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A STRATEGY FOR MUSSEL CULTIVATION

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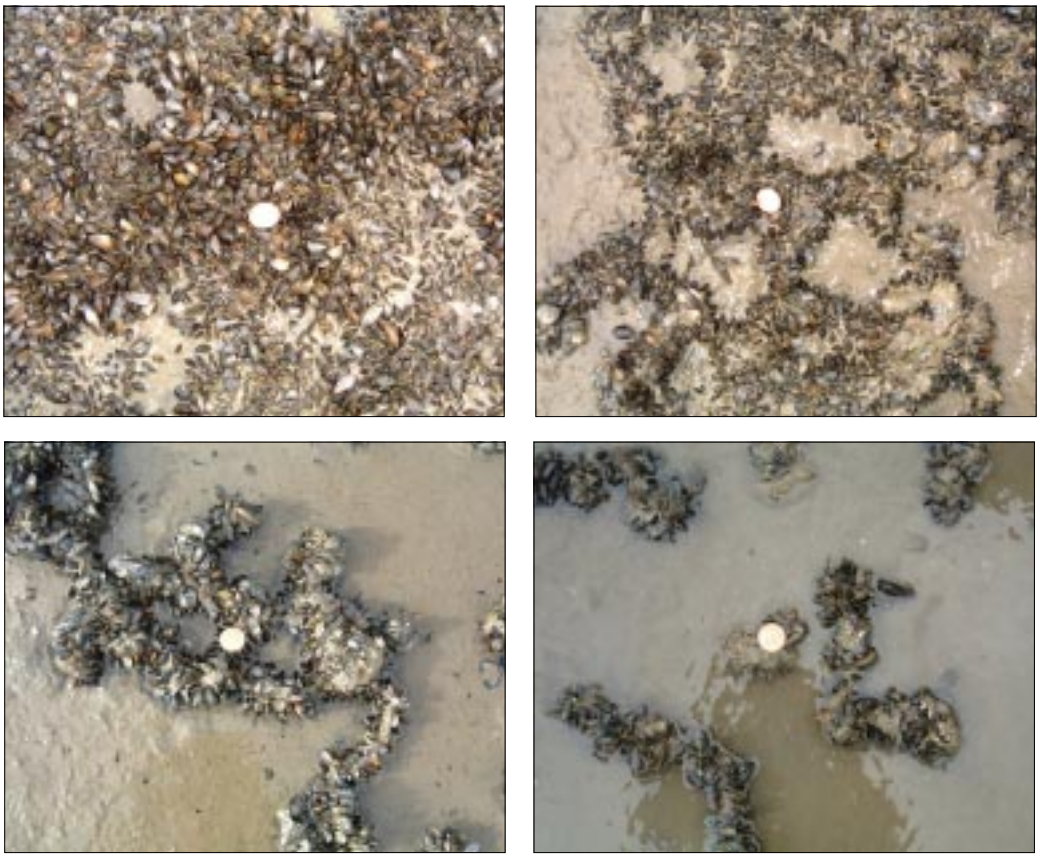
Introduction

The mussel cultivation industry is currently the fastest expanding and most valuable area of shellfish aquaculture in the United Kingdom. The potential for continued success and expansion of the industry is constrained by an unpredictable supply of seed for relaying as well as possible conflicts over the use of areas for cultivation. Seed mussels are currently re-laid with little attempt to manipulate stocking strategies to maximize yields. Hence the survival of these seed mussels is often poor. Many die from either starvation or are eaten by predators. The aim of this study is to recommend a management plan to improve productivity by determining optimum stocking density and management strategies to maximise mussel growth rate, reduce predation losses, yet minimise ecological effects on bird and invertebrate communities.

Materials and methods

In September 1999 an experimental site at Bangor Pier, on the Menai Strait, North Wales was marked out. This included adjacent control areas. The invertebrate infaunal community was sampled in October 1999. The area was seeded with mussels in April 2000, with four different mussel densities (7.5, 5, 3 and 2 kgm^{-2}) at four tidal heights. In addition, a caged experiment was set up in close proximity with six tidal heights and four mussel seeding densities. The mussels were sampled regularly, with the most intensive sampling over periods of greatest mussel growth.



Mussels re-laid at four different initial densities in the experimental plots

Results

Preliminary results from the main experimental site show a marked difference in mussel growth rates and mortality levels at the different seeding densities. Mussel growth rate was lower and mortality higher at the highest seeding density. Mussels reached greater lengths at the lowest density (Figure 1). Shore level effects were not apparent at the main experimental site, which has a very shallow gradient.

Growth rates in the caged experiments showed similar trends to the main experiment; the greatest mussel growth was achieved at the lowest initial seeding density and this became more pronounced at the lower shore levels. Mussel growth was also better at the lower shore level and this became more distinct at the lower seeding densities.

Discussion

To date, the results from the main experimental plots and caged experiments seem to corroborate expectations of the response of mussels to density treatments and shore level position. The final results from the experiments will be used in the development of a model to predict the growth of mussels cultured on the seabed in the intertidal zone. This model will also include the effects of density (self-thinning) and predation by birds and crabs, which is being monitored concurrently with the growth experiments.

The infaunal analysis will be repeated in one year after the initial seeding of the mussels to establish the changes in the community.

Acknowledgements

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Centre for Ecology and Hydrology,
Environment Agency, SOS Bangor, Myti Mussel Ltd,
Deep Dock Ltd, Shellfish Association of Great Britain.

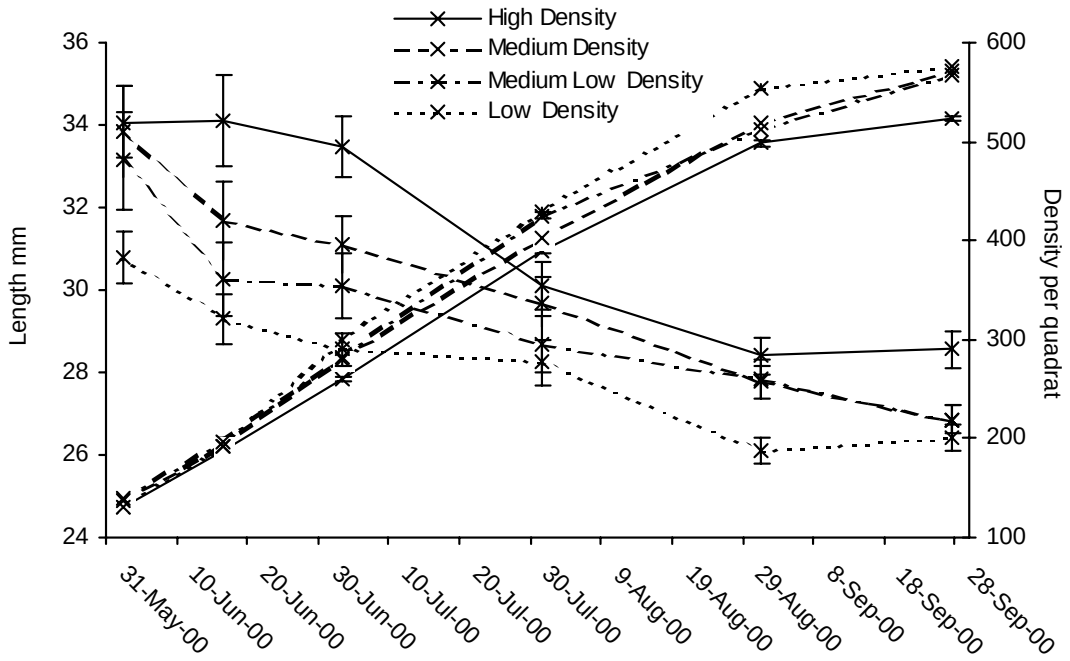

Figure 1. Mussel length and density (mean ± standard error bars) from four initial seed densities on the main experimental plot between June and October 2000

NATIVE OYSTER SPECIES ACTION PLAN

Below follow two articles on the Native Oyster Species Action Plan (NOSAP).
The first, by Bernadette Clarke, Marine Conservation Society Fisheries Officer, is an edited version of an article that appeared in the Spring 2001 issue of 'Marine Conservation', the official magazine of the Marine Conservation Society, Vol. 5, no. 2.
The second article, by Dr. Stephen Lockwood, chairman of the NOSAP steering group, explains in more detail the background to Biodiversity Action Plans and the structure, remit and function of NOSAP and the steering group.

Native oysters (photograph courtesy of Loch Fyne Oysters Ltd.)

UK BIODIVERSITY ACTION PLAN FOR THE NATIVE OYSTER

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Introduction

The native or flat oyster, *Ostrea edulis* is a filter feeding, bivalve mollusc. While native and Pacific oysters (*Crassostrea gigas*) are marketed in the UK and throughout Europe, the flat oyster is the only oyster that is actually native to UK and European shores. Of all the native oysters consumed worldwide, 90% are cultivated or farmed. The largest oyster hatchery in Europe exists at Whitstable on the north Kent coast.

Current status

Since the late 1800s there has been a dramatic decline in the native oyster population in UK waters. Today approximately 1100 tonnes (100-200 tonnes from farmed production and about 900 tonnes from Fishery Order sites) are produced, with the major exploited grounds in the Solent. The Solent ground is a Regulated Fishery and is surveyed annually by the Centre for Environment, Fisheries and Aquaculture Science (CEFAS). Data is collected in order to monitor abundance, size, recruitment and density levels. Other main UK stocks are found in the River Fal, on the west coast of Scotland and in Lough Foyle in Northern Ireland.

Factors causing loss or decline

The dramatic reduction in stock abundance is attributed mainly to overexploitation. Other factors include the introduction of alien or non-native species such as the American oyster drill (*Urosalpinx cinerea*) and the slipper limpet (*Crepidula fornicata*). The American oyster drill is a sea snail that kills oysters by drilling through their shells and injecting them with poison before consuming them. Although slipper limpets do not feed on oysters they grow extensively on oyster beds producing a smothering effect as well as competing with oysters for food. Native oysters have also suffered from the introduction of the parasitic protozoan *Bonamia ostreae.* Infection by the parasite causes lesions in the gills and digestive glands of the oysters, leading to their death.

The Native Oyster Species Action Plan (NOSAP)

A steering group (see following article) has been formed with responsibility for implementing the stated objectives and targets of the action plan. These are to '*maintain and, where possible, expand the existing geographical distribution and abundance of the native oyster within UK inshore waters*'. Dr. Stephen Lockwood (Coastal Fisheries Conservation & Management) chairs the group, on behalf of English Nature.

In addition to a desire to increase stock to a level where it is contributing to UK marine biodiversity it is hoped that the Plan might also prove an effective vehicle for other initiatives. These include encouraging improvements in legislation covering the control of (biological) competitors, pests and diseases; designation of more shellfish growing waters; promotion of further improvements in coastal water quality; and obtaining more stock assessment information, including data on distribution and genetic diversity of *Ostrea edulis* stocks.

As a first priority a comprehensive review of all available information (published and anecdotal) on the distribution and abundance of the native oyster has been commissioned. It is possible that divers may be able to contribute to surveys on the distribution and abundance of the native oyster by participation in the Marine Conservation Society *Seasearch* project.

Legislation

Native oyster fisheries in the UK are primarily subject to UK shellfisheries conservation legislation. There is a national closed season (14 May to 4 August) to protect wild native oysters during the spawning season.

Water quality

Oysters are filter feeders and therefore require clean water to ensure that the flesh does not become contaminated with pollutants. EU Directives have been established to protect shellfish beds from pollution and to protect human health.

The quality of shellfish waters is regulated by Directive 79/923/EEC, adopted in 1979 and administered in the UK by the Department of Environment, Transport and the Regions (DETR). It seeks to ensure a suitable environment for shellfish growth. There are 162 designated shellfish waters in the UK – 93 in England, 26 in Wales, 33 in Scotland and 10 in Northern Ireland (see *Shellfish News*, Vol. 9, p 19).

A separate directive, the Shellfish Hygiene Directive (91/492/EEC), adopted in 1991 and now administered by the Food Safety Agency (formerly by MAFF) is concerned with protecting consumers of shellfish, laying down bacteriological and chemical standards for live bivalves (see *Shellfish News*, Vol. 10, p 23).

Rights and ownership of oyster fisheries

In tidal waters in England and Wales any individual may fish for oysters, provided there is no contravention of local bylaws or the Public right has been removed. Private property rights preclude public fishing in some tidal waters. In some cases these rights are ancient, granted by the Magna Carta of 1215.

In Scotland wild oysters are the property of the Crown and no person can fish or grow these species without the consent of the Crown. This consent is given through the Sea Fisheries (Shellfish) Act 1967 as amended by the Sea Fisheries Act 1968 and the Fishery Limits Act 1976 for wild fisheries or through appropriate consent from the Crown Estate Commissioners for farming activities.

In addition to Private ownership other arrangements controlling the rights of oyster fishing are Several and Regulating Orders which are granted in England and Wales by MAFF, and in Scotland by the Scottish Executive.

A *Several Order* is an Order where an exclusive right to fish is granted to the person or body applying, covering the named species, in a defined area and for a specified time limit. The individual or body granted the Order has the exclusive rights of depositing, propagating, dredging, fishing for and taking shellfish named in the Order, thus prohibiting unauthorised fishing or collecting.

