, around the Shetland Islands. Farmed shellfish production from the Scottish sites is included in the above report.

For England and Wales, information was obtained for all sites, and is included in the table. There was shellfish production at 13 of the 16 Several Fishery sites. Some of the other sites are still being developed; two are affected by adverse hygiene classification, which effectively prevents harvesting of the shellfish on the beds. There was also production at six of the Regulated Fisheries and both of the Hybrid Order Fisheries. The other Regulated Fishery is operated for supplying seed mussels. Various levels of other cultivation activity took place at many of the productive sites, for example relaying of cultch and or stock.

The table shows an estimated total value of production from the Fishery Orders in 2001 of just under £10.5 million. This is an increase of about 25% on the value for 2000, and the total value of production from Fishery Orders is now four times what it was ten years ago.

The 2001 increase was mainly due to further increased production of mussels. The estimated value of this production is the highest to date, from a production figure only marginally lower than the record level of 1997. Mussels made up about 40% of the total value of production from Fishery Orders in 2001, with Welsh Fisheries contributing 65% of this amount. All of the mussel production from Fishery Orders is also recorded as coming from registered farms, with the majority of mussel farming taking place within Fishery orders.

The total production of cockles increased slightly, to 21,231 tonnes, maintaining the record level of 2000. Although landings were lower in some areas, due to closures brought about by detection of DSP toxins, these were compensated by increased production in other areas. Most cockle production is from managed fisheries, with a very small proportion (less than half of one percent) from farming. The total value of the cockles harvested increased by 29%, to a record level of over £4 million.

Production of clams from Fishery Orders increased by around 42% compared to 2000, to a new record of 257 tonnes. The total value almost doubled compared with 2000, due to a recovery in unit price to around £3,000 per tonne, similar to that obtained in the mid 1990s. Clam farming now accounts for only just over 10% of total production, the remainder coming from a managed fishery.

There was a small (8%) increase in production of flat oysters compared with 2000, maintaining the high level of production of the previous year. Care should be taken in interpreting year on year differences in production, however, as the figures are invariably estimated from incomplete information. The estimated total value of these oysters increased by 22%, to over £1.3 million. The industry is proceeding with the native oyster recovery programme, in line with the aims of the Biodiversity Action Plan. This will hopefully further improve the prospects for the cultivation of this species in future years.

The level of production of Pacific oysters from Fishery Orders in 2001 was similar to the previous year. All Pacific oyster production in England and Wales is from registered shellfish farms (and is included in the farmed production figures) showing that only around 23% of the total production of this species takes place in Fishery Orders. The reported estimated value decreased considerably, compared with 2000, continuing the pattern in apparent fluctuation in value of this species from year to year.

Production/Landings (tonnes) of shellfish from Fishery Orders in England and Wales in 2001

Type	Several	Regulated	Hybrid	Total	Estimated Value (£,000s)
Pacific oyster	31.5	0	20	51.5	52
Native (flat) oyster	95	906	16	1,017	1,321
Clams	-	0	257	257	774
Mussels	8,727	311	4,109	13,147	4,260
Cockles	-	12,225	9,006	21,231	4,068

UK SHELLFISH IMPORTS AND EXPORTS

Source: H M Customs and Excise.
Data prepared by Statistics (Commodities & Food) Accounts and Trade, ESD, Defra

The UK is a net exporter of shellfish, with over 91,000 tonnes leaving the country in 2001, compared with imports of 53,000 tonnes. Trade increased in both directions, compared with 2000, with imports up by 8% and exports up by 4%. The UK exported a total of £732 million worth of fish (including shellfish) and fish products in 2001, a five per cent increase over 2000.

Trade in selected shellfish species, together with the totals for crustaceans and molluscs are shown in the table.

UK trade in selected shellfish in 2001 (tonnes)

	Exports	Imports
Crabs	13,790	1,116
Lobsters	1,028	1,464
Shrimps and Prawns	24,707	38,136
Crustaceans Total	**54,601**	**41,684**
Mussels	15,232	3,996
Oysters	905	392
Scallops	10,128	844
Molluscs Total	**36,552**	**11,371**

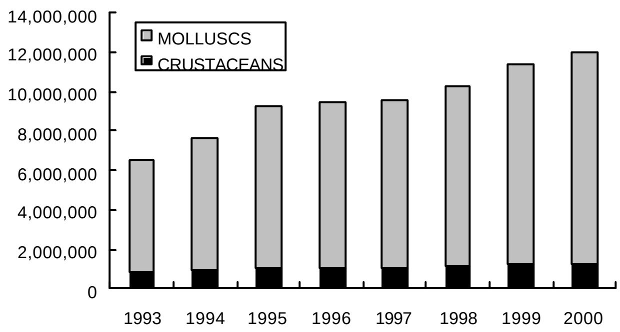
Crustaceans account for the bulk of the trade, making up 60% of total exports and 78% of the imports. Shrimps and Prawns provide most of the trade in crustaceans, with the bulk of the exports, over 20,000 tonnes, going elsewhere in the EU, with Italy being the main customer. The majority of the imports, over 32,000 tonnes, come from Asian countries, with India and Bangladesh being the main suppliers. Most of the crabs exported from the UK go to Spain and France. Almost all the lobsters imported are live animals, coming mainly from Canada.

For molluscs, most of the mussels exported from the UK are sent to France, predominantly as a live/fresh or chilled product. France and Spain take the majority of our oyster exports, all in a live/fresh or chilled state. About two thirds of the scallops exported are frozen, most going to France, Italy, and Spain. France is the major importer of UK live/fresh or chilled scallops and is by far the largest European importer for scallops of various species, with over 90,000t consumed every year. These are supplied by imports from North and South America, Vietnam, Russia, Iceland and New Zealand, as well as from the British Isles. About 75% of UK mussel imports are frozen, coming mainly from New Zealand, Denmark and the Irish Republic. Denmark, the Netherlands and Ireland are the main suppliers of live/ fresh or chilled mussels to the UK. Most of the oysters imported into the UK come from Ireland.

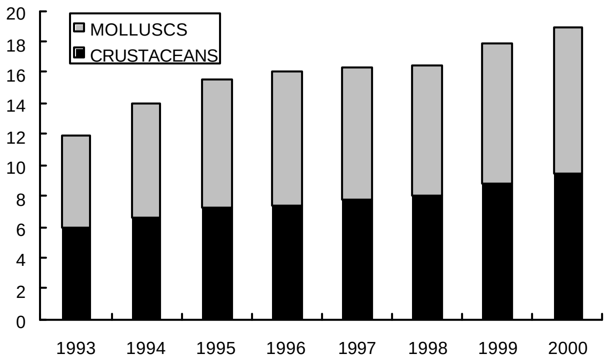
WORLD SHELLFISH PRODUCTION

Each year, the Food and Agriculture Organisation of the United Nations (FAO) publishes data on the status of global fisheries and aquaculture. The figures for 2000 are now available.

Shellfish (crustaceans and molluscs) account for about 48% of total world marine or brackish water aquaculture production, by weight, and 59% of the value. The total production also includes marine fish as well as aquatic plants (mainly seaweed), together with small quantities of other invertebrates, amphibians and reptiles. The figures translate to 27% of the total weight and 33% of the total value for all aquaculture, including freshwater production. The charts show that world shellfish aquaculture production continues to increase. There was an annual increase in production by weight of about 5.5% in 2000, from 10.7 million metric tonnes in 1999 to over 12 million metric tonnes. There was also a 6% increase in the total value of these shellfish, from 17.9 billion US dollars in 1999 to almost 18.9 billion US dollars in 2000.



World Aqaculture - shellfish production (metric tonnes)



World Aqauculture - shellfish value ($US billion)

Molluscs make up almost 90% of the total production by weight, but the greater unit value of crustaceans gives them roughly equal value. Around 90% of all shellfish production is from Asia, although Europe contributes about 7% of total world mollusc production.

The Pacific oyster (*Crassostrea gigas*) is by far the most important individual species, making up over a third of the production and value of the molluscs. Production of this species reached almost 4 million metric tonnes in 2000, an increase of over 9% compared with the previous year. Production of this species has increased by 3.3 times over the last ten years.

Mussels make up only just over 4% of total world mollusc production. Spain is the largest European producer. About 230,000 tonnes of mussels were produced from Galicia last year, with a first sale value of 115 million Euro. The volume of production rose 25 per cent by volume and 30 per cent by value, compared with the previous year, according to statistics from the Mussel Regulatory Council of Galicia. While production in 2000 was only 184,000 tonnes due to the bad weather that affected the region, last year's figures show a return to a steady rate of growth in output. In 1998, production reached 220,000, rising to 225,000 tonnes in 1999. According to a report from the Regulatory Council, the increase in sales of Galician mussels is associated with the increasing popularity of the shellfish, which consumers see as a natural product with great nutritional value.

RESEARCH NEWS

Research News includes abstracts of recent work that may be of interest to the shellfish industries. These abstracts are taken both from papers published in international scientific journals and from project work undertaken by students at Universities and Research Laboratories. Results from the latter are usually not widely available and ***supervisors of student projects are encouraged to submit abstracts to Shellfish News as a means of publishing this information.***

1. Preserving algae diets

A flocculation method for preparing concentrates of seven microalgae was assessed. The flocculates were stored at 4°C for 9-21 days and were compared against the corresponding fresh microalgae. The results from this study demonstrated that flocculated concentrates of microalgae, especially of the two *Chaetoceros* diatom species tested, can be used effectively as major dietary components for larval and juvenile oysters.

Reference

Brown, M. (malcolm.brown@marine.csiro.au), Robert, R., 2002. Preparation and assessment of microalgal concentrates as feeds for larval and juvenile Pacific oyster (*Crassostrea gigas*). Aquaculture Vol 207, pp 289-309.

2. Conditioning oyster broodstock with lipid emulsions

Pacific oyster broodstock were hatchery-conditioned with either a mixed algae diet (*Dunaliella tertiolecta*, *Tetraselmis suecica* and *Rhodomonas* sp), a single diet of *D. tertiolecta* or a single diet of *D. tertiolecta* supplemented with an emulsion rich in eicosapentaenoic (20:5n-3) and docosahexaenoic acid (22:6n-3). Oysters were spawned after a conditioning period of 7 and 8 weeks and larvae were reared for 1 week. The results indicated that supplementation of a poor broodstock diet (*D. tertiolecta*) with a lipid emulsion gives more, better quality D-larvae.

Neither the broodstock diet nor the conditioning period affected the size of eggs or D-larvae, larval performance, or lipid content and lipid class distribution of the eggs. The fatty acid composition of the eggs was modified by the fatty acid composition of the algae diet and the lipid emulsion. The supplementation of the emulsion resulted in a pronounced increase in the percentage of 22:6n-3 in the polar and neutral lipids of the eggs. The percentage recovery of D-larvae from eggs from oysters fed the supplemented diet was no different to that from the oysters fed the mixed algae diet, and was much higher than from eggs produced by oysters fed only *Dunaliella*. The reduction in the percentage recovery of D-larvae as a result of temperature or salinity stress was most severe in eggs from oysters fed only *Dunaliella*.

Reference

CAERS, M. (marrit.caers@belgacom.net), UTTING, S.D., COUTTEAU, P., MILLICAN, P.F., SORGELOOS, P., 2002. Impact of the supplementation of a docosahexaenoic acid-rich emulsion on the reproductive output of oyster broodstock, *Crassostrea gigas*. Marine Biology Vol 140, pp 1157-1166.

3. Triploid oysters - a review

The commercial benefits of triploidy have been evaluated in the Pacific oyster (*Crassostrea gigas*), eastern oyster (*C. virginica*), Sydney rock oyster (*Saccostrea glomerata*) and European flat oyster (*Ostrea edulis*). However, this technique has so far only been commercialised for Pacific oysters. Commercial production of triploid pacific oysters on the West Coast of North America began in 1985. Since then production of triploids has greatly increased and the use of tetraploid males to fertilise eggs from diploid females, to produce batches of 100% triploids has been developed.

In 1999/2000, triploid Pacific oysters made up about 30% of all Pacific oysters farmed on the West Coast of North America. Some hatcheries now use tetraploid males instead of chemical or physical stress to produce triploids. The rapid uptake of triploid and tetraploidy techniques has been facilitated by the almost total dependence that these oyster industries have on hatcheries for the supply of seed. This industry in the Pacific Northwest of the US and in British Columbia, Canada would not have developed to its current size without hatchery seed supplies. Triploids are preferred over diploids in summer because diploids are less marketable when in spawning condition.

In France there was only limited interest in triploidy production until 1999, when IFREMER began to make sperm from tetraploids available to commercial hatcheries. In 1999/2000, only 10% to 20% of all the hatchery-supplied Pacific oyster spat were triploids, but with the use of sperm from tetraploid oysters, this could increase sharply.

Elsewhere around the world, the commercial uptake of triploid oysters has been slow to develop. However, in countries where the production of Pacific oysters is based on hatchery supply of seed, it is likely that with the use of tetraploid oysters, the farming of triploid oysters will increase in the near future.

Reference

NELL, J.A. (nellj@fisheries.nsw.gov.au), 2002. Farming triploid oysters. Aquaculture Vol 210 pp 69-88.

4. Triploids always do better

An increasing number of hypotheses are being proposed to explain the faster growth potential of triploids in molluscs, including their partial sterility or their higher heterozygosity compared to diploids. Triploid advantage however, remains controversial for poorer sites, because of a potential trade-off with survival. These questions were addressed in *Crassostrea gigas* by deploying triploids and their diploid siblings from a single mass spawning of three males and seven females at one good and one poor on-growing site.

Higher performance of triploids was observed at the fast-growing site for all traits except shell weight, and triploids had greater weights and biochemical contents than diploids at harvest. Triploids also grew faster at the poorer site, and showed similar survival rates to diploids at both sites.

Reference

GARNIER-GERE, P.H., NACIRI-GRAVEN, Y. (Yamama.Naciri-Graven@cjb.ville-ge.ch), BOUGRIER, S., MAGOULAS, A., HERAL, M., KOTOULAS, G., HAWKINS, A., GERARD, A., 2002. Influences of triploidy, parentage and genetic diversity on growth of the Pacific oyster *Crassostrea gigas* reared in contrasting natural environments. Molecular Ecology Vol 11, pp 1499-1514.

5. Oyster herpes virus

Since 1972, several herpes-like virus infections have been reported among different bivalve species around the world. Most of these reports involved larvae or juveniles and infections were associated with high mortalities. Molecular techniques including PCR and in situ hybridization (ISH) have recently been developed to detect the oyster herpes virus. Using these techniques it has been shown that oyster herpes virus can also infect adult oysters, with a high prevalence, and the virus may persist in its host after primary infection. The detection of viral DNA and viral proteins in the gonad of several individuals supports the possibility of vertical transmission of the infection.