Baskets of dredged flat oysters

A *Regulating Order* is similar to a Several Order except it bestows on the beneficiary the right to manage and regulate a fishery or a number of fisheries within a large area. The species must be nominated in the Order, which may cover any portion of the shore or seabed, or of an estuary or tidal water, above or below the low water mark and up to six nautical miles from baselines. The beneficiary (a group of fishermen, Sea Fisheries Committee etc.) can charge tolls and royalties in order to improve the fishery.

If viable populations of native oyster can be restored to our coastal waters and commercial aspirations for sustainable fisheries met, this Action Plan will have demonstrated that sustainable, well managed and responsible fisheries can complement nature conservation.

NATIONAL REVIVAL PLAN FOR THE NATIVE OYSTER

Stephen J. Lockwood
CFCM (Coastal Fisheries Conservation and Management), Colwyn Bay, North Wales

Decline of the oyster

For undergraduate students in the mid-1960s there was never a problem finding vacation work in London. The post-war office-building boom was in full swing and it never took more than two days to find somewhere to wield a pick and shovel. One of the more interesting holes I helped to dig was in Shoreditch, just east of Liverpool Street station. We uncovered a very substantial layer of native flat oyster (*Ostrea edulis*) shell along with clay pipes, buttons, bones and shards of pottery. It was a clear indication that oysters were, indeed, once abundant and, in view of the location, cheap. Alas, they are no longer cheap or abundant. Whereas native oyster fisheries in the mid-19th century were widespread and prolific, they are now few and tightly regulated to safeguard the limited resource. As part of the effort to stem and, hopefully, reverse the decline, the native oyster is one of the 19 individual named marine species in the UK Biodiversity Action Plan.

Biodiversity - habitats and species

The UK Biodiversity Action Plan (BAP) is a central plank of our national commitment to the International Convention on Biodiversity (Rio de Janeiro, 1992). It comprises a broad range of habitat action plans (HAP) intended to safeguard good examples of widely distributed habitats, for example sandy gravels or honeycomb worm (*Sabellaria* spp) reefs, and all sites of rare habitats, for example saline lagoons.

Species action plans (SAP) have been drafted for:

- Species that are nationally or globally threatened.
- Species for which the UK is host to 25% of the global population.
- Species that have declined by 25% or more over the past quarter century.
- Species already protected by UK legislation or for which the UK has international obligations.

NOSAP

The Native Oyster Species Action Plan (NOSAP) has identified numerous probable causes for the oyster's decline in abundance, both from man-made and natural causes. They include pests (American oyster drill and *Crepidula*), parasites (*Bonamia*), over-fishing, TBT, harsh winters (1947 and 1963) and poor spawning and spat-fall (numerous factors, mostly beyond our ken). Current action tends to be limited to fishery management apart from some more generic measures for environmental protection of coastal waters, including the ban on TBT for vessels over 25 m in length. The published oyster action plan, however, has proposed numerous steps that can be taken to help improve the state of the stocks. These proposals appear under four headings:

- Policy and legislation,
- Site safeguards and management,
- Species management and protection,
- Future research and monitoring.

There is also a commitment to prepare guidance notes, codes of practice and more general publicity as and when appropriate. Under the first heading are proposals to review existing national and European legislation. This is to assess its effectiveness in protecting native stocks from the introduction of pests and disease from overseas and preventing their spread within UK waters. Site safeguards and management includes the potential for improving areas for spatfall by re-working the grounds, not least for the benefit of commercial fisheries but even in the absence of a fishery. It is intended that such proposals should be integrated with the management plans for statutory conservation areas, e.g. marine nature reserves (MNR), special areas of conservation (SAC), and local coastal or estuary management plans.

The direct proposals for the species protection are closely related with research and monitoring. Improving our understanding of the spawning and recruitment processes that are central and then doing what we can to maximise the prospect of successful spawning and spatfall. Inevitably, this is closely allied with stock management and ensuring that critical densities are established and maintained for synchronous spawning but without compromising efforts to control the spread of disease. Improving our knowledge and understanding of the genetic structure of UK oyster stocks is also of importance if we are to enhance stocks by direct intervention (seeding) but without contributing to further declines in (genetic) biodiversity.

The Steering Group

This programme is not the responsibility of any one group. It is a UK national plan and anyone and everyone who has a professional or leisure interest in UK coastal waters must contribute. There is however a steering group that must take the lead in developing the plan and seeing that it is implemented. The group comprises *representatives* from the major interest groups (stakeholders). These include industry (SAGB, ASSG, SFC, SFIA) and academics (Queen's University, Belfast), fishery departments (MAFF/CEFAS) and nature conservation groups, both statutory (CCW, EN, SNH) and voluntary (MCS). Further organisations, with representatives from the Crown Estate, County Councils,

Oyster dredger, Stanswood Bay, The Solent.

SERAD, DARDNI, NIFFO, WWF and the Wildlife Trusts, are also participating, some by correspondence. Each representative is expected to act as the point of contact for, and maintain two-way communication with, a wider network of individuals and organisations within their particular sector of industry, academia, government or nature conservation.

The steering group has already commissioned a review of the distribution and abundance of oysters over the past one hundred years or so, and a set of guidelines on current accepted oyster ground management practice. Overall steering group progress with implementing NOSAP is reported through the group chairman to a national Marine Biodiversity Group, which in turn reports to the National Biodiversity Group. The National Chairman answers to the Secretary of State for Environment, Transport and the Regions, and the first ministers of the devolved parliaments and assemblies. They must be satisfied that this aspect of the government's nature conservation policy is being delivered.

Further information

For more information on NOSAP and the work of the Steering Group, contact the chairman:
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PRESERVED ALGAE - NEW PRODUCTS FOR AQUACULTURE

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Background

Fresh algae culture is fed to all stages in the hatchery production of bivalve molluscs. It is also required for feeding to zooplankton used in the hatchery rearing of the larval stages of some commercially valuable marine fish species. Maintaining a supply of fresh algae culture to match the demands of the animals can be tricky, and this has led to a desire to find some way of preserving algae such that the cells retain their nutritional and physical characteristics.

It would then be possible to increase the efficiency from current algae culture production methods by maintaining systems at optimum capacity and preserving and storing any excess culture for later use, as required. It would also be possible to exploit the seasonal production from extensive culture systems to a greater degree than at present. A preserved diet has the potential to increase profitability, as algal culture represents a significant hatchery cost.

LINK funding

MAFF, through the LINK AQUACULTURE scheme, funded a joint research project on preserving microalgae diets. Two research partners were involved - the School of Ocean Sciences, University of Wales Bangor and CEFAS. Two industrial partners – Seasalter Shellfish, Whitstable and Mainland Salmon, Orkney supported the work.

The project, which ran for three years, finished in September 2000. The potential of three techniques (concentration by centrifugation and storage at low temperature, spray-drying and freeze-drying) were assessed as methods for preserving algae. Freeze-drying was found to be unsuitable. The nutritional value of algae preserved by the other two methods was compared with fresh, live algae diets for bivalve molluscs as well as for zooplankton used as food for fish larvae.

Pastes

All algae food species concentrate well when centrifuged at speeds of 3500 rpm, with excellent recovery rates. Storage life of the pastes at 4-6°C varies with species. Some algae, e.g. T-ISO and *Chaetoceros* sp. begin to smell 'off' after 2/3 days and T-ISO smells strongly even after 24 hours. This can be improved by bubbling the concentrated algae overnight, instead of holding it in a fridge. Concentrated pastes stored at 4-6°C have a much shorter shelf life than other preservation methods, with an average of about 2 weeks.

Preservation

It was found that freezing (at -20°C) can preserve cells of some species, and protocols were developed for this method. *Tetraselmis suecica* (≈ 60% cells recovered), T-ISO (≈ 45% cells) and *Nannochloropsis oculata* (100% cells) could all be preserved by freezing. For other species, a soup-like substance with very few intact cells resulted. This situation might be improved with the use of cryo-protectants, which were not investigated in this study.

Spray drying of the pastes in a laboratory-scale dryer was also investigated. The resultant powder after spray-drying contains 5-7% of algae by dry weight, the rest of the powder comprising of salts, and with 55-71% recovery in terms of total algae dry weight from the original paste. The best method for re-hydration of the

Live algae tested and food value for bivalve molluscs		Preservation methods		
		Short term	Long term	
		Cold storage (+4°C.)	Frozen (-20°C)	Spray dried
Nannochloropsis occulata	Poor	√√√	* * * * *	ΔΔΔΔΔ
Tetraselmis suecica	Moderate	√√√	* * * *	ΔΔΔΔ
Rhinomonas reticulata	Moderate	√√	Not suitable	ΔΔΔ
T-ISO	Good	Not suitable	* *	ΔΔ
Pavlova lutheri	Good	Not suitable	*	Δ
Chaetoceros calcitrans	Excellent	√	Not suitable	Not suitable
Chaetoceros ceratosporum	Excellent	√	Not suitable	Not suitable
Pond water (mixed sp.)	Good	√√√	* * * *	Not tested

Preserved algae for aquaculture - the greater the number of symbols, the more suitable the species for that particular preservation method.

cells was found to be by adding the spray-dried powder to filtered seawater and blending for around 20 seconds in a domestic blender. This aided the breaking up of clumps of cells, especially for the larger species. When examining the re-hydrated cells under a light microscope, some physical changes could be seen. In *Chaetoceros* sp. the cells appeared very shrunken and shrivelled with many damaged cells. With T-ISO, *P. lutheri*, and *Rhinomonas reticulata* the cells appeared shrunken, although the majority remained intact. *T. suecica* was less affected and *N. oculata* cells did not appear to be any different after spray drying. A summary of preservation methods for a range of species is given in the Table. Unfortunately the higher food value species tend to be less suitable for preservation.

Food value

Feeding trials were carried out using Pacific oysters and king scallops. In the short-term (cold storage of pastes) nutritional value of algae is retained. Preservation for longer-term storage (freezing or spray drying) gives an immediate decline in food value. This is probably associated with the loss of essential long chain fatty acids.

Oyster larvae fed dried diets gave very little growth and showed high mortalities. Spat fed preserved diets, in three-week trials, survived and increased in organic weight, but at only 20% of the rate with the live algae control. Mixed live:preserved diets gave intermediate results, and supplements of preserved algae to lower rations of live algae significantly improved growth of spat. An experimental concentrated paste diet (heterotrophically-grown *Cyclotella cryptica* supplied by Liverpool John Moores University) was slightly more successful, with oyster growth rates of 50% of that with a live diet.

Preserved algae generally gave more encouraging results as foods for zooplankton. Algae pastes supplied to Mainland Salmon to evaluate as diets for rearing *Artemia* for feeding to Halibut larvae were used successfully. Similar results were obtained in laboratory experiments. There has been some uptake of commercially available equivalents, which have become available during the course of this work. Pastes are also being used for green-water techniques. Seasalter have further developed improved methods for large-scale algae production, in both extensive (ponds) and intensive bag systems. These methods are suitable for producing algae in bulk for short or longer-term storage.

The future

During this course of this study preserved algae diets, both frozen and dried, have become commercially available and there has been significant uptake, particularly by the fish farming industry. The results from this work have contributed to developments in this field. We have shown that preserved diets cannot fully replace live algae in shellfish hatcheries but have limited application as supplemental diets and could prove beneficial when the supply of algae within a hatchery is interrupted for any reason. There is considerable potential for preserved diet products in fish hatcheries.

TETRAPLOID SHELLFISH - A PATENT ISSUE

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Background

Oysters are normally diploid, and contain two sets of chromosomes in each cell. Triploid oysters, which have three sets of chromosomes, can be produced in the hatchery by treating eggs during early development. Triploid shellfish are theoretically sterile. They usually retain a better meat quality in the summer months and do not go ‘milky’, because there is little development of the gonad. This makes them commercially valuable. However, the usual techniques of producing triploids (chemical, pressure and temperature shock treatment to the eggs) do not guarantee 100% success. Triploid oysters can be produced much more reliably by crossing normal (diploid) oysters with ***tetraploid*** oysters. Tetraploids have 4 sets of chromosomes. Maintaining a broodstock of tetraploids will thus allow the production of triploids to requirements.

The patent

Rutgers State University of New Jersey submitted an application to the European Patent Office (EPO) in July 1995 for a patent for a method for producing Tetraploid shellfish. Rutgers had to wait nearly four years for the patent office to respond, and when they did they expressed some reservations on the application. Rutgers addressed the points raised by making some modifications to the application, and this satisfied the examiners. At this point the patent covered the following:

Producion of a viable tetraploid (4N) in three stages -

(i) Fertilise eggs from a Triploid Female using sperm from a diploid Male.
(ii) Block the release of polar body I from the fertilised egg.
(ii) Cultivate the fertilised tetraploid egg.

The application also includes applying this technique for any species of bivalve mollusc, using the chemical Cytochalasin B for stage (ii), and producing triploids by mating a tetraploid *(as produced by the above method)* with a diploid. The application also covers mating tetraploids *(as produced by the above method)* to create further tetraploid broodstock.