Reference

ARZUL, I., RENAULT, T. (trenault@ifremer.fr), THEBAULT, A., GERARD, A., 2002. Detection of oyster herpesvirus DNA and proteins in asymptomatic *Crassostrea gigas* adults. Virus Research Vol 84, pp 151-160.

6. Monitoring oyster performance in France

Every year since 1993, from February to December, the French network IFREMER/REMORA has monitored mortality, growth and quality criteria of two oyster year-classes ('juveniles' of the first-year class and 'adults' of the second-year class), distributed among various sites in French oyster farming areas. This has provided a standard and simple annual assessment of performance. Each year, data series have been obtained, from which mean values (references), chronological trends or spatial differences can be analysed.

Results in Brittany, from 1993 to 1998, show that 80% of oysters of 30 g in February grow to a range of 55-85 g at the end of the year, with a mortality rate lower than 20%. Mortality occurs mainly in spring for adults and in summer for juveniles. Although annual fluctuations exist, connected to climatic and hydrological influences, differences remain high between the sites monitored. This allows characterisation of sites. Some chronological trends appeared significant, but the time period is too short for any prediction. Unusual mortalities (in 1995), lack of growth (1998) and problems with quality (infestation by the worm *Polydora*) have been identified and quantified. The observation of unusual results, which might not be fully explained by annual variation or site specific factors gives the REMORA network the role of watchdog and the possibility of giving advice for collective oyster management.

Reference

Fleury, P.G. (IFREMER Shellfish Laboratory Brittany, 12 Rue Resistants, F-56470 La Trinite Sur Mer, France), Goyard, E., Mazurie, J., Claude, S., Bouget, J.F., Langlade, A., Le Coguic, Y., 2001. The assessing of Pacific oyster (*Crassostrea gigas*) rearing performances by the IFREMER/ REMORA network: method and first results (1993-98) in Brittany (France). Hydrobiologia Vol 465, pp 195-208.

7. Birds and oyster culture

The species composition, numbers and behaviour of birds in an inter-tidal oyster culture area in Cork Harbour were observed and comparisons made with similar observations at a nearby area free of aquaculture within the same estuary.

Species that occurred in the aquaculture-free area were also observed in the trestle-area. The most abundant species were oystercatcher, redshank, dunlin, curlew, black-headed gull and common gull. There were fewer oystercatcher, curlew, black-headed gull and common gull in the trestle area, compared with the aquaculture-free area. Similar numbers of redshank and dunlin were observed in both areas.

The percentage of birds feeding did not differ between the two areas. Oystercatcher, redshank, dunlin and curlew fed in both areas. Black-headed gull and common gull were not observed feeding in either area. The number of birds, except for the dunlin, was similar whether or not oyster bags covered the trestles. Dunlin were significantly more frequent beneath trestles with bags on, compared with those without bags. Oystercatcher, redshank and curlew all spent more time underneath the trestles than outside them.

These preliminary observations at a single time period give some insight as to the potential interactions between shellfish aquaculture and intertidal birds.

Reference

Hilgerloh, G., O' Halloran, J. (University College Cork, Department of Zoology & Animal Ecology, Cork, Ireland), Kelly, T.C., Burnell, G.M., 2001. A preliminary study on the effects of oyster culturing structures on birds in a sheltered Irish estuary. Hydrobiologia Vol 465, pp 175-180.

8. Acclimation of scallop spat

Hatchery-produced great scallop (*Pecten maximus*) spat of 1 to 5 mm shell height were transferred to a sea-based nursery from March to August 1995. Because the growth season in Norwegian waters is limited by low sea temperature in the spring (5°C-10°C), acclimation to a colder temperature (10°C) than the 15°C in the hatchery was considered in order to enhance survival after deployment. Survival and growth of spat deployed directly to the sea were compared with spat acclimated for 1 wk and 3 wk.

Mean survival of the acclimated groups was 0% to 9% for small spat (0.7-2.3 mm) and 25% to 36% for bigger spat (4 mm). Acclimation improved mean survival by up to 7% for the small spat and 11% for the bigger spat. There was no difference in results for the two (1 wk and 3 wk) acclimation periods.

Acclimation to a temperature lower than 10°C gave only limited increase in survival It was found that small spat (<2.6 mm) should not be transferred to temperatures <7°C. By deploying bigger spat (>4 mm) to low sea temperatures, high survival can be expected, and thereby the production period is extended.

Reference

Christophersen, G (University of Bergen, Centre for Studies on the Environment & Resources, Bergen, Norway), Magnesen, T., 2001. Effects of deployment time and acclimation on survival and growth of hatchery-reared scallop (*Pecten maximus*) spat transferred to the sea. Journal of Shellfish Research Vol 20, pp 1043-1050.

9. Scallop discards

The objective of this study was to use changes in adenylic energetic charge (AEC) and righting and recessing behaviour as indicators of stress in scallops caused by the act of dredging. It was found that following dredging disturbance discarded (undersized) animals may be less able to escape from predators, and may have reduced chances of survival in the open sea.

Two field experiments using a commercial dredge and four laboratory experiments using a dredge simulator were carried out. AEC levels decreased in the striated muscle from 0.9 to approximately 0.5 after dredging, however, no difference was found between different lengths of tow, or length of time in the dredge simulator (15, 30 or 45 min). The AEC levels of dredged scallops returned to normal after 3 days in optimal conditions. Dredged smaller scallops (<65 mm shell height) had a higher AEC level (0.54-0.58) and were more active than dredged larger animals (>70 mm shell height, AEC level: 0.41-0.46). Dredging followed by emersion had a negative effect on AEC levels and on the righting and recessing speed of scallops. Physical movement of the scallops within the dredge bag combined with anaerobic respiration during valve closure has an added stress effect during dredging. Overall, AEC levels were not reduced enough to cause mortality, but the righting and recessing speed of scallops was greatly reduced after dredging.

Reference

MAGUIRE, J.A. (maguire_julie@hotmail.com), COLEMAN, A., JENKINS, S., BURNELL, G.M., 2002. Effects of dredging on undersized scallops. Fisheries Research Vol 56, pp 155-165.

10. Effects of scallop dredging

A 2 square km area off the south west coast of the Isle of Man (Irish Sea) has been closed to commercial fishing with mobile gear since March 1989. This area was heavily fished for king scallops (*Pecten maximus*) prior to closure, and the seabed immediately surrounding the closed area is still one of the most heavily dredged in the Irish Sea. Two methods have been used to study the effect of scallop dredging on the benthos in this closed area and adjacent fished areas. Firstly, twice-yearly grab sampling of experimental plots inside and outside the closed area since 1995 has enabled comparisons of the benthic infauna and epifauna of experimentally dredged plots, undredged control plots and plots exposed to commercial dredging. Secondly, divers have carried out visual surveys of scallop numbers regularly since closure.

Communities of experimentally disturbed plots have become less similar to adjacent undisturbed control areas and more similar to commercially dredged areas. Since 1989, there have been increases in the mean numbers of scallops in the closed area. The age structure of the closed area scallop population is also different to that outside, with a higher mean age due to the presence of larger, older individuals. These results present strong evidence that scallop dredging alters benthic communities and suggest that the closure of areas to commercial dredging may allow the development of more heterogeneous communities and permit the populations of some species to increase. A common problem with studying fishing disturbance is the lack of good control sites and this work also demonstrates the value of closed areas to scientific studies of demersal fishing.

Reference

BRADSHAW, C .(CBRADS88@hotmail.com)., VEALE, L.O., HILL, A.S., BRAND, A.R., 2001. The effect of scallop dredging on Irish Sea benthos: experiments using a closed area. Hydrobiologia Vol 465, pp 129-138.

11. Restoring New Zealand clam beds

The New Zealand little neck clam, *Austrovenus stutchburyi*, is widely distributed in sheltered inter-tidal habitats around New Zealand and has long been harvested by recreational and traditional fishers. Clam populations have declined on many beaches due to excessive harvesting and habitat change, such as sedimentation and pollution. The feasibility of transplanting clams as a method of shellfish enhancement was tested. These pilot-scale trials demonstrated that transplant is feasible and would be particularly successful for adult clams.

Manipulative field experiments using tagged clams examined parameters likely to affect growth and survival of transplanted clams, including the size of seed used, density and shore level at which seed is planted out, and the season in which the transplant is undertaken. Juvenile clams (10-18 mm) had a mean recovery rate of 30% after 1 y. Growth was highest for clams transplanted to low on the shore, but mortality was also highest for these clams. Optimal placement of juvenile seed for enhancement would be at mid-shore levels, where more clams were retained and reasonable growth still occurred. A much higher recovery rate (60%-90%) was achieved for adult clams (25-32 mm), and they were more likely to remain in the new area.

Reference

STEWART, M.J., CREESE, R.G., 2002. Transplants of intertidal shellfish for enhancement of depleted populations: Preliminary trials with the New Zealand little neck clam. Journal of Shellfish Research Vol 21, pp 21-27.

12. Manila clams and Green crabs

The introduced European green crab (*Carcinus maenas*) poses a potential risk for commercial production of Manila clams, a growing fishery in western North America. We investigated methods for modifying commercial production of Manila clams in order to reduce losses to green crab predation. We conclude that in years of high green crab abundance, delayed planting out is an effective means of reducing losses of commercially produced Manila clams.

In both 1997 and 1998, the timing of the planting out of seed clams was varied such that one portion of the total clam production was planted out early in the year (March) and another portion planted out later in the year (August/September). In July and August 2000, we examined the bags planted out in 1997 and 1998 and quantified the clam mortality and the abundance of crabs, including green crabs. We found significantly fewer green crabs and less predation on Manila clams in bags that were planted out in the late season. Year of planting out also influenced clam survival and green crab abundance, and delaying planting out significantly increased clam survival.

We suggest that the increased Manila clam survival in bags planted out later was probably due to reduced green crab recruitment and consequently lower green crab predation. We conducted additional experiments on relative predation rates by green crabs on Manila clams. We found that green crab predation is strongly size dependent, and that while juvenile green crabs were not effective predators of market size Manila clams (> 36 mm in width) these clams were easily consumed by adult green crabs (> 50 mm carapace width).

Reference

GROSHOLZ, E., OLIN, P., WILLIAMS, B., TINSMAN, R., 2001. Reducing predation on Manila clams by nonindigenous European green crabs. Journal of Shellfish Research Vol 20, pp 913-919.

13. Hermaphrodite clams

Inmature individuals of the native palourde, *Ruditapes decussatus*, collected from the Galician coast (Spain), were maintained in a laboratory open-flow seawater system over a 76-day period at a temperature of 18-20 °C and fed with *Isochrysis galbana* clone T-ISO. A histological study of gonad development was performed in sub-samples of clams collected every 15 days. Two hermaphrodite individuals were found, in which both male and female gametes were present.

Reference

DELGADO, M., CAMACHO, A.P. (alejandro.perez@co.ieo.es), 2002. Hermaphroditism in *Ruditapes decussatus* (L.) (Bivalvia) from the Galician coast (Spain). Scientia Marina Vol 66, pp 183-185.

14. Razor clam bed study

A razor clam (*Ensis siliqua*) bed of 21 square km was discovered at Gormanstown on the East coast of Ireland in 1997. Between July 1998 and August 1999, dredge samples were collected from vessels fishing there and these provided material for biological analysis. As harvesting proceeded smaller individuals appeared in the samples; these may have come onto the bed from the periphery where there were high densities of larger clams. On the clam bed the animals ranged from 0+ to 19+ years old. They grew at a slower rate on the west coast of the Irish Sea than on the coast of North Wales. Males grew slightly faster and longer than females and males were more numerous in the landings. The clams are estimated to commence maturation at approximately 4 years of age. They have a similar reproductive cycle to those in Portugal, with a similar spawning period from mid-May to the end of July or early August. Condition reflects gonad development, reaching a peak in May. Harvesting by hydraulic dredging causes breakage, which is higher in quarters 1 and 4 than in quarters 2 and 3. Bruised razor clams do not eliminate sand in de-sanding tanks and so processors reject them. The total biomass of the Gormanstown bed is estimated at approximately 1,500 tonnes of which two thirds had been removed by July 1999, two years after exploitation commenced.

Reference

FAHY, E (Fisheries Research Centre, Institute of the Marine, Dublin 15, Ireland), GAFFNEY, J., 2001. Growth statistics of an exploited razor clam (*Ensis siliqua*) bed at Gormanstown, Co Meath, Ireland. Hydrobiologia Vol 465, pp 139-151.

15. Irish razor clam mortality

Mortalities of the razor clam *Ensis arcuatus* were widespread in western Ireland in the spring months of 2001. Losses from one razor clam bed were estimated at 74%. Larger razor clams were more susceptible. Histological and bacteriological examinations and TEM were carried out on moribund and live individuals but no pathological cause was identified. Gonadal staging revealed that large clams were partially or completely spent. Mortality is explained as a post-spawning phenomenon, being unusually severe in 2001.

Reference

FAHY, E., ALCANTARA, M.L., NORMAN, M., BROWNE, R., ROANTREE, V., PFEIFFER, N., 2002. Mortalities of *Ensis arcuatus* (Jeffreys) (Solenacea) in western Ireland. Journal of Shellfish Research Vol 21, pp 29-32.

16. A study of mussel beds (1)

An annular flume was used to measure the effect of increasing current velocity on mussel (*Mytilus edulis*) feeding rate and the stability of beds of mussel from the mouth of the estuary of the River Exe (SW England).

It was found that the feeding rates of mussels from open coast sites were unaffected by current velocities up to 0.8 m per second. Algal cell depletion in the water column above the mussels increased with declining current velocity below 0.05 m per second.

The stability of the mussel bed was found to be a function of the nature of the substrate and the density of the mussels. Sediment re-suspension was about five and four times higher for 25% and 50% mussel cover, respectively, compared with sand with no mussel cover. This was due to the increased turbulence and scouring around the clumps of mussels in low-density parts of the bed, and this resulted in some mussels detaching from the bed. At full (100%) mussel cover, the sandy bed was more protected by the dense surface layer of mussels None became detached during erosion due to the high number of byssal attachments between individuals and sediment re-suspension was about three times lower than with no mussel cover. Erosion of the bed with 50% mussel cover resulted in burial of a large proportion of the mussels, with a 6 cm increase in sediment level.

However, the mussels returned to the surface and recovered in 1-2 days, due to a combination of migration upwards and substrate settlement.

Channels on the edge of the main Exmouth mussel bed were characterised by a more stable substrate comprising pebbles and sand with varying mussel densities. At these sites, where mussels experience high current velocities on spring tides (up to 0.9 m per second), there was no difference between the erosion rate of the pebble/sand substrate irrespective of the amount of mussel cover. Also, the sediment erosion rate was lower than that with 100% mussel cover on the sandy substrate.