Objections

At a meeting in London in January last year between SAGB, MAFF and CEFAS it was agreed that 'observations' would be filed against the grant of this patent. The SAGB have concerns that it might otherwise affect future development of the UK industry. The observations were based mainly on the fact that the method was already in the public domain ('prior art'), as it had been described in a thesis published in 1991. IP consultants Mewburn Ellis were contracted and, working to advice from CEFAS, filed the observations. This had the effect of holding up the grant of the patent. We have learned recently that this attempt to prevent grant of patent was unsuccessful. The EPO are not obliged to explain why. The grant of patent will now go ahead, and the fee was paid in December 2000. However, objections to the patent can also be made up to 9 months following grant. The French, who have been fully consulted all along, intend to make such an objection. They see great potential for triploid Pacific oysters and they have a large industry, which produces 150,000 tonnes of oysters per year. The French objections are being co-ordinated and led by IFREMER, who are currently compiling a case against the patent. This issue is not likely to be resolved very quickly, but the outcome will be reported in a future issue of Shellfish News.

'ECO HARVESTER' FOLLOWS NEW HORIZONS

John Bayes
Seasalter Shellfish Ltd. (Whitstable)

A clue to better quality oysters

The 'Eco Harvester', the Seasalter Shellfish Company's elevator dredger, has been doing good service fishing for clams and cockles on their private fishery for almost two years now. The occasional stray or wild native or pacific oyster encountered was landed in excellent condition. We noticed too that the Pacific oysters were of better quality and faster grown than those from French style oyster bags on trestles. Whitstable, justly famous for its 'Natives', cannot attract the same accolades for bag grown Pacifics. Try as we might the cupped oysters seldom had a good meat yield. Triploids were, if anything, even worse! The pattern was always the same: excellent growth and fish during the late spring; ripen during June and July then, sometime around the end of the month, spawn out and remain thin and watery (but very flavoursome) right round to the following year. Oysters that escaped the bags, such as those stuck to the trestles or lying free on clean ground did not follow this

The Eco Harvester at work

pattern. The bags were the problem, but *only* in Whitstable. The same oysters in the same bags on the same trestles in Morecambe Bay produce one of the best oysters to be found anywhere.

Seabed cultivation at Whitstable

We knew what had to be done. Scatter them on the seabed; give them more room to live. But would we ever see them again? What about storm damage, starfish, crabs, and poachers? It was a chance we had to take. Against a background of falling oyster prices, increasing competition and more economical hatchery production, this had to be the way forward. Thankfully, the new dredging system recovers all shellfish with minimal damage.

Such are the savings in labour and overheads that the Company is moving almost entirely away from trestle parcs and equipping their existing oyster 'chaland' (aluminium barge built in Nantes in 1992) with a dredging system as well. The two vessels will work together harvesting cockle seed for relaying in France, where there has been no spatfall for over two years. There, customers are reporting a good return on this enterprise. Market cockles and clams are proving a steady earner. Plans are afoot to start mussel farming but first we need an answer to the problem of pea crabs. Infestation level is so high that almost every mussel has two 'squatters'! Has anyone got the answer?

Surplus equipment

Bags are still used to get seed to a size suitable for relaying but the recent move towards setting oysters on cockle shell will eliminate the need for bags and trestles altogether.

If anyone starting up in oyster farming would like to purchase some second hand trestles, please contact John Bayes on **01227 363359**.

ENVIRONMENTAL FACTORS AND BROWN RING DISEASE IN THE MANILA CLAM

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Background

The increasing demand for shellfish in Europe, coupled with the decline in production of several native species, has led to the introduction of several non-indigenous species that show promise for aquaculture. These include the Manila clam, *Tapes phillipinarum* (also known as *Ruditapes philippinarum* or *Tapes semidecussatus*), which was introduced into France in the 1970s, England in 1980, and Spain and Italy in 1985. Although culture of this clam species was initially very successful in France, mass mortalities occurred at one site in France in 1987. This previously unknown disease was characterised by a typical brown deposit forming as a ring on the inner margin of the shell (Figure 1). The disease was therefore called 'Brown Ring Disease' (BRD) and the causative agent was later shown to be a new *Vibrio* species, now termed *Vibrio tapetis*. Although bacterial disease in hatchery-reared bivalve larvae is quite common, and is usually caused by *Vibrio* species, it is unusual to find bacterial disease in adult bivalves.

Although BRD has been established in France for several years it was recently recognised in stocks of Manila clams in the UK and the causative organism is thought to be widespread in marine sediments.

Figure 1. Brown Ring Disease in the adult Manila clam. The disease is characterised by an abnormal brown conchiolin deposit on the inner face of the shell, within the extrapallial space (Photo - Christine Paillard)

The DISENV project

The group led by Christine Paillard in Brest has carried out detailed studies on the pathology and epidemiology of the disease, and the immune response of Manila clams to infection. However, it is not known whether particular environmental conditions can affect disease

susceptibility and the host defence mechanisms of the clams. This applies to other diseases of adult bivalves too and an EU-funded project *'Environmental Factors and Shellfish Diseases'* (DISENV) - is now under way to investigate this problem. Two parallel studies are being undertaken on how environmental conditions affect host-pathogen interactions, with BRD as an example of a bacterium-bivalve pathogen-host interaction and Bonamiosis representing a parasite-bivalve interaction. The project partners are Dr. Michel Auffret (UBO, Brest), Dr. Christine Paillard (UBO, Brest), Dr. Tristan Renault (IFREMER, La Tremblade) and Dr. Harry Birkbeck (University of Glasgow).

Occurrence of BRD is seasonal, with increased incidence in the post-winter period. As *V. tapetis* is not at its most prevalent at this time in natural waters and sediment, development of disease has been attributed to deficiencies in the immune system in the Manila clams in the post-winter period, when their energy reserves are depleted.

The project aims to identify which immune parameters of the clams are affected by seasonal changes, and this is being investigated both with field and laboratory studies.

Field studies

Currently ongoing, the field studies have seen the seeding of disease-free clam stocks at various sites in France (from Marennes, close to the Gironde, to the Bay of Brest on the Brittany peninsula) and in the UK (Poole and Whitstable). Over the course of a year, environmental parameters from each site are being recorded and samples of clams are analysed every 3 months to measure their immune capabilities. Immune parameters measured include differerential haemocyte (phagocytic cell) counts, and concentrations of protein, various enzymes, including lysozyme, present in their circulatory system, and their condition index. The animals are also examined to determine whether there is *V. tapetis* associated with them. It is hoped that by comparing clams from these geographically diverse sites, a correlation between environmental conditions and a perturbation in the clam immune status might be recognised. Should any environmental trigger for disease be identified, it may eventually explain the epidemiology of BRD, and indicate sites that could be disease free.

Laboratory studies

In conjunction with the field studies, experiments are being performed in the laboratory in order that environmental factors can be altered in a controlled manner to determine the effect on the clams and development of disease. The effect of water temperature on clams has already been studied. Approximately 100 clams were allowed to acclimatise at 7, 13 and 21°C for 2 weeks. After this time, the animals were injected with either sterile seawater (controls), or a dense culture of the pathogen *V. tapetis*, and maintained for 4 weeks before samples were taken. The holding temperature of the clams had a significant effect on the development of BRD, with clams held at 13°C having the highest prevalence of disease as compared to clams at 7°C and 21°C. Clams held at the highest temperature had the highest concentration of haemocytes circulating in their haemolymph, which reflects results from similar studies on other bivalves. These clams reared at 21°C also had a higher mean concentration of lysozyme in the haemolymph.

As well as directly measuring the above serum parameters of the clams, more detailed studies of their immune capabilties were also performed by measuring the phagocytic activity of the haemocytes *in vitro*, and the cytotoxic effect of *V. tapetis* on these cells. In control animals, the phagocytic rate increased with the maintenance temperature of the clams. With infected animals, the phagocytic rate was highest in 13°C reared clams and lowest in 7°C clams. In general, the inoculation of *V. tapetis* in to the animals did not significantly alter the phagocytic rate of the haemocytes. The cytotoxic effect of *V. tapetis* on haemocytes was measured by recording conformational changes in haemocytes challenged with the pathogen, from a healthy 'spread' shape of a motile haemocyte to a round cell that was non-motile and in which normal phagocytic functions appeared to have ceased. Haemocytes from both control and infected clams maintained at the lowest temperature were most susceptible to cell rounding induced by *V. tapetis*, but there was little difference between the response of haemocytes from control and infected clams. This indicates that temperature, and not the presence of the pathogen, has more impact on the immune potential of the clams, with clams from colder temperatures being less capable of phagocytosis and more susceptible to cytotoxic effects.

Similar laboratory studies are presently being performed with clams maintained at different salinities. As with the previous laboratory experiment, clams have been acclimatised to various salinities before injection with either *V. tapetis* or seawater. It is hoped that the integration of results from both the laboratory and field experiments will indicate which are the most significant environmental parameters influencing the susceptibility of Manila clams to BRD.

Further information

A comprehensive review of Brown Ring Disease can be found in C. Paillard, P. Maes and R. Oubella (1994) Brown Ring Disease in Clams, Annual Review of Fish Diseases, 4, 219-240.

Acknowledgements

We thank Christine Paillard for the figure, and John Bayes and Gary Wordsworth for provision of samples.

HEMATODINIUM IN NORWAY LOBSTERS

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A parasite is discovered

The Norway lobster, *Nephrops norvegicus* is the subject of an important fishery in the north-west Atlantic, with annual landings of over 60,000 tonnes. It supports a major fishery in the United Kingdom, with the Scottish fishery contributing over 76% of the total (22,000 tonnes, £57 million in 1999). During the early 1980s, fishermen in the Firth of Clyde, western Scotland captured some Norway lobsters in a moribund state, with dull orange colouration and a milky-white haemolymph. This happened mainly in the spring, coinciding with the main moulting period, and so the condition was designated 'post-moult trauma'. By the late 1980s, the increasing incidence of lobsters in this poor condition began to evoke comment from fishermen and processors and led to a regular sampling programme to define its seasonality and geographic incidence. Further studies on these affected lobsters led to the discovery that the condition was in fact caused by a parasitic dinoflagellate (a type of unicellular marine algae), similar to the *Hematodinium* species described from other species of decapod crustaceans. Members of the genus *Hematodinium* are primarily parasites of decapod crustaceans and infections have been reported from a number of commercial crab hosts around the world. This was the first description of *Hematodinium* infection in a lobster.

Identification of infected animals

To date, the major field diagnostic method for the detection of *Hematodinium* infection in Norway lobsters has been the pleopod method, in which a pleopod is removed from the underside of the abdomen and is assessed for the presence of parasite material under low-power microscopy (Figure 1). This has been used to show that *Hematodinium* infection is highly seasonal in the Norway lobster, with peak infection prevalence occurring during the winter and spring and low levels of infection occurring during the summer and autumn (Figure 2). However, the pleopod method fails to

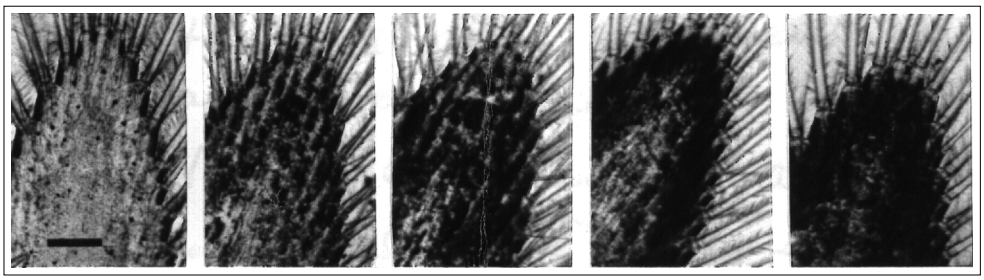

Figure 1. The pleopod staging method. Stage 0 (left) is classed as 'uninfected' using this method. Note the accumulation of parasite (dark) material within the pleopod as infection progresses from Stage 1 to Stage 4 (right)

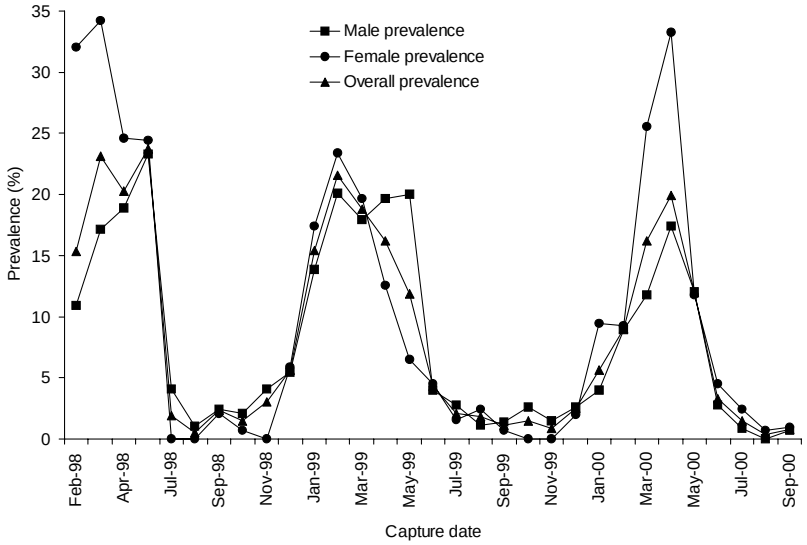

Figure 2. Seasonal Hematodinium infection prevalence in Norway lobsters captured from the North Clyde fishery. Note that infection prevalence in females (circles) is usually higher than that seen in males (squares)

diagnose low-level (sub-patent) blood infections and tissue-based (latent) infections. For this reason a polyclonal antibody was raised against the cultured *Hematodinium* species originally isolated from *N. norvegicus* and has been used to study the true epidemiology of this infection in *N. norvegicus*. This test has been shown to be much more sensitive than the pleopod method (Figure 3).