Sampling of different parts of the mussel bed at Exmouth showed mussels at low densities were made up of smaller clumps with a lower mass ratio of mussels to attached substrate (pebbles/sand), thus providing a greater degree of anchorage.

Reference

Widdows, J. (jwiddows@pml.ac.uk), Lucas, J.S., Brinsley, M.D., Salkeld, P.N., Staff, F.J., 2002. Investigation of the effects of current velocity on mussel feeding and mussel bed stability, using an annular flume. Helgoland Marine Research Vol 56, pp 3-12.

17. A study of mussel beds (2)

An analysis of habitat suitability for littoral mussel beds in the Dutch Wadden Sea was carried out. The analysis was based on the presence of mussel beds in the years 1960-1970.

Wave action (maximum orbital velocity) was the main structuring factor for the beds. A low orbital velocity was preferred. Neither very low, nor maximum current flow rates were favourable for mussel beds. Very coarse sands or silty environments were not favoured. Sites close to the low water line had fewer mussels; when emersion time was above 50%, hardly any mussel beds could be found.

Reference

Brinkman, A.G. (a.g.brinkman@alterra.wag-ur.nl), Dankers, N., van Stralen, M., 2002. An analysis of mussel bed habitats in the Dutch Wadden Sea. Helgoland Marine Research Vol 56, pp 59-75.

18. Mussel hybrids in south west England

The distribution of the mussel species *Mytilus edulis*, *M. galloprovincialis*, and their hybrids was examined in mussel populations in south west England in 1996 and 1998. This is a region where both parents and populations containing large numbers of hybrids co-occur, yet a fine-scale mapping of the hybrid populations had not been conducted.

In this study the geographic distribution of hybrid populations was determined over 360 km of coast in south west England from Tintagel Castle in north Cornwall to Beer in south Devon. Sample localities were spaced from 5 to 20 km apart. Genotypes for individual mussels were determined using PCR by a method to distinguish between *M. edulis* and *M. galloprovincialis*.

There was a patch of mussels on the south coast of Devon extending at least 70 km east of Start Point that consisted entirely of pure *M. edulis*. In contrast, mussel populations on the north Cornwall coast east of St. Ives were predominantly *M. galloprovincialis*. Along the 180 km of open coast between these two locations hybrid populations, characterised by high frequencies of individuals with heterozygous genotypes, were found. There was a pattern of decreasing frequency of *M. edulis* alleles with increasing shell length, suggesting that strong natural selection in hybrid populations results in a decline in the frequency of *M. edulis* alleles with increasing size. Wave-exposure has previously been implicated as the agent producing this pattern of selection, but in the present study the relationship between allele frequency and body size was not correlated with variation in wave shock intensity among localities within the hybrid zone. The age of mussels was not measured, so it is possible that selection and growth interact to confound the interpretation of the gradient of the slope describing the decline in frequency of *M. edulis* alleles with increasing mussel size.

The transition between hybrid populations and those containing pure populations of *M. edulis* or *M. galloprovincialis* is abrupt, which suggests that coastal circulation patterns may provide strong barriers to larval dispersal. This would account for the position and maintenance of the hybrid zone.

Reference

Hilbish, T.J. (hilbish@biol.sc.edu), Carson, E.W., Plante, J.R., Weaver, L.A., Gilg, M.R., 2002. Distribution of *Mytilus edulis*, *M. galloprovincialis*, and their hybrids in open-coast populations of mussels in southwestern England. Marine Biology Vol 140, pp 137-142.

19. TBT stresses mussels (1)

The effect of very low concentrations (1, 3 and 6 ng Sn (tin) per litre) of tributyltin (TBT) and dibutyltin (DBT) on the internal defence of adult blue mussel *Mytilus edulis* were determined under flow-through conditions. The results show that both TBT and DBT can affect the internal defence system of mussels at concentrations as low as 1 ng Sn per litre after only a few days of continuous exposure.

Samples of the hemolymph were taken from the mussels, without harming them, on Days 0, 1, 4 and 11 of exposure to the butyltins. TBT at 6 ng per litre caused an increase in hemocyte count from Day 1 and DBT at 3 and 6 ng per litre gave an increase on Day 11. Other indicators of a stress response were also looked at. No difference was detected between the impacts of TBT and DBT on lysosome retention, which was increased by both butyltins at concentrations as low as 1 ng per litre, from Day 4. DBT had a greater impact on phagocytic activity, giving an increase from Day 4 at 6 ng per litre.

Reference

St-Jean, S.D., Pelletier, E. (emilien_pelletier@uqar.qc.ca), Courtenay, S.C., 2002. Very low levels of waterborne butyltins modulate hemocyte function in the blue mussel *Mytilus edulis.* Marine Ecology Progress Series Vol 236, pp 155-161.

20. TBT stresses mussels (2)

The effects of a range of concentrations of tributyltin (TBT) and dibutyltin (DBT), containing 5-80 ng Sn (tin) per litre, on the hemocyte functions of the blue mussel *Mytilus edulis* were investigated. The study established strong and sustained responses of hemocyte functions of blue mussels exposed to environmentally relevant, waterborne concentrations of TBT and DBT. It is assumed that this will increase their vulnerability to other environmental stresses and pathogens, even at low seawater temperatures.

Both TBT and DBT significantly affected all cellular functions measured. Membrane injury was present as early as Day 1 for TBT doses greater than 10 ng Sn per litre and DBT doses greater than 20 ng Sn per litre. All TBT and DBT doses had produced significant membrane injury in 32 days. Phagocytic activity was reduced by all doses of TBT and DBT by day 18. Lysosyme retention was significantly elevated by a DBT dose of 80 ng Sn per litre between days 1 and 4 but not thereafter. Significant elevations and depressions in haemocyte count were observed in mussels exposed to both butyltins, although effects were highly variable and not clearly related to either dose or time of exposure. Mature and juvenile mussels were injected with the common bacterium *Vibrio anguillarum* after exposure to the TBT or DBT concentrations described above. For both butyltins, a significant dose-related impairment in clearing *Vibrio* from the hemolymph was observed. Clearance of bacteria was slower for the juveniles than for the adults suggesting that the early life stages of mussels may be more affected by butyltin exposure than are the adults.

Reference

St-Jean, S.D., Pelletier, E. (emilien_pelletier@uqar.qc.ca), Courtenay, S.C., 2002. Hemocyte functions and bacterial clearance affected in vivo by TBT and DBT in the blue mussel *Mytilus edulis*. Marine Ecology Progress Series Vol 236, pp 163-178.

21. Contaminants in shellfish

Fish and shellfish are exposed to a wide range of polycyclic aromatic hydrocarbons (PAHs) following oil spills at sea, and can become contaminated as a result. Finfish are able to metabolise and excrete PAHs more effectively than invertebrates. Thus, contamination by high-molecular weight PAHs, including those with carcinogenic potential and so of concern with regard to human consumers, is therefore usually observed in shellfish, and particularly in bivalve molluscs.

Oil spills are not the sole source of PAHs, however, as parent compounds are also generated by a wide range of combustion processes. Monitoring data gathered following recent oil spills (both of crude oil and diesel fuel) alongside data from other studies, including studies conducted around a former gasworks site and downstream of an aluminium smelter in the UK, were examined.

Our aim was to assess the utility of this approach in fishery resource monitoring and control following oil spills. Certainly this approach seems useful from the data assessed in this study, and the relative ranking of the various studies seems to reflect the relative degree of concern for human consumers due to the differing contamination sources. As a simple tool for control purposes it is equally applicable to PAHs derived from oil spills, and from industrial and combustion sources.

References

Law, R.J. (r.j.law@cefas.co.uk), Kelly, C., Baker, K., Jones, J., McIntosh, A.D., Moffat, C.F. 2002. Toxic equivalency factors for PAH and their applicability in shellfish pollution monitoring studies. Journal of Environmental Monitoring Vol 4, pp 383-388.

22. Viral contamination of mussels

A study of the presence of hepatitis A virus and enterovirus in shellfish from the northwestern coast of Spain, one of the most important mussel producers in the world, was carried out. In addition, bacterial contamination of the samples was evaluated by *Escherichia coli* counts, according to the European Union standards of shellfish microbiological quality. Shellfish samples included raft-cultured and wild mussels, as well as wild clams and cockles. The results reinforced the inadequacy of bacteriological standards to assess viral contamination and suggest that although analysis of shellfish for viruses is possible using molecular techniques, inter-laboratory standardisation and validation studies are needed before they can routinely be used in monitoring shellfish microbiological safety.

Bacterial counts showed that the majority of samples could be classified as moderately polluted, and therefore should undergo depuration. However, differences in bacterial contamination were observed between cultured mussels and wild shellfish. The percentage of clean samples was clearly higher in cultured mussels (49.1%) than in wild mussels (22.8%) or clams and cockles (10.7%).

Hepatitis A virus was detected in 27.4% and enterovirus in 43.9% of the samples that were analysed. Simultaneous detection of both viral types occurred in 14.1% of the samples. There was no relationship either between viral and bacterial contamination, or between the presence of hepatitis A virus and enterovirus. Comparative analysis of two methods of viral detection yielded different results depending on the virus type that was being identified.

Reference

Romalde, J.L. (mpromald@usc.es), Area, E., Sanchez, G., Ribao, C., Torrado, I., Abad, X., Pinto, R.M., Barja, J.L., Bosch, A., 2002. Prevalence of enterovirus and hepatitis A virus in bivalve molluscs from Galicia (NW Spain): inadequacy of the EU standards of microbiological quality. International Journal of Food Microbiology Vol 74, pp 119-130.

23. Shellfish hygiene indicators

The sanitary classification of harvesting areas for bivalve mollusks in France is based on the level of *Escherichia coli* contamination detected in shellfish meat, as defined in EC Directive 91/492 EEC. However, outbreaks of gastroenteritis or hepatitis after consumption of shellfish meeting current bacteriological standards suggest that *E. coli* is a poor indicator of viral contamination. The purpose of this study was to assess the adequacy of enterovirus and F-specific RNA bacteriophages as new indicators of human enteric viruses.

Shellfish were sampled in two coastal areas over a 37-month period to characterise microbial contamination from different sewage contamination inputs. Contamination by *E. coli*, F-specific RNA bacteriophages (F+ RNA) and human enteric viruses (enterovirus, hepatitis A virus, Norwalk-like virus, astrovirus, and rotavirus) was measured in the same samples.

The validity of *E. coli*, enterovirus, and F-specific RNA bacteriophages as viral indicators was evaluated by measuring their sensitivity and specificity in the presence of enteric viruses. None of the tested indicators proved adequate to protect the public from viral shellfish contamination. The sensitivity of all indicators was better in the highly contaminated zone, and enteroviruses showed the highest specificity for both sites.

Reference

Miossec, L. (IFREMER, Microbiology Lab, BP 21105, F-44311 Nantes 3, France), Le Guyader, F., Pelletier, D., Haugarreau, L., Caprais, M.P., Pommepuy, M., 2001. Validity of *Escherichia coli*, enterovirus, and F-specific RNA bacteriophages as indicators of viral shellfish contamination. Journal of Shellfish Research Vol 20, pp 1223-1227.

24. Vibrio survey of French coastal waters

The results of this study demonstrated the presence of pathogenic *Vibrio* species in French coastal waters, indicating the potential sanitary risk associated with these species in cultivated mussels and in the aquatic environment.

Samples of coastal waters and mussels were collected between July and September 1999. Presumptive *Vibrio* colonies were isolated and identified using selected biochemical tests. The identification of *Vibrio vulnificus*, *V. parahaemolyticus* and *V. cholerae*, was confirmed. *Vibrio alginolyticus* was the predominant species, followed by *V. parahaemolyticus* and *V. vulnificus*.

Reference

Hervio-Heath, D. (dhervio@ifremer.fr), Colwell, R.R., Derrien, A., Robert-Pillot, A., Fournier, J.M., Pommepuy, M., Occurrence of pathogenic vibrios in coastal areas of France. Journal of Applied Microbiology Vol 92, pp 1123-1135.

25. Toxic algae introduction

In 1998, the toxins responsible for paralytic shellfish poisoning (PSP) were detected in the Thau Lagoon, France. The causative organism was preliminarily identified as *Alexandrium tamarense*, a member of the 'tamarensis' species complex. This dinoflagellate was first observed in the lagoon in 1995 by a monitoring programme, following more than a decade with no observations of this species. The species is thus new to these waters, but its origins were unknown.

Two clonal cultures, established from the 1998 bloom, were examined in detail. Thecal plate morphology, restriction fragment length polymorphism, DNA sequencing and toxin analyses demonstrate that the Thau Lagoon strains are in fact *Alexandrium catenella*, and are closely related to populations of *A. catenella* found in temperate Asia. They show no similarity with strains from western European waters, including the Mediterranean. Until now, this species has not been reported outside the western Pacific. The most likely means by which *A. catenella* was introduced to the Thau Lagoon is via the ballast water of a ship docked at Sete, France, a shipping port with a direct water link with the lagoon.

Reference

Lilly, E.L. (elilly@whoi.edu), Kulis, D.M., Gentien, P., Anderson, D.M., 2002. Paralytic shellfish poisoning toxins in France linked to a human-introduced strain of *Alexandrium catenella* from the western Pacific: evidence from DNA and toxin analysis. Journal of Plankton Research Vol 24, pp 443-452.

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26. Rapid PSP assessment

A recently developed commercial rapid test kit (MIST Alert™) was assessed for determination of the presence of paralytic shellfish poisoning (PSP) toxins in shellfish. These results suggest that MIST Alert may be suitable as an initial screen for PSP toxins as part of routine monitoring programs, thereby greatly reducing the number of mouse bioassays. Non-scientific personnel used the kits to evaluate the ease of use and interpretation of results obtained by MIST Alert. The results indicated that the kits could be readily used and accurately interpreted by individuals with no technical or scientific background.

Several commercially important shellfish species obtained from the UK shellfish toxin monitoring program, containing a range of total PSP toxicity, as determined by the mouse bioassay, were tested. The kit detected toxin in all samples containing the European Community tolerance level of 80 µg saxitoxin (STX) equivalents/100 g shellfish flesh as determined by the mouse bioassay. With one exception, the kit detected toxin in all samples that contained more than 40 µg STX equivalents/100 g, according to the mouse bioassay. Among samples in which the mouse bioassay did not detect toxin, the kit disagreed in 25% of the tests, although further analysis by liquid chromatography and mouse bioassay of some samples confirmed the presence of toxins.