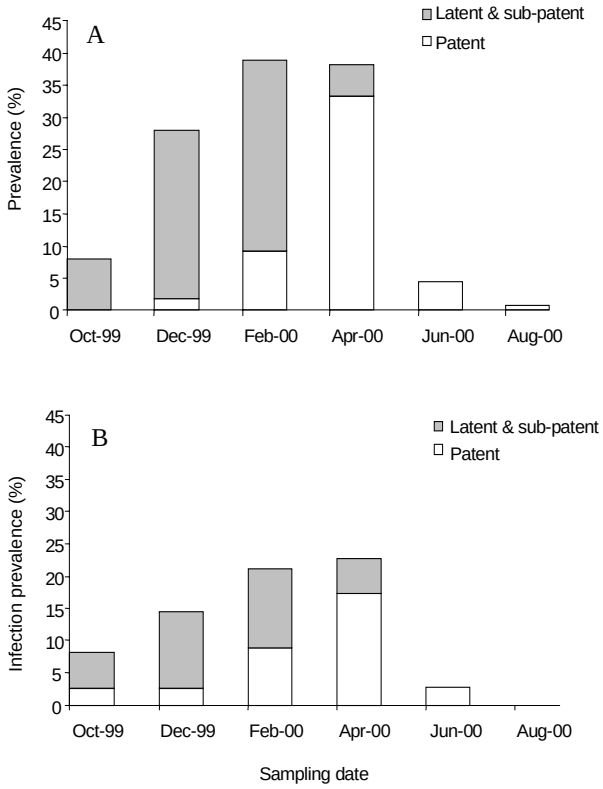

Figure 3. Immunoassay-corrected Hematodinium infection prevalence estimates for female (A) and male (B) Norway lobsters. Immunoassay data (grey bars) allowed addition of a sub-patent/latent infection component to patent infection as estimated by the pleopod method (white bars)

How are the lobsters affected?

Studies on *Hematodinium* infections of other commercially important crustacean host species have described major pathological disruptions to the muscle and to the blood. Similar observations on the pathological progression of infection (such as milky-white blood, infiltration of tissue and organs by parasite cells and a general morbidity) have also been made for Norway lobsters. Infected lobsters show depleted carbohydrate and protein reserves and an altered profile of free amino acids in the blood and in the tissues. Biochemical alterations to the meat of heavily infected animals may render it unmarketable, a problem previously encountered in *Hematodinium*-infected tanner crabs. Behaviour of the lobsters is also affected (see below). Infected animals also show a disruption to their normal blood hormone levels. The latter change is the first such demonstration of a hormonal disruption being due to infection by a parasite in an invertebrate host. Overall, the prevalence of *Hematodinium* infection in *N. norvegicus*, especially during epizootic seasons, is now being considered as an important natural mortality factor in *N. norvegicus* stock assessment models.

What is the effect on the fishery?

Most (c. 80%) Norway lobster landings are from trawler capture, the remainder from creel captures. As lobsters can only be captured when present on the surface of the sediment, both trawl and creel capture depend upon lobsters leaving their burrows. Once on the surface of the sediment, capture by trawlers is further affected by the ability of lobsters to perform escape swimming. Both the speed and endurance of tail flip swimming have implications for capture by trawl nets. It has recently been shown that infected lobsters spend longer periods out of their burrows and are less able to perform escape swimming than their uninfected counterparts. As such, estimations of *Hematodinium* infection prevalence in lobsters from trawl-caught samples may give a false value of true levels of infection in natural populations. Estimations of stock size based on trawl capture should also take account of the fact that lobsters are more likely to be caught if they are infected.

Future studies are planned

The detailed description of the epidemiology of this marine pathogen in wild populations is noteworthy due to the dearth of other such studies. Recently, proposals to study the prevalence of this infection in other European populations have been made. The application of the new rapid, sensitive and non-subjective immunoassay test described above will allow for the accurate comparison of *Hematodinium* infection prevalence data from different fisheries, at different European locations. These may allow us to compare elements of the host-parasite relationship in lobsters across the whole of their geographic range.

Further information

This article summarises some of the research work funded by MAFF and carried out principally at the University of Glasgow into *Hemtodinium* infection of the Norway lobster. It is particularly pertinent in light of increasing interest in epizootics that affect marine crustacean species. Further information on specific aspects of the work mentioned in this article can be obtained by contacting the author at the above address.

TRANSPORT OF LIVE CRUSTACEANS

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Brown crab

Introduction

This article gives a summary of an EU funded project to examine methods for reducing mortality during long distance/duration shipment of lobsters and crabs by air freight. The project was proposed and co-ordinated by Ocean West, Ireland and was funded jointly by the European Union and the commercial companies participating under the 'Innovation' programme of DG XIII of the European Commission.

The partnership comprised:

- Four crustacea/shellfish merchanting companies - Ocean West (Ireland), Ocean Maree (Belgium), Busanel (Italy) and Altifisk (Sweden).
- One technology provider - AquaMedic (Germany).
- One air transport agent - Expeditors Sea Sky (Ireland).
- Two scientific and technical advisors - Marine Institute (Ireland), Sea Fish Industry Authority (UK).

Objectives

The objective was to reduce mortality in crustaceans, especially crabs, during all stages of the export-import supply chain, with particular emphasis on seeking to open up new opportunities in markets beyond the accepted limits.

The method was to test whether the proven technologies in use for the transportation of pet-fish, which involve using specially designed tank systems for conditioning the animals prior to transport and holding them subsequently, could be extended to and used economically for the long distance/duration transport of crustaceans.

A new tank system

A prototype tank system with the capacity to hold and condition 400–450 kg of lobster or 350–400 kg of Brown Crab, either before or after transportation by air freight for up to 72 hours duration was designed, constructed and tested.

The property rights to the design and operation of the conditioning and re-tanking system reside with the commercial partners who took part in the project. Prospective customers who wish to exploit these developments are invited to contact Ocean West at the address at the end of this article to discuss licensing agreements. It is possible, however, to give a broad over-view of the system without compromising those rights.

The filtration and cooling system is the main component of the tank. Carefully designed and tailored protein skimmers are the critical items, being more important to the maintenance of high water quality than biological filtration in these systems. Calcium reactors play little part in maintaining pH or Ca^{2+} concentrations during the short storage and conditioning periods, but become more important in longer-term storage facilities. Automated slow cooling of the animals from ambient temperatures to the storage and packing temperatures is

another key component of success. Efficient aeration systems were of a standard design.

Further development of the prototype is underway to produce commercial units.

Water quality within the tank was optimised to provide and maintain stable conditions: Temperature, 4–6°C; Ammonia < 5 ppm; PH, 7.8 – 8.0; Redox potential, 350–400 mV; Oxygen, 100% saturation.

Results

Lobsters and Crawfish (Spiny Lobsters) survive long distance/duration transport by airfreight better than Brown Crabs. Initial trials showed that Lobsters and Crawfish could be transported successfully using this system. Subsequent attention was focused on Brown Crabs.

There was variability in the results between boxes of crabs subjected to identical experimental treatments, but some broad trends were apparent. Losses in crabs transported at ambient temperatures were greater than those transported under cooled conditions. In general, the higher the temperatures, the greater the losses (>70%). However, there was a suggestion that subjecting the animals to prolonged periods below 3°C, when coupled with the stress of transportation, may increase mortality. Crabs which were inverted (i.e. ventral side uppermost) in the boxes were more likely to die than those transported under similar conditions with their dorsal surface uppermost. Individually separating animals within the boxes did not decrease mortality. Subjecting crabs to rough handling during transportation or storage and packing increased mortality.

Mortality of crabs increases with the duration of transportation. For example, without using the tank system, a 24 hr transport regime results in a 13.5% mortality, increasing the duration to 48 hr gives 22% mortality, whilst a 72 hr or longer duration produces losses of 66% or more. Trials using the new system reduced 24 hr losses to approximately 1% and 48 hr losses to only 3%. The system has been used successfully to ship commercial consignments of Brown Crab to the Far East. Mortality was 20%, compared with 80% previously, without using the system.

Summary

- A system has been developed which is applicable to the transport of all crustaceans, with great improvements in survival with crabs, compared with traditional methods.
- Transportation temperatures should be maintained below 10°C, with crabs packed the right way up. There is no advantage in separating individuals, but rough handling at any stage, from capture to final destination, significantly increases mortality
- Air freight transport operators need to improve their systems to ensure consistent treatment and care of consignments.
- Transfer to optimised holding conditions after unpacking from transport containers significantly reduces mortality at the destination.
- No viable alternative packaging system to the polystyrene box was identified at this time.

Contacts

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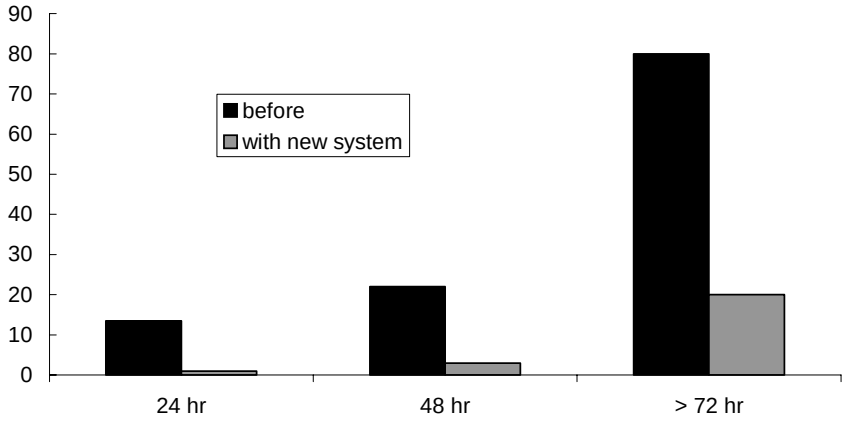

Losses of Brown Crabs during transport (%)

ASSESSING THE STATE OF SHELLFISH STOCKS – SCALLOP STUDIES IN THE WESTERN ENGLISH CHANNEL

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Background

Like many shellfish, scallops do not move about very much. This may seem an obvious point, but it has important repercussions when it comes to interpreting the state of a scallop stock on the basis of fishery statistics. It means that we cannot treat scallops simply as fish with shells on. Many fish are able to re-distribute themselves in response to fishing effort. By contrast, a scallop removed by fishing has no immediate prospect of being replaced in its location by other scallops within the population.

Since settlement of spat is not uniform across the area of a stock, neither will be the distribution of fishable adults. This is important because there is an assumption underlying many stock assessments that the catch per unit of fishing effort is an index of the abundance of the stock. If, by targeting areas of high scallop density, fishermen are able to maintain catch rates at a relatively high level then this assumption does not hold. Catch rates could remain relatively stable even if the stock was declining, right up until the point when all high-density patches were used up. Clearly, there is the potential for significant stock trends to be masked.

CEFAS scientists are currently engaged in research intended to help us understand how we need to take account of the spatial distribution within shellfish stocks in constructing valid stock assessments. To this end, since November 2000 we have carried out three sets of experimental fishing for scallops in the western English Channel. We need answers to three specific questions: (1) How do scallops distribute themselves on the seabed? (2) How does this affect the targeting of fishing effort? (3) How do scallop dredge catches reflect the populations from which they are drawn?

Scallop studies in the western English Channel

On our first cruise in early November 2000, aboard the CEFAS research vessel *CORYSTES*, we used standard commercial spring-loaded dredges to fish for scallops at 54 locations grouped into six areas within two ICES rectangles (Figure 1). Three 15-minute tows were undertaken at each location. The work was aimed not so much at describing the distribution of scallops within this area of the Channel, but at describing the *characteristics* of this distribution. That is, how do scallop abundance, sizes and ages vary over long and short distances, and how much variability is inherent in the dredge sampling process?

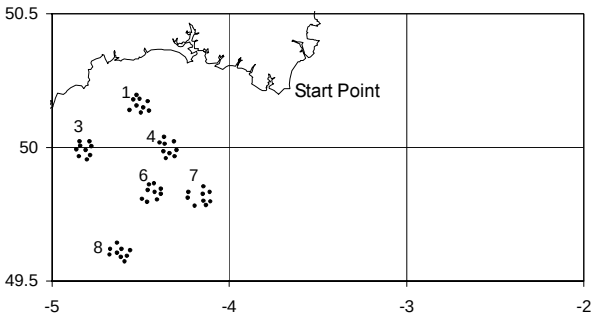

Figure 1. Location of tows

It will take some time to collate results completely from this cruise. Determination of the age of each of the 2000 scallop shells is a particularly lengthy process, requiring microscopic analysis of shell markings (Channel scallops lack the clear annual rings that are evident on shells from other areas). It is already apparent, however, that there are strong spatial patterns in catch rates that will need to be considered in assessments and in the design of any future survey. Variation within locations, variation between locations within areas and variation between areas each accounted for around a third of the total variability in catch rates. Average catch rates varied nearly twenty-fold between areas, correlating strongly with ground type – lowest on the 'clean', sandy ground of Area 1 and highest on the hard, stony ground of Area 8 (Figure 2).

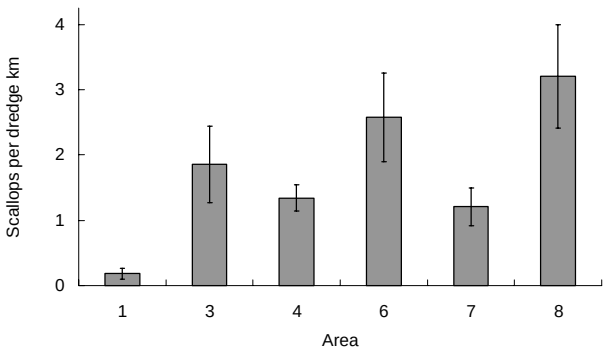

Figure 2. Variation in scallop density

How does the targeting of fishing effort relate to this distribution? Immediately after the research cruise, the commercial scallop vessel *GEESKE* operated by McLeod Trawlers of Brixham was chartered to fish in the same two ICES rectangles. The pattern of fishing was as close to commercial as possible, with no knowledge of the earlier *CORYSTES* catch rates. The cruise yielded useful information on the pattern of exploratory fishing. It is clear that the search pattern related strongly to past experience of commercial fishing in the area. Data from this cruise and from analysis of log-book records will allow us to describe commercial fishing behaviour, in much the same way as a behavioural ecologist describes the decision rules of a shorebird preying on mussels.

A difference in catch rates can mean differences in either or both stock density and catchability. Were the differences in catch rates on our *CORYSTES* cruise a result of real differences in scallop density, or was it simply that our dredges were more efficient on hard than soft grounds? To help answer this question we undertook a third cruise in January 2001, again chartering the fishing vessel *GEESKE*. In five of the six areas fished in November, we carried out a series of 'depletion' experiments. This involves measuring the rate at which catch rates decline as scallops are cumulatively removed from the area of experimental fishing, thereby allowing us to estimate the number present at the start of fishing. The results show that much, but by no means all, of the variation in *CORYSTES* catch rates can be attributed to differences in density (Figure 3). The remaining variation is due to differences in gear performance – the dredges appear in fact to have been more efficient on 'clean' than on rough, stony ground.

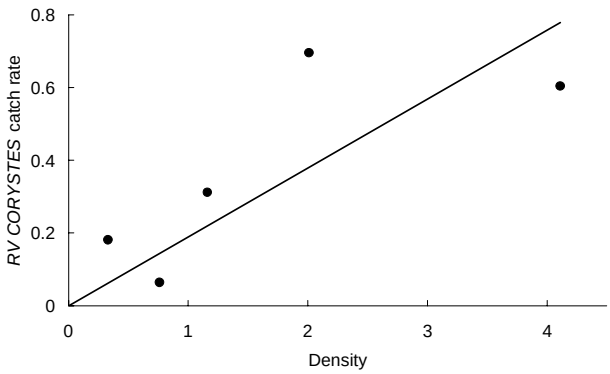

Figure 3. RV Corystes catch rate

Conclusions

Work continues on interpreting the results of these three cruises, and there is much to be done to develop a coherent understanding of how commercial catches relate to the stock from which they are taken. For now, we can make use of the results in several important ways – to help interpret commercial catch rates, to design efficient stock surveys and to model the interaction between scallop population dynamics and fishing. Our eventual aim is to formulate stock assessment models that consider patterns of exploitation of scallop stocks at the appropriate spatial scale. We are already planning preliminary scallop stock assessments for the western English Channel in the near future. Research continues into the spatial characteristics of commercially exploited stocks of scallops and other shellfish species.

FOULING IN SCALLOP AQUACULTURE: FRIEND OR FOE?

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Background

Fouling by plants and animals is a ubiquitous and costly problem for scallop growers worldwide; it increases the weight and drag of cultivation equipment and can adversely affect scallop appearance, growth and mortality. Cleaning or changing the pearl or lantern nets in which scallops are grown is labour intensive and can stress scallops, reducing growth rates. However, experiments in Manx waters suggest that pearl net fouling may actually encourage scallop growth rates in winter months and have no effect or a slightly negative influence in the summer. This study aimed to discover the mechanisms by which net fouling influences the growth of scallops in suspended culture and thus help us to tackle fouling efficiently.

It is often assumed that fouling of the nets in which scallops are suspended reduces scallop growth and survival, and this has been shown for scallop spat. Competition for food (many fouling organisms filter-feed on the same particles as scallops), low oxygen levels and reduced water flow (and hence food flux) are often suggested to explain reduced bivalve growth in fouled nets. Fouling can also kill spat by smothering and entanglement. Occasionally, studies report that fouling has a positive effect on scallop growth. This could be because fouling reduces water currents that can inhibit scallop feeding in areas with high current speeds. Decaying fouling organisms could also provide food for scallops or nutrients for the plankton on which scallops feed.

Investigation of the problem

A clean pearl net with scallops

Experiments were carried out on two longlines off the South West coast of the Isle of Man (Irish Sea). Tidal streams in this area reach up to 2.5 knots. The longlines were positioned in 23 m of water and the pearl nets sampled were suspended 11.5-13.5 m below the surface. The pearl nets had a full mesh size of 33 mm and each contained ten great scallops of 65-85 mm shell length.

I aimed to find out whether the environment for scallop growth within pearl nets used for scallop cultivation was different to the external environment; also whether differences were due to the presence of the net or fouling or a combination of both. To do this a range of factors important for scallop growth were measured inside of clean nets, fouled nets and in open-water positions, (under the headrope of the longline). Divers collected water samples from the inside of nets and open-water sites using 60 ml syringes with 12 cm Teflon tubing tips. On each longline, water samples were taken from each of five replicate nets. The amount of oxygen, particulate organic matter (POM), particulate inorganic matter (PIM), dissolved nitrogen (nitrate and ammonia), chlorophyll *a,* plankton (size and type) and zooplankton faeces in water samples was measured. Water motion was estimated from the dissolution of plaster of Paris spheres suspended inside the pearl nets and under the head rope.

To investigate whether the effects of fouling varied seasonally, experiments were carried out in June and November. In November two fouling communities at different stages of development were used to see whether the composition of the fouling community influenced the environment inside the nets.

In June, fouled nets were almost entirely covered (>90%) with the hydroids *Tubularia indivisa* and *T.larynx* and silt tubes of the amphipod *Jassa falcata*, - nudibranchs were also common. Clean nets were sparsely colonised (<5%) by small hydroids. In November, the fouling communities were more diverse than in June, but covered only 60-70% of the net surfaces. Fouled nets were dominated by the tunicate *Ascidiella scabra.* Nets fouled for six months also

Nudibranchs feeding on a pearl net that had been submerged for four months and was covered in hydroids

supported a mixture of hydroids, those fouled for ten months were colonised by more species, including; feather stars, queen scallop spat, mussels and anemones. Again, clean nets were sparsely colonised, mainly by small hydroids.

The diverse fouling community on a pearl net that had been submerged for 10 months

Results

In June, water movement was reduced by both nets and fouling. November results showed a reduction in water flow in nets fouled for six months compared with clean nets, nets fouled for ten months and open-water sites. This

is probably because hydroids and tunicates occluded the mesh spaces more thoroughly than mussels and feather stars. Ammonia and nitrate concentrations were not affected by the presence of fouled or clean nets.

In June, total particulate matter was highest in fouled nets. Zooplankton faeces were counted under a microscope, they accumulated significantly in fouled nets in June and nets fouled for ten months in November.

Planktonic organisms were highly concentrated in fouled nets, in June (Figure 1). However, plankton distributions were patchy. Some fouled nets contained high concentrations of plankton, whilst others contained similar levels to clean nets. November results showed that the type of fouling could affect plankton abundances; nets fouled for ten months supported significantly higher plankton concentrations than all other treatments, including nets fouled for six months. Chlorophyll *a* concentrations reflected the abundance of phytoplankton (Figure 1) but were unusually low in June given the high plankton concentrations, this is probably an artefact caused by strong sunlight degrading chlorophyll in June samples. Oxygen was only successfully measured for the north system in November; when levels were highest in nets fouled for ten months. Phytoplankton produce oxygen and their high abundance in nets fouled for ten months probably explains the high oxygen levels in these nets (about 99% saturation compared with 96% in other treatments).

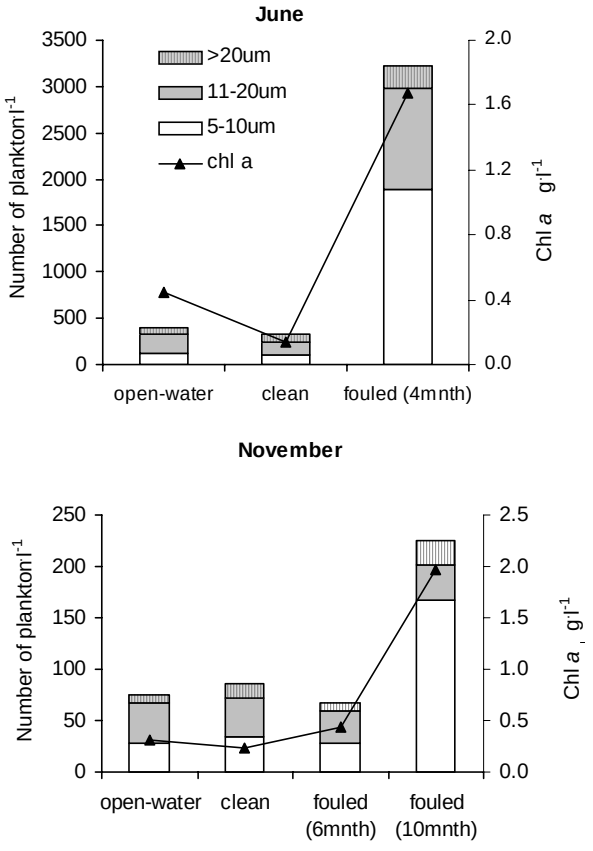

Figure 1. Concentrations of chlorophyll a and three sizes of plankton

In June, significantly different plankton communities were associated with each of the three treatments on each system. Fouled communities were most strongly defined, supporting both higher abundance of common species (5-11 mm monads, 11-20 mm flagellates and 11-20 mm pennate diatoms) and different types of organism (including benthic ciliates, nematodes and invertebrate larvae) to clean and open-water sites. November communities were less distinct than June ones; only nets fouled for ten months differed significantly from all other treatments. Again, differences in the abundance of monads, flagellates and pennate diatoms were important in distinguishing sites, as was the presence of eggs and spores in long-fouled nets.

Conclusions

Fouling alters the environment within pearl nets, and the effects of fouling vary with season and the composition of the fouling community. In high current areas off the Isle of Man, fouling appears to increase food availability, perhaps by retaining plankton in a favourable environment. There was no gross build up of decay products (nitrate and ammonia), dilution of food (organic) particles by inorganic matter or an oxygen deficit in fouled nets. Although fouling reduced water-flow, the common inference that this leads to food depletion was not born out. The effects of low water-flow on scallop feeding efficiency, however, are not known. The presence of nematodes and invertebrate larvae in fouled nets may be undesirable because nematodes can interfere with scallop feeding, and invertebrates (e.g. crabs and starfish) could prey on scallops if they settle and grow.

These results help to explain how fouling could enhance the on-growth of scallops in suspended cages. It could also be inferred that negative effects on scallop growth are caused by fouling organisms mechanically interfering with scallops (e.g. binding them in unfavourable positions, smothering or disrupting feeding behaviour) rather than altering the net environment. The production of anti-predator or anti-fouling chemicals by fouling organisms, and parasitism, were not investigated and might be important. Further work to determine more precisely how different fouling organisms affect the net environment at different times of year should help growers when choosing sites, depths or methods of fouling control.

Acknowledgements

I am very grateful to divers and boat crew for help with sampling, especially in cold November seas. Thanks to Ian Laing and John Berges for advice on nutrient and plankton sampling.

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ASP IN KING SCALLOPS

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Background

Since the first outbreak recorded from Prince Edward Island, Canada, in 1987, global awareness of Amnesic shellfish poisoning (ASP) has been raised. To date domoic acid (DA) toxin producing species and/or ASP events have been reported from the gulf of Mexico, North America, Canada, Europe, Australia, New Zealand and Japan.

The incorporation of systematic ASP/domoic acid testing of shellfish into the Food Standards Agency (FSA) Scottish waters surveillance programme was initiated early in 1999. By July 1999, king scallops harbouring DA in the gonad at levels above the internationally accepted closure limit (20 µg DA g^{-1}) were detected across a wide area of northern, western and north eastern Scottish waters. This prompted a widespread closure of the king scallop fishery that persisted in excess of 10 months, until late May 2000. During the height of the incident the ban covered in excess of 19,000 square miles; to date the largest fisheries closures resulting from a Harmful Algal Bloom (HAB) event. The toxin levels peaked in August with 250 µg DA g^{-1} detected in scallop gonad tissue. The ASP problem appeared to be confined to the king scallop, as only sporadic, short-term toxicity was noted in the queen scallop and negligible levels detected in other shellfish. ASP in King Scallops returned in July 2000 and by late August a majority of the West coast and Orkney and a few Moray Firth scallop fishing boxes were again closed to fishing. The second event appeared less severe as highest toxicities detected were only 69 µg DA g^{-1} in scallop gonad tissue and by early December the majority of closures had been lifted. By the end of March 2001, all boxes had been re-opened.

The king scallop is a valuable economic resource in the UK and the closures resulted in considerable financial hardship for scallop dredging, diving and cultivation industries. The direct cost to the industry of the 1999 closures was an estimated £10 million while the loss of skilled processing staff and disruption of established supply routes to continental markets led to serious concern for its survival. The restriction on scallop landings provoked controversy and stimulated much media interest. However, to date there has been no documented history of human illness caused by ASP in scallops in the UK.

Field Study

In December 1999 the Scottish Association for Marine Science and the Scallop Association conducted a survey of the southern region of the closed harvest areas. The data collected provided basic information to assist with the development of rational management strategies for future ASP events. The three objectives were (1) to describe ASP toxin variability among individual and neighbouring scallop populations over varying spatial scales (<5 metres to >5km), (2) to determine the anatomical distribution of the ASP toxin, (3) to identify causative *Pseudo-nitzschia* species. This research was funded by Highlands and Islands Enterprise, the Highland Council, HIE PESCA and the Scallop Association.

Summary of results

- The DA content of tissues always followed a predictable rank order of 'all other' tissue (digestive gland/mantle/gills) > gonad > gonad + adductor (combined 'roe on' product)> adductor.
- Individual toxin variability among scallops was high which further complicates the management of the king scallop fishery during ASP events.
- The toxin levels within 'all other' tissue consistently accounted for 99% of the total toxin burden. The maximum DA concentrations in 'all other' tissue recorded in this study were approximately 180 times the regulatory limit, and are among the highest levels of DA recorded in bivalves.
- DA levels in the gonad contributed to less than 0.5% of the total toxin burden. Levels above the regulatory limit were detected in some individual gonad samples. However, the occurrence of individuals with elevated toxicity was not consistent at each location.
- Adductor muscle contained the lowest concentrations of DA, within 2 to 3 orders of magnitude below levels in all other tissue. The levels never exceeded the statutory limit even when toxicity was extremely high in all other tissue.

- Due to the low levels of DA in adductor muscle and its comparatively large mass, DA within the combined roe on product never exceeded the statutory limit.
- Despite the inherent individual variation, toxin levels differed between groups of individuals only 25 m apart and thus give an indication of the scale on which microhabitat differences influence ASP toxicity in scallop populations.
- In total, 7 species of *Pseudo-nitzschia*, were identified from West Coast waters. A suspected causative species, *P. australis*, readily produced high levels of DA, in culture.

Mitigation

During an ASP event the marketing of digestive gland, mantles and gill poses a high risk to public health. However, when gonad toxicity is greater than the regulatory limit discarding of tissues that selectively sequester the DA toxin may provide an effective strategy to enable the marketing of adductor muscle, in conformity with the domestic 'roe off' market of the U.S and Canada. A multi-tiered monitoring and control regime is being proposed by the Scottish Scallop Advisory Committee and the SFIA Scallop working group. If testing reveals that the whole animal is unsafe then marketing of the whole scallop should be banned but the landing of scallops for processing should continue, providing that toxin testing demonstrates that the processed product remains safe. If testing reveals that the gonad is unsafe then marketing of the processed product with gonad should be banned and the option to market adductor muscle 'meat' alone made available. FRS Aberdeen have prepared a report for the EU Standing Veterinary Committee (SVC) which should address the SVC concerns regarding the proposed tiered testing system. It is hoped that the system can be in place either late summer or early autumn this year. Northern Ireland have already implemented a restricted tiered system for their industry.

High DA variation among individual scallops dictates that a large number of individuals are needed if pooled tissue samples are to accurately reflect mean population toxicity. However, in species where toxicity is extremely variable, it is now the consensus that monitoring tissues on an individual basis is more informative. Data describing individual variability in gonad toxicity at a given locality allows populations with a low frequency of individuals with elevated gonad toxicity to be distinguished. This would then permit evaluation of the real level of risk these tissues pose to human health, with respect to their rate of consumption. While complicated to implement, such systems could prove applicable to the aquaculture and diver sectors, as it is the nature of these industries to distinguish and harvest discrete beds/ populations of scallops. The use of risk assessment models should be considered to continue to maintain public safety standards, yet ensure optimum utilisation of the high quality king scallop resource.

Scottish Scallop Advisory Committee

The Scallop Advisory Group presents an opportunity for all stakeholders in the scallop sector to meet on a regular basis and so form a more cohesive relationship between Government and industry. The initiative aims to give members of the scallop industry the opportunity to voice their concerns, discuss potential solutions and influence policy effecting the scallop sector in particular and the shellfish industry in general. The Committee has representatives from: Food Standards Agency Scotland, Scottish Executive Rural Affairs Department, Fisheries Research Services, Scottish Fishermen's Federation, Association of Scottish Shellfish Growers and the Scallop Association. The committee may on occasion call on other groups or Associations for advice in specialist areas.

For further information on the Scottish Scallop Advisory Committee contact:
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INVESTIGATIONS INTO THE IMPACT OF SURFACE WATER RUN-OFF FROM AGRICULTURAL LAND INTO THE DART ESTUARY, DEVON, UK

Introduction

The tidal section of the River Dart, Devon has a long tradition of commercial oyster cultivation. Although currently small-scale in economic terms, the existing oyster fishery is considered to have significant environmental importance in relation to the management of the estuarine system. The shellfishery was officially designated as a 'harvesting area', in 1999. Devon Sea Fisheries Committee (DSFC) has ambitious proposals to enhance the fishery in size and production methods and recently (2001) received confirmation of a hybrid Several and Regulatory Order empowering it to take these proposals forward. Dart Estuary Environmental Management (DEEM) is a partnership of local stakeholder organisations whose objective is the sustainable use of the estuary. DEEM works closely with shellfish producers and regulators in pursuit of this objective.

Shellfish cultivation in the Dart

Background to Investigations

Since the introduction of the Shellfish Hygiene Regulations, approximately a decade ago, the Environmental Health Service (EHS) of the local District Council (South Hams District Council) has routinely monitored the oysters of the Dart Estuary. Throughout the greater part of the period, despite the variability inherent in the existing sampling and analytical methodologies, the Dart remained within the Category 'B' Classification for shellfish harvesting purposes.

In 1998, rising concentration levels of *E.coli* bacteria present in the shellfish samples led to a downgrading of the classification to Category 'C'. This had an obvious and serious negative impact on the commercial viability of oyster production in the river. During 1999 the harvesting area remained within the Category 'C' Classification and currently (March 2001) it is classified differentially as Category 'B' for oysters, and Category 'C' for mussels. The uncertainty associated with the classification procedure continues to act as a disincentive to existing and potential producers and an impediment to the ambitions of DSFC.

The evidence of the *E. coli* data described above suggests that there has been a substantial fall in water quality in recent times (post 1998) but no causative factor has been identified. A shortcoming of the existing *E. coli* assay procedure is that the provenance of the bacteria is not defined. It was therefore unknown if sewage of human origin was to blame or if the increase in *E. coli* was attributable to agricultural or wildlife origins. The human population within the catchment had not increased significantly during the period and in fact most of the settlements within the catchment are subject to a development embargo pending improvements to the sewage treatment facilities available. Although there may have been seasonal increases in population attributable to rises in tourist trade there was no corresponding seasonality in the *E. coli* data.

It was therefore suspected that agricultural run-off was a likely source of the elevated level in *E. coli* concentrations. There had been changes in agricultural practice within the catchment, within the period. In particular there had been a significant switch from pastureland to intensive organic vegetable production. DEEM therefore proposed a study to investigate the impact of agricultural practice on water quality in the area.

Outline of study

The shellfish and water quality sampling undertaken by the statutory agencies (District Council, EHS and the Environment Agency (EA)), has the disadvantage of being conducted on a regular, predetermined schedule. This may, or may not, coincide with rainfall events. The Dart Estuary is characteristically a steep-sided valley (geologically, a 'ria') and is considered a very 'flashy' catchment i.e. there is an extremely short response time to rainfall events. The 'first flush' effect immediately following rainfall was considered an important factor with regard to resultant water quality and was frequently missed by the regular sampling schedules of the statutory agencies. Additionally, the *E. coli* (and associated) data was collected purely for classification purposes and little analysis or correlation with hydrometric data was undertaken.

DEEM has a policy of recruiting a final year graduate student to undertake a dissertation project in an area of topical interest. In the summer of 2000, Emily Allen, a final year student at Bournemouth University reading Environmental Protection, was employed to research the question of agricultural impacts on water quality. Ms Allen has a home base conveniently situated close to the river giving her opportunity to collect samples in rapid response to rainfall events.

Emily Allen sampling in the Dart

Her study involved two main themes:

(a) Water Quality Investigations – involving the collection of samples throughout the study period, in particular immediately following 'significant' rainfall events.

(b) Compilation of data on land ownership and use.

Finally, analysis of the data collected would attempt to assess any correlation between (a) and (b).

Methodology

The rationale of the study was to supplement the statutory agency data and to attempt to plug some of the information gaps. As such the project was strongly supported by the agencies concerned, for which DEEM and the researcher are extremely grateful.

A weekly regime of sampling at nine locations throughout the study area was established. This was to provide comprehensive background data that could also be supplemented by the monthly data collected by the agencies. This provided a more intensive dataset than would normally be available and also a useful cross-correlation of data. Additionally, samples were taken immediately following heavy rainfall (within 24 hours). For the purpose of this study 'heavy rainfall' was defined as >15-20 mm/hr. Logistical support was provided by DSFC in the form of a boat and assistant.

The sampling sites were limited by the analytical costs involved but were chosen having regard to potential run-off in relation to topography and major sources of input i.e. tributaries. The samples were delivered (within a maximum period of 6 hours) to a Public Health Laboratory (NAMAS accredited) for analysis. The District Council, recognising the value of the data provided by the project, generously underwrote the analytical costs involved.

The Environment Agency (EA) also gave support to the project by providing hydrometric data and additional water quality data. Significantly, the EA also gave Ms Allen access to the rainfall monitoring section so that she could respond to rainfall events quickly. The study was conducted over the summer period, firstly because of the availability of the researcher but secondly, because the 'first flush' effects can be more pronounced in the summer season when isolated rainfall events occur over relatively dry land.

Resource limitations dictated that the land use mapping had to be restricted in extent. It was not possible to compile data in respect of the full extent of the catchment and the study was limited geographically to the vicinity of the shellfish harvesting area. A nominal boundary was defined at the first contour break, which was generally within a 2-3 field depth of the river banks.

The District Council made available access to their GIS for compiling and manipulating the data. In this aspect the study provided a pilot scheme for the use of the GIS as a management tool for the estuary. Details on land ownership were compiled from local knowledge, interviews and questionnaires. Questionnaires were distributed to all the agricultural holdings concerned requesting information on land utilisation currently (2000) and formerly (1995) and fertilisation policy for the corresponding years (1995 and 2000).

The response rate (72%) was considered a positive indication of the support to the project from the agricultural sector. It has enabled a detailed local picture to be developed of current land use and recent changes in patterns of land use. A useful by-product of the study has been the raising of awareness of the local agricultural community to the run-off issue by involving their co-operation in the data gathering.

Results

Preliminary results demonstrated that *E. coli* levels in the river at points in the vicinity of land under intensive cultivation were elevated above the background values in the periods immediately following rainfall. In some cases the *E. coli* levels were increased by a factor of one hundred-fold over background. This increase in bacteriological loading confirmed that agricultural run-off in the Dart Estuary is a significant factor and one that is frequently undetected by the regular monitoring protocols.

The Dart Estuary is fortunate in having a significant portion of the riverbanks as natural or managed woodland to the water's edge. Samples taken in the vicinity of wooded banks showed low levels of *E. coli*, demonstrating the buffering effect of woodland on bacteriological (and probably other) inputs. Conversely samples collected in the vicinity of land under intensive organic production showed relatively high concentrations of *E. coli.*

Collection of data on land use revealed that at the beginning of the study there was generally a low level of awareness amongst the land-based farming community that their activities could have such a direct, large and negative effect upon the activities of their river-based farming colleagues.

Future Work

The study yielded useful data confirming the problems relating to agricultural run-off in the Dart Estuary. The study has identified the need for further work in this area. As such it has proved a very cost-effective pilot study which can be used as a basis for seeking further resources to carry out comprehensive catchment studies for the Dart.

The Dart Estuary currently has a poor level of provision of sewage treatment to point- source discharges. There is, however an extensive programme of improvements planned for the period 2000-2005. It is hoped that further catchment studies can be undertaken to measure the bacterial loading in the shellfish harvesting area both before and after the improvements are commissioned. In that way the research could measure the efficacy of the improvement programme and quantify the relative importance of diffuse sources, in relation to the system as a whole.

The study demonstrated the effectiveness of partnership working between the various regulatory agencies responsible in tackling the diffuse pollution problem.

The study was also useful, in a local context, in raising awareness of the problems affecting mariculture and the importance of mariculture both to the local economy and as an indicator of the environmental well being of an estuarine system.

Contacts

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ANNOUNCEMENTS

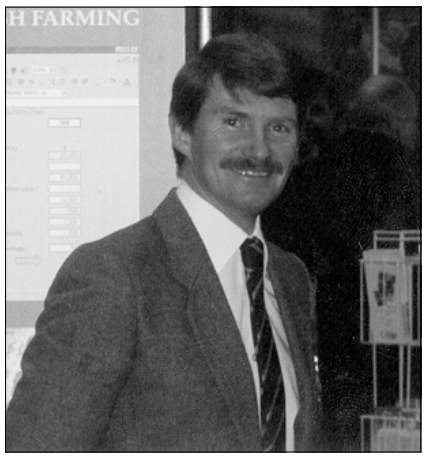
SEAFISH AQUACULTURE DEVELOPMENT SERVICE

The new team

At the beginning of September 2000, Seafish's Aquaculture Development Team was charged to provide this new service to the shellfish and marine finfish industry sectors. Nick Lake heads the team with two regional Development Officers, namely Craig Burton for Scotland and Northern Ireland, and Sue Utting for England and Wales. Although Craig and Sue have prime responsibilities for their respective regions, the territorial limits are not cast in stone. For example, Sue has already spent time visiting mussel farms on the West Coast of Scotland, meeting the operators and gathering information on the techniques and costs of suspended mussel culture.

Shellfish modelling

The collation of such information along with production data collected for other species farmed in the UK (i.e. oysters, king scallop, dredge mussels and clams) has been developed into a series of economic models showing the investment needed in setting up and/or expanding shellfish businesses. This project which was co-funded by MAFF, will be very useful for existing shellfish producers and any new entrants to the industry, allowing development of business plans and commercial operations. The models will also be useful for government departments, agencies and funding bodies in order to evaluate where investment should be directed to assist the further development of UK aquaculture.



Craig Burton

Sue Utting

Today many problems and uncertainties challenge the industry and it will take a concerted effort by all parties to address these. The economics modelling tool that Seafish has developed can be used to demonstrate the financial implications to shellfish businesses of environmental changes such as water quality classifications and additional depuration costs, changes in lease durations, and through not meeting expected harvests for any reason including biotoxin closures, pollution incidents etc. This tool will hopefully assist in making decisions on the strategic development of aquaculture in the next 5 to 10 years.

Other help

The Seafish Aquaculture Development Team will also be working to help the industry in a range of other ways as outlined in Seafish's strategy document 'The UK Shellfish Cultivation Industry – A Strategy for Development' (January 2000). On a day-to-day basis these include providing help and advice to the shellfish industry through a variety of methods including visits to shellfish sites, responding to enquiries by phone, fax, letter and e-mail, attending SAGB and ASSG meetings and conferences, and liasing with SFCs as and when appropriate. The boundary between aquaculture and extensive fisheries management is not distinct and the Team has participated in initiatives such as the Native Oyster Species Action Plan Steering Group, which aims to re-establish larger scale managed fisheries. In a similar light the re-establishment of the Wash mussel fishery, development of the Conwy fishery and increased production of shellfish through the use of Several, Regulated and Hybrid Fishery Orders in other areas will be supported to ensure that the opportunities for volume production are recognised.

Grants and funding

The industry needs the opportunity to seek grant aid assistance, even though as many have found, the application process can sometimes be less than straightforward. Deadlines for receiving proposal applications can be very short when you are trying to run a business that is dependent on breaks in the weather or state of the tide! The Team is able to provide advice on sources of funds available to existing businesses and potential new investors, particularly in areas receiving Objective 1 and transitional funding. To facilitate this, and provide technical advice and information to those considering funding applications, contacts have been established with local government and development agencies including those in the South West, Wales, Scotland and Northern Ireland. The team may not be able to help everyone with individual applications but we will act as facilitators, and steer you in the right direction for contacts, if we are unable to help you ourselves.

Contact us

The current status of the industry - in terms of who is out there, what is being produced, and where - is proving difficult to establish for every individual operator and cultivation area. Some of the information held by agencies is confidential and so if you require to meet or gain advice from the team, please contact us in the first instance. Despite being a small team which has only been in existence for eight months we have put together a lot of benchmark information and used it to raise the profile of the sector, both at local and national levels. Any feedback that you can give us (such as a contact name and number for your business and what you produce - just to species level) would be useful to build up a true picture of the importance of the sector.

The Aquaculture Development Team will be working closely with Seafish's Marketing and Technology Groups to provide a full and comprehensive service, and act as a contact point for accessing any of the services Seafish provide for the industry. Equally, the long-term future of the industry will depend on new entrants who will require training in established as well as new skills. The Aquaculture Development Team will be working with industry and the regional Group Training Associations to ensure that this can happen.

For further information and advice please contact:

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SHELLFISH RULES

Fish Health Inspectorate on the web

The CEFAS Internet site (http://www.cefas.co.uk) has a new and improved section devoted to the work and responsibilities of the Fish Health Inspectorate (FHI) based at the CEFAS laboratory in Weymouth, Dorset. The FHI pages are located in the **Info Centre** part of the CEFAS site, under the '**Aquaculture and Fish Health**' heading (http://www.cefas.co.uk/fhi/).

Information on the FHI pages is designed to help both shellfish and fish farmers, and is divided into six areas: Farm Registration; Movements, Imports and Exports; Disease Monitoring and Investigation; Controls and Enforcement; Advice and Legislation; Publications.

Farm Registration

The Registration of Fish Farming and Shellfish Farming Businesses Order 1985 requires all shellfish farming businesses to submit details for registration within two months of commencing business. The information is required specifically to help control the introduction and spread of disease throughout the industry and into wild stocks. Registration of businesses and farm sites is explained in detail, and the relevant application forms can be printed out directly from the site or downloaded (as *.pdf files) and printed out later using Acrobat Reader. This software can also be downloaded via the CEFAS web site. It is intended that eventually it will be possible for all forms to be submitted electronically, but at present these must be returned by post.

Movements, Imports and Exports

This has a section devoted exclusively to shellfish. The rules governing imports, exports and deposits of shellfish, both molluscs and crustaceans, particularly lobsters, are explained. The forms required for application or notification to import or deposit shellfish are available on-line.

Disease Monitoring and Investigation

The FHI implements the fish health regime in England and Wales on behalf of MAFF and NAWAD. It discharges these duties by monitoring for notifiable diseases (including *Bonamia* and *Marteilia* in native oysters) in support of UK applications for Approved Zone status, investigating disease outbreaks or unusual mortalities, and arranging for the diagnosis of the causes of such outbreaks. Where necessary, the FHI will also place statutory controls on movements, to prevent the spread of disease. These movement controls are explained more fully in the section on **'Controls and Enforcement'**.

Advice and Legislation

Some general advice on disease prevention and management as well as on welfare issues can be found here. A brief summary of the various parts of the legislation covering fish and shellfish disease controls is also given.

Publications

This section has links to some on-line publications giving general guidance and information on farm registration, Several and Regulating Orders, and shellfish health controls. There is also an on-line link to Shellfish News, where back copies, as *.pdf files, can be accessed. You can also email direct to the library at the CEFAS Lowestoft Laboratory from here, and request to be put on the mailing list for Shellfish News.

Our code of practice, together with the latest Customer Charter performance, is also on the FHI site.

UK MICROBIOLOGICAL LABORATORIES UNDERTAKING SHELLFISH TESTING

First meeting

A periodic meeting of laboratories undertaking microbiological testing of bivalve shellfish was held at the Central Public Health Laboratory on 6 April 2000. The group comprised representatives from CEFAS Weymouth (the National Reference Laboratory), the Public Health Laboratory Service, the Marine Laboratory Aberdeen and Belfast City Hospital. The remit of the group was agreed as: 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.

Resolutions

The group agreed the following resolutions:

1. The NRL should compile a list of laboratories in the UK undertaking shellfish testing for purposes of Directive 91/492/EC in order to seek comment on issues associated with shellfish testing and to inform them of the activities of the group.
2. To enable a review of methods for shellfish analysis the NRL should circulate a questionnaire to the laboratories identified in resolution 1. The questionnaire would seek details of methods used, shellfish species tested, etc, and would be used to inform further debate on the development of standard shellfish testing methods.
3. In order to ensure consistency of approach throughout the UK, the published standard UK *E.coli* MPN method for shellfish should be used by all laboratories undertaking *E.coli* testing for purposes of Directive 91/492/EEC. The FSA would be advised of the views of the group.
4. The group would examine alternatives to the MPN approach for analysis of shellfish for *E.coli*, on their merits, as they arose.
5. Given the emphasis in Council Decision 1999/313/EC on quality assurance, it was appropriate for all laboratories undertaking microbiological testing for purposes of Directive 91/492/EEC to participate in an external quality assurance scheme. The group recognised the scheme run by the PHLS Food Safety Microbiology Laboratory, Colindale, as an appropriate scheme. The FSA would be advised of the views of the group.
6. Given the emphasis in Council Decision 1993/313/EEC on compliance of testing laboratories with EN 45,000 criteria it was appropriate that all laboratories undertaking microbiological testing for purposes of Directive 91/492/EEC should be UKAS accredited. The FSA would be advised of the views of the group.
7. A sub-group would be established to review and update, if necessary, the published UK method for detection of salmonella in shellfish.
8. The group would review the standard shellfish sampling protocols in the light of logistic difficulties experienced with some aspects.
9. Council Decision 1993/313/EEC focuses on the need for development of methods for viruses, or potential indicators of virus contamination, in shellfish. Given the likelihood of potential European initiatives in this regard the group would discuss potential approaches to viral contamination at future meetings and would welcome comment from other parties.
10. The group would meet at least annually or more frequently as necessary to progress the group's business or initiatives arising at the European level.

Second meeting

A second meeting of the laboratories undertaking microbiological testing of bivalve shellfish was held at Ergon House, London on January 17th 2001. The group comprised representatives from CEFAS Weymouth (the National Reference Laboratory), the Public Health Laboratory Service, the Marine Laboratory Aberdeen and Belfast City Hospital.

Resolutions

The group agreed the following resolutions:

1. The group noted that more clarification regarding the minimum sample size for the analysis of shellfish is required. The group undertook to carry out a practical investigation into shellfish sample size and to report results when available.
2. The group noted that the shellfish industry had requested that the Malthus impedance method for detecting *E.coli* be investigated for use in the UK. This group agreed that they would be willing to carry out investigative trials into this method if appropriate resources were made available.
3. The group expressed concern that the definition of *E.coli* given in the proposals by the European Commission for a consolidated framework Regulation for hygiene of foodstuffs (2000/0178(COD) was out of date with regard to current technology. The group suggested that a preferred definition of *E.coli* would be the one given in ISO 16649 (currently in draft). The FSA would be informed of this concern.
4. Consideration will be given to the adoption of the PHLS Salmonella food method for the detection of salmonella in shellfish by the Salmonella Sub-Group and reported to the next meeting of UK Testing Laboratories.

NEWS FROM THE TRADE ASSOCIATIONS

SHELLFISH ASSOCIATION OF GREAT BRITAIN (SAGB)

SAGB QUESTIONS VALUE OF UK CLASSIFICATION OF SHELLFISH HARVESTING WATERS, COMPARED WITH DUTCH AND FRENCH SYSTEMS

Taskforce investigation

A small group of members of the Shellfish Association of Great Britain recently met the Taskforce investigating the Burdens of Food Legislation on small Businesses. The Association regards the classification system, as it is applied in the UK, as being the greatest burden disadvantaging our industry in relation to neighbouring states. After presenting what the Association believes to be a more correct and relevant interpretation of the Bivalve Hygiene Directive, the group was questioned in detail and the members of the Taskforce were given a thorough grasp of the problems faced by our industry.

Fact-finding visit

When it came to making detailed comparisons with the systems used in other member states, however, no one was in a position to give the exact basis of the Dutch, Irish and French system. The Association agreed to send three members, Kim Mould of Myti Mussels in Bangor, David Jarrad of River Exe Shellfish Farms and Clive Askew the Assistant Director, to both Holland and France to find out more about their systems. The Food Safety Authority of Ireland has also provided details of their approach. The team drove over to Yerseke for a one-day visit on 27 March and the following week they spent a day at the headquarters of IFREMER in Nantes. In both places they were impressed by the clear logic and practicality that had been built into the systems, and the way both were directed at protecting public health whilst allowing the industry to operate.

Dutch approach

In Holland, Mamix Poelman, who is responsible for classification, explained in fine detail how the RIVO laboratory in Yerseke classifies the mussel plots. The waters are all nominated Class A unless the microbiological results show otherwise. Sample results are reported within 24 hrs, so that the authorities and industry can react quickly if the quality of the mussels falls below the Directive standards. Beds can be closed at short notice and re-opened as Class A as soon as the bacterial numbers have fallen back below the limit. It has to be said that Dutch harvesting waters are very clean, as the Government has invested over many years to divert sewage and other pollution well away from the shellfish beds.

The French system

France has a much greater variety of types of growing area, so decisions on water classification are taken at a local Prefecture level, with the industry involved in discussions. Although this gives rise to some feeling within France that some areas are more lenient than others, the criteria are laid down in such fine detail that they are clear to everyone, including our team. Martial Catherine of IFREMER gave the team a full set of their documentation, including every sample site. The results are available on their website. The impressive thing was again the ability to respond quickly if things go wrong. Microbiological results are available within 8 hours, so waters with the higher A and B grades can be temporarily suspended when necessary and then revert to normal, once the problem has passed.

Rapid response systems

The main point that has become clear to the team is that these other countries use their response systems for the protection of public health and for the benefit of commercial operations. The UK system is less responsive because it relies on ‘historical classification’ and so gives the waters a more pessimistic classification. The Association maintains that this approach is putting people out of business, and scaring off the supermarkets and major caterers. In Holland and France, the industry carries out a lot more of its own analyses, but the authorities respect it and use the information, certainly during ‘alert states’ when the classification is suspended. The results are always available the day after sampling for the authorities and industry to react to together.

Further information

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ASSOCIATION OF SCOTTISH SHELLFISH GROWERS (ASSG)

It took the passage of the entire winter season before the final vestiges of the ASP event of 2000 eventually disappeared from Box SM12 and the scallop farm of 'Seabed Direct'. Now we have the long wait to see whether ASP and the other biotoxins reappear in west coast waters this summer.

Spring meeting

Meanwhile, Spring is the usual time for a review of the past year, particularly on the occasion of the ASSG's Annual General Meeting, and this year (3 April in Oban) was no exception. My 'Chairman's Review' highlighted a number of issues that had occupied my time during 2000. Various water quality issues were top of the priorities list, ranging from discharges, Designations and Classifications through to the Water Framework Directive and biotoxin events. Other areas of representational effort included the on-going reviews of shellfish health and food hygiene European Directives, the transfer of planning responsibilities for aquaculture from the Crown Estate to Local Authorities and the review of the aquaculture regulatory framework recently initiated by the Scottish Executive.

Two particularly positive and 'high profile' events of the year were highlighted, namely the extremely successful Conference and Biotoxin Workshop of last October and the successful enactment of the 'Creeling Amendment' to the Sea Fisheries (Shellfish) Act by The Scottish Parliament in September, under the guidance of Tavish Scott, MSP.

I closed my report with a summary of last year's participation at the total of 85 meetings on behalf of the ASSG, ranging from local government to the European Commission, from environmental conservation bodies to fellow shellfish associations.

On-going concerns

Major on-going concerns among members of the Association about biotoxin management, in particular the so-called 'tiered marketing regime' for scallops and ASP, and Harvesting Area Classifications were thoroughly aired in the pre-meeting to the AGM. The keynote speaker to that gathering was Michael Gibson, Board Member of the Food Standards Agency (FSA) with specific responsibilities for Scottish issues (as one of the two Scottish members of that Board). His first task was to fully explain the remit and role of the FSA, an important task as the Agency is now the major regulatory authority with regard to shellfish aquaculture. He then up-dated members on the situation with regard to amending legislation to enable the marketing of adductor muscle from scallops when whole animal testing results show toxin levels above the Action Level. However, the majority of questions, concerns and complaints were voiced over the issue of the Harvesting Area Classifications for 2001, which have generated more complaints to me than the previous ten years put together! The ASSG and SAGB are maintaining liaison over the discussions between our organisations and FSA representatives. I believe that Michael took away from the Meeting copious notes on perceived problems from the industry's perspective. This, in my view, is an example of one of the major reasons for inviting such a speaker to our meetings, namely so that members can achieve direct and personal contact with a senior figure in these regulatory organisations.

Shellfish and finfish

Almost the final piece of business of the AGM was consideration of a member's proposal that the ASSG should "call for a moratorium on the further expansion of seacage finfish aquaculture". Following a serious and thoughtful debate over the merits of such a formal Resolution, members voted in favour, by a ratio of two to one. Both the discussion and the decision reflect an unease over the as yet unknown impact of the current rate of expansion of salmon farming, both additional sites and incremental biomass on established sites, on the marine environment in general and shellfish cultivation downstream of these farms in particular.

The ASSG's decision should be seen as a call for a 'pause for reflection' on the future direction for the salmon farming sector (indeed, aquaculture in general), particularly as we expect a Public Inquiry into seacage farming to be convened by the Scottish Executive in the near future. Such an Inquiry will hopefully bring together relevant information, informed insight and varied perceptions, to allow an evaluation of the *status quo*. In the wider sense it will also help society to consider the extent it wishes to see the inshore marine environment playing host to intensive fish farming operations, rather than the industry continuing to expand under the economic drivers of the international market for protein. My hope is that the Inquiry will generate a 'benchmark' for the industry and enable operators, regulators and policy-makers to reach better informed decisions and create more optimal policies in the future.

Coastal strategy

The second strand of thought behind the ASSG proposal is the encouragement of the creation of a comprehensive national aquaculture strategy. This is to substitute the current patchwork of incoherent and inconsistent development decisions with a consistent and long term vision for the utilisation of the Scottish coastal resource based on science, biological carrying capacity, agreed prioritisation on the basis of sustainability and rational

environmental objectives. In view of the recently started SERAD review of the regulatory framework and the transfer of planning responsibilities to Local Authorities, it would appear that some of the elements for the evaluation of a national aquaculture strategy are already in place. Overall, despite some inevitable negative 'knee jerk' reactions, I believe the ASSG proposal is a positive contribution towards the development of a multi-species, commercially successful, environmentally sustainable aquaculture industry for Scotland. This is a vision that must bring together all the 'stakeholders' in the sector, from the Scottish Executive and its Agencies to the scientific community and the operators themselves. I also believe that the evolving pressures in favour of European Community-wide implementation of holistic Integrated Coastal Zone Management (ICZM) policies will require the development of such a strategic approach in the relatively near future.

Here is an opportunity for Scotland to take the lead, in a European industry that has an annual turnover well in excess of 2 Billion Euros, a particularly appropriate leadership position in light of our relatively pollution-free waters.

Further information

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MONITORING REPORTS

THE MARINE BIOTOXIN MONITORING PROGRAMME FOR ENGLAND AND WALES 2000–2001

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Introduction

The monitoring programme for algal biotoxins is a requirement of the Shellfish Hygiene Directive 91/492/EEC which is implemented in England and Wales by the Food Safety (Fishery Products and Live Shellfish Hygiene) Regulations 1998 as amended. This legislation requires EU member states to monitor for the possible presence of toxin producing plankton in production and relaying areas, and biotoxins in live bivalve molluscs. Within England and Wales a monitoring programme is carried out throughout the year (April to March) on shellfish harvesting areas. These areas have been selected on a risk assessment basis to be included in either the water or shellfish flesh monitoring programmes. Samples are collected on a monthly basis, except in areas historically prone to algal biotoxins, in which case samples of both water and shellfish are requested on a fortnightly basis.
The Food Standards Agency (FSA) has overall responsibility for ensuring that this monitoring programme is effectively carried out, and the CEFAS Weymouth Laboratory is responsible for identifying the sampling areas and co-ordinating the programme. The regional Food Authorities are responsible for collecting the water and shellfish samples from the designated sites. The water samples are analysed at the CEFAS Lowestoft laboratory and for the period this report covers, the FRS Marine Laboratory in Aberdeen analysed the flesh samples. Where biotoxin action limits are exceeded, the FSA determines the necessary course of action.

The results of the monitoring year April 2000 to March 2001 are reviewed below.

Results of the 2000/01 sampling programme

For the monitoring year commencing 1 April 2000, 34 harvesting areas were included in the primary shellfish testing programme, and 20 harvesting areas in the primary water testing programme. Additionally, there were 5 ports where samples of scallops were obtained. During the year a total of 350 water samples were tested along with 703 shellfish samples. There were 438 flesh tests for Paralytic Shellfish Poison (PSP); 579 flesh tests for Diarrhetic/Diarrhoeic Shellfish Poison (DSP) and 365 flesh tests for Amnesic Shellfish Poison (ASP), giving a total of 1382 test results for shellfish samples.

Action taken to protect customers

The action limits used for water samples and the maximum permitted limits used for shellfish samples are listed in Table 1. If, when analysed, the water samples exceed the specified action levels, then samples of

Table 1. Action limits and maximum permitted levels

Water	Algal Group	Action Limit (cells l^{-1})
	Alexandrium Spp.	Presence
	Dinophysis/Prorocentrum Spp.	100
	Pseudonitzschia Spp.	150,000
Shellfish Flesh	**Toxin**	**Maximum Permitted Levels**
	PSP	80 µg per 100 g
	DSP	Presence
	ASP	20 µg per g

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

PSP

PSP toxicity was detected in 8 samples of shellfish from 3 areas: Falmouth and the River Avon on the SW English coast and Craster on the NE English coast. All three areas had a history of PSP occurrences

As with the previous year at Craster, the toxicity was detected in mussels in May and June, during this period the maximum permitted level was exceeded on 3 occasions (80-384 µg/100 g). However, shellfish toxicity did not coincide with any occurrence of *Alexandrium* cells in the water column. As this area does not currently have any commercial shellfisheries no closure was necessary. Warning notices were in place to inform casual gatherers.

Toxicity in Falmouth (again detected in mussels) occurred at the end of June until early August. This corresponded with the presence of *Alexandrium* cells in water samples taken at Falmouth Wharves during June and July with a maximum concentration of 89,100 cells l^{-1} found in June. The water samples continued to show the presence of *Alexandrium* although at a lower level, until the middle of August. The concentration of PSP toxins also exceeded the action limit during July when the concentration reached 161 µg per 100 g shellfish flesh and resulted in a Temporary Prohibition Order (TPO).

The other site to be found positive for toxicity was the River Avon in Devon when mussels were sampled during the early part of August. At no time was *Alexandrium* identified from water samples and the concentration of toxins found in the shellfish flesh was less than the action limit.

Alexandrium did occur in water samples taken from three other sites during the year: Weymouth Harbour, the Fleet and Helford River. Many of these are the same areas that have harboured *Alexandrium* in past years, and again the highest concentration, as with previous years, was Weymouth Inner Harbour, which yielded a count of just over 5.3 million cells l^{-1} during July. As before, there was no associated toxicity in shellfish sampled from the area around Weymouth during the peak of the algae bloom, which lasted for most of July but disappeared rapidly. Once more the Fal Estuary was the only area where the presence of *Alexandrium* in water samples was coincidental with PSP toxins being found in shellfish flesh.

DSP

Toxicity was detected in 115 samples from 35 areas, showing a significant increase over the previous monitoring period, when only 15 sites were positive and 5 areas were affected. The earliest detection occurred in the first month of the monitoring programme and was found in mussels sampled from Craster.

The widespread occurrence of DSP around the England and Wales coastline caused large scale closures (TPOs and Voluntary Closures) within the Solent and Thames shellfisheries. Areas within the Thames estuary were affected from July until September with DSP detected in mussels, oysters and cockles. Within the Solent area, including Portsmouth and Chichester harbours, toxicity occurred within one or more of these locations in mussels and oysters from June until November.

Within the whole of England and Wales peak DSP frequency was reached during September, when 20 samples proved positive for toxicity. There were a total of 67 positive samples for the summer months (July – September). In contrast to the high number of flesh samples that were positive for toxicity, there were only 25 water samples in which algae associated with DSP were identified. Of these, the highest levels were recorded off Blyth during September when a count of 5480 cells l^{-1} was recorded. Even given this figure the average cell count was just 318 cells l^{-1}, and the smallest cell count was 2 cells l^{-1}. The low water counts of *Dinophysis* Spp. compared with the high incidence of toxicity may reflect the fact that DSP toxins can be produced by *Prorocentrum* Spp. a benthic species of algae which would not necessarily be found in water column samples.

The large scale and widespread nature of the DSP toxicity affecting the country's shellfish grounds meant that a number of closure orders were placed over the period of the monitoring programme, and significantly one closure order is still in place on the Camel Estuary in Devon for mussels. This site has been positive for DSP since August 2000 and toxicity has been identified in samples taken in every month since then up to the end of February 2001.

ASP

Toxicity was detected in 32 areas during the 2000/01 monitoring programme; however, none of the samples exceeded the action level for ASP. The highest level recorded was found in scallops from Falmouth and was measured at 3 µg/g. The majority of ASP concentrations were at the lowest detectable level of 2.5 µg/g, and although 9 areas provided positive water samples, none was over the action levels of 150,000 cells l^{-1} set in the directive. The organism responsible for ASP, *Pseudonitzschia* spp., were only found in 15 samples, all at levels less than 1000 cells l^{-1}, well below the action limit.

Programme for 2001/2002

In 1999 EU Commission inspectors visited the UK to evaluate the implementation of the shellfish hygiene Directive. One of the main recommendations they made was that the shellfish flesh testing programme in England and Wales should be expanded so that all shellfish production areas are monitored each year. In order to address this recommendation, the 2001-2002 algal biotoxin monitoring programme for shellfish flesh testing will now include all shellfish production areas in this programme. In the future, these areas will continue to be monitored every year unless the production area loses its classification or is no longer active. The water monitoring programme will continue as a rolling programme.

After the large scale DSP incident in the Solent and Thames areas during 2000 it was decided to develop a zonal system in these locations. This is to allow division of these areas into a number of separate zones. This will facilitate easier control when there is a need to close part of the area because of the presence of toxins in shellfish. On examination of all classified shellfish production areas it was also decided that the geography/hydrology in the West Mersea area would also benefit from such an approach and this has now been implemented.

THE BIOTOXIN MONITORING PROGRAMMES FOR SCOTLAND 2000-2001

Godfrey Howard, Eileen Bresnan and Joyce Petrie,
Fishery Research Services, Marine Laboratory, Aberdeen.

Introduction

An extensive monitoring and surveillance programme for the detection of algal biotoxins in shellfish flesh has been operated in Scotland since 1991, and a programme to monitor levels of the causative phytoplankton since 1995.The monitoring programmes are run in parallel and are operated to comply with the requirements of the EC shellfish hygiene directive, 91/492/EEC, and the current implementing UK legislation [The Food Safety (Fishery Products and Live Shellfish) (Hygiene) Regulations 1998 as amended].

Algal biotoxins, which are produced by certain phytoplankton species, can accumulate in the flesh of filter feeding bivalve molluscs, and move through the food chain through predation on those molluscs