Reference

Mackintosh, F.H., Gallacher, S., Shanks, A.M., Smith, E.A. (smithe@marlab.ac.uk), 2002. Assessment of MIST Alert™, a commercial qualitative assay for detection of paralytic shellfish poisoning toxins in bivalve molluscs. Journal of AOAC International Vol 85, pp 632-641.

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27. Azaspiracid shellfish poisoning

A number of recent acute human intoxications in Europe from the consumption of Irish mussels have been attributed to the presence of a new class of toxins named azaspiracids. These toxins are distributed throughout shellfish tissues, which could account for some false-negative results using conventional mouse bioassays.

Reference

James, K.J. (kjames@cit.ie), Lehane, M., Moroney, C., Fernandez-Puente, P., Satake, M., Yasumoto, T., Furey, A., 2002. Azaspiracid shellfish poisoning: unusual toxin dynamics in shellfish and the increased risk of acute human intoxications. Food Additives and Contaminants Vol 19, pp 555-561.

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28. Bonamia in Ireland

The main oyster species produced in Ireland up to the 1980's was the European flat oyster *Ostrea edulis*. However, since then, production of this species has been severely affected by the presence of *Bonamia*, which was diagnosed in a population of flat oysters on the south coast following heavy mortalities. Research has been ongoing since the first diagnosis in Ireland and has concentrated on aspects of the biology of both the host and the parasite. In recent years research has concentrated on screening populations of oysters to identify any with reduced susceptibility to the parasite.

Reference

Culloty, S.C. (University College Cork, Department of Zoology & Animal Ecology, Cork, Ireland), Mulcahy, M.F., 2001. Living with bonamiasis: Irish research since 1987. Hydrobiologia Vol 465, pp 181-186.

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29. An intermediate host for Marteilia

Marteilia refringens is a major pathogen of the European flat oyster. However, the life cycle of this protozoan parasite is still unknown. Attempts to infect oysters experimentally have been unsuccessful and led to the hypothesis of a complex life cycle involving several hosts. Knowledge of this life cycle is of central importance in order to manage the disease.

Molecular detection tools and a mesocosm pond with low biodiversity were used in this investigation. Screening of the entire fauna of the pond for DNA of *M. refringens* was systematically undertaken, using PCR techniques. The copepod *Paracartia* (*Acartia*) *grani* was found to be a host of *M. refringens*. Not only was DNA of *M. refringens* consistently detected in *P. grani* but the presence of the parasite in the ovarian tissues was also demonstrated, using In-Situ Hybridisation. Finally, successful experimental transmissions provided evidence that *P. grani* can be infected from diseased flat oysters.

Reference

Audemard, C., Le Roux, F., Barnaud, A., Collins, C., Sautour, B., Sauriau, P.G., de Montaudouin, X., Coustau, C., Combes, C., Berthe, F. (fberthe@ifremer.fr), 2002. Needle in a haystack: involvement of the copepod *Paracartia grani*, in the life-cycle of the oyster pathogen *Marteilia refringens*. Parasitology Vol 124, pp 315-323.

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30. Brown ring disease

Brown ring disease causes high mortalities in the introduced Manila clam *Ruditapes philippinarum* cultured in western Europe, The etiological agent, the bacterium *Vibrio tapetis*, adheres to and disrupts the production of the periostracal lamina, causing the anomalous deposition of periostracum around the inner shell (seen as a brown ring). The primary sign of brown ring disease is therefore found outside the soft tissues, and so the processes leading to death are not as obvious as for internal pathogens.

This study was designed to find the way in which *V. tapetis*, invades and kills the clams. High mortalities (up to 100%) of clams followed the inoculation of *V tapetis* into the extrapallial space (between mantle and inner shell) or the posterior adductor muscle of healthy Manila clams. The pathogen was rapidly eliminated from tissues and hemolymph of animals that survived the inoculation. In clams that died, the bacteria were found to have proliferated, resulting in severe tissue disruption. Bacteria were able to penetrate into tissues from the extrapallial space through the external epithelium of the mantle. In contrast, no mortalities were observed following injection of *V tapetis* in the native European clam *Ruditapes decussatus*, which is resistant to brown ring disease. This clam rapidly eliminated the bacterium from hemolymph and soft tissues. Clam mortality associated with brown ring disease in the field is likely to result from the penetration of *V. tapetis* into the clam's extrapallial space through the disrupted periostracal lamina and from there into the soft tissues through the irritated mantle epithelium. Some bacteria also penetrate through the digestive epithelia, In either case, bacteria proliferate rapidly in the soft tissues, causing severe damage and subsequent death.

Reference

Allam, B., Paillard, C., Ford, S.E. (susan@hsrl.rutgers.edu), 2002. Pathogenicity of *Vibrio tapetis*, the etiological agent of brown ring disease in clams. Diseases of Aquatic Organisms Vol 48, pp 221-231.

31. Bait for whelks

Landings from the whelk fishery in the south west Irish Sea rose from 63 tonnes in 1990 to 6,587 tonnes in 1996, although landings had declined to 2,919 tonnes in 1998. Whelks are caught in pots baited with a combination of dogfish and brown crab. The input of bait crab is estimated at 7.2% of whelk landed. Most of the crab comes from south east Ireland where some of it is a by-product of the claw fishery; some is targeted as bait crab, and this includes sub-size or recently moulted individuals. Fishing effort has been increasing on brown crab for human consumption and there is concern about the sustainability of the crab fishery.

Alternative bait trials examined a number of readily available fish species, some of them offal, whose attractiveness was evaluated by reference to crab and dogfish. These were whitefish (whiting and cod), pelagic species (mackerel and scad) and blue mussel. An artificial bait ration which included some crabmeat, but 60% less than its natural equivalent, proved as effective as natural bait crab. Bait that consisted of a single species was less successful than a combination of two species and some of the combinations (notably of whitefish) performed very effectively. Pelagic species performed poorly. The trade in brown crab for human consumption will always produce some form of discards that should be used; extending its use in a mixture with artificial bait is desirable.

Reference

Fahy, E., Conflict between two inshore fisheries: for whelk (*Buccinum undatum*) and brown crab (*Cancer pagurus*), in the southwest Irish Sea. Hydrobiologia Vol 465, pp 73-83.

Shellfish in the Press

The following pages contain clippings from various newspapers and periodicals of items of interest to the shellfish farmer and harvester.

Because of copyright requirements the review of press cuttings is not available in this web edition

INFORMATION FILE

WHERE CAN I GET HELP OR ADVICE?

Policy Matters

Department for the Environment, Food and Rural Affairs, Nobel House, 17 Smith Square, London SW1P 3JR
(Switchboard tel. 020 7238 3000)
(General fax. 020 7238 6591)

Several and Regulating Orders, shellfish farming -
Fisheries Division II, Room 308 Nobel House,
(Tel. 020 7238 5947) (Fax. 020 7238 5938)

Shellfish Health -
Fisheries Division II, Room 308 Nobel House,
(Tel. 020 7238 6049) (Fax. 020 7238 5938)

Public shellfisheries, excluding Regulating Orders -
Fisheries Division III, Room 425A Nobel House
(Tel. 020 7238 5593) (Fax. 020 7238 5721)

Shellfish Licensing Scheme -
Fisheries Division IV, Room 420 Nobel House,
(Tel. 020 7238 6730) (Fax. 020 7238 6474)

Grant Aid -
Fisheries Division 1B, Room 441 Nobel House,
(Tel. 020 7238 5710) (Fax. 020 7238 5951)

Marine Environment Protection and Pollution -
Marine Policy Branch, Rural and Marine Environment Division, Room 150 Nobel House
(Tel. 020 7238 5880) (Fax. 020 7238 5881)

Monitoring of fishing activities, licensing -
Sea Fisheries Inspectorate, Room 513 Nobel House
(Tel. 020 7238 5811) (Fax. 020 7238 5814)

Research and Development Programmes -
Science Directorate, Cromwell House, Dean Stanley Street, London, SW1P 3JH
(Tel. 020 7238 3000) (Fax. 020 7238 1590)

You can also visit the Defra website at http://www.defra.gov.uk

Welsh Assembly Government, Agricultural and Rural Affairs Department,
New Crown Buildings, Cathays Park, Cardiff CF1 3NQ
(Tel. 029 2082 3567) (Fax. 029 2082 3562)
(*http://www.wales.gov.uk*)

Scottish Executive Environment and Rural Affairs Department,
Pentland House, 47 Robbs Loan, Edinburgh EHG14 1TW
(Tel. 0131 244 6224) (Fax. 0131 244 6313)
(*http://www.scotland.gov.uk/who/dept_rural.asp*)

Department of Agriculture and Rural Development for Northern Ireland,
Fisheries Division, Annexe 5, Castle Grounds, Stormont, Belfast, BT4 3PW
(Tel. 028 9052 3431) (Fax. 028 9052 2394)
(*http://www.dardni.gov.uk*)

Shellfish Hygiene

England - Food Standards Agency
Aviation House, 125 Kingsway, London, WC2B 6NH
(Tel. 020 7276 8000)
(*http://www.food.gov.uk*)

Food Standards Agency (Scotland),
St Magnus House, 25 Guild Street, Aberdeen AB11 6NJ
(Tel 01224 285100);

Food Standards Agency (Wales),
Southgate House, Wood Street, Cardiff CF10 1EW
(Tel 029 20 678918);

Food Standards Agency (Northern Ireland),
10C Clarendon Road, Belfast BT1 3BG
(Tel 02890 417711)

Scientific and technical advice

CEFAS Weymouth Laboratory,
Barrack Road, The Nothe, Weymouth, Dorset DT4 8UB
(Tel 01305 206600) (Fax 01305 206601) -
Cultivation techniques; health regulations; disease control; shellfish hygiene classifications and purification plant approvals; shellfish water quality and effluent discharges (microbiology) (England & Wales)

CEFAS Lowestoft Laboratory,
Pakefield Road, Lowestoft, Suffolk, NR33 0HT
(Tel 01502 562244) (Fax 01502 513865) -
Shellfish stocks (England & Wales)

CEFAS Burnham Laboratory,
Remembrance Avenue, Burnham-On-Crouch, Essex, CMO 8HA
(Tel. 01621-787200) (Fax 01621 784989) -
Pollutants (contaminants) and their effects

You can also visit the CEFAS website at http://www.cefas.co.uk

Fisheries Research Services,
Marine Laboratory, PO Box 101, Victoria Road, Aberdeen AB9 8DB
(Tel. 01224 876544) (Fax. 01224 295511)
(*http://www.marlab.ac.uk*)-
Shellfish stocks, cultivation, hygiene, and disease control (Scotland)

SEAFISH - Aquaculture Development Officers:
For Scotland and Northern Ireland: Craig Burton,
Marine Farming Unit, Ardtoe, Acharacle, Argyll, PH36 4LD
(Tel. 01397 875402) (Fax. 875001)
(email: c_burton@seafish.co.uk)
For England and Wales: Sue Utting,
P.O. Box 68, Colwyn Bay, North Wales, LL28 5WR
(Tel/Fax. 01492 650884)
(e-mail: s_utting@seafish.co.uk)

SEAFISH Technology,
Seafish House, St. Andrew's Dock, Hull, HU3 4QE (Tel 01482 327837) (Fax 01482 223310)

You can also visit the SEAFISH website at http://www.seafish.co.uk

Advice on commercial activities

The Shellfish Association of Great Britain,
Fishmonger's Hall, London Bridge, London, EC4R 9EL
(Tel. 020 7283 8305) (Fax. 020 7929 1389)
(*http://www.shellfish.org.uk*)

The Association of Scottish Shellfish Growers,
Mountview, Ardvasar, Isle of Skye, IV45 8RU
(Tel/Fax: 01471 844324)

Wildlife conservation and status of on-growing sites

Joint Nature Conservation Committee,
Monkstone House, City Road, Peterborough PE1 1JY
(Tel. 01733 562626) (Fax. 01733 555948)
(*http://www.jncc.gov.uk*)

English Nature,
Northminster House, Peterborough, PE1 1UA
(Tel. 01733 455000) (Fax. 01733 568834)
(*http://www.english-nature.org.uk*)

Countryside Council for Wales,
Ffordd Penrhos, Bangor, LL57 2LQ
(Tel. 01248 385500) (Fax. 01248 355782)
(*http://www.ccw.gov.uk*)

Scottish Natural Heritage,
12 Hope Terrace, Edinburgh, Scotland, EH9 2AS
(Tel. 0131 447 4784) (Fax. 0131 446 2277)
(*http://www.snh.org.uk*)

Other Useful Numbers

Crown Estate Commissioners,
Crown Estate Office, Marine Estates Division,
16 Carlton House Terrace, London SW1Y 5AH
(Tel. 020 7210 4322, Dr Tony Murray)
(Fax. 020 7839 7847)
(*http://www.crownestates.co.uk*)

Central contact for local Sea Fisheries Committees - The Association of Sea Fisheries Committees of England and Wales,
24, Wykeham Village, Scarborough, North Yorkshire, YO13 9QP
(Telephone and Fax: 01723 863169).

LINK Aquaculture,
c/o Freshwater Fisheries Laboratory, Faskally, Pitlochry, Perthshire, PH16 5LB
(Tel. 01796 472060) (Fax. 01796 473523)
(*http://www.linkaquaculture.co.uk*)

USEFUL PUBLICATIONS

CEFAS

A variety of booklets and leaflets are available, including:

- A Guide to Shellfish Health Controls
- The Fish Health Inspectorate and You - Service Standards and Code of Practice for Enforcement
- Bivalve cultivation: criteria for selecting a site
- Scallop cultivation in the UK: a guide to site selection
- Storage and care of live lobsters

The above may be obtained from the CEFAS Weymouth Laboratory, Barrack Road, The Nothe, Weymouth, DT4 8UB, (Tel no: 01305 206600; Fax no: 01305 206601)

A catalogue of CEFAS publications is available from the CEFAS Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk, NR33 0HT, (Tel no: 01502 562244; Fax no: 01502 513865). Electronic copies of many of these publications can be found on the CEFAS web site at *http://www.cefas.co.uk/publications/default.htm*

Back copies of issues 6-13 of *Shellfish News* can also be viewed and/or downloaded as .pdf files from the CEFAS web site (*http://www.cefas.co.uk/publications/shellfish_news.htm*)

Seafish Aquaculture

Detailed information on the technical and economic aspects of cultivation for individual shellfish species is available from Seafish Aquaculture. They publish a series of 'hyper-books' on CD-ROM that covers all aspects of cultivation. Economic models are also available. For further information contact the Aquaculture Development Officer for your area (see above for contact details, or *http://www.seafish.co.uk/aquaculture/development.htm* for further information). A full list of Seafish publications can be found on the Seafish web site at *http://www.seafish.co.uk/publications/publications.htm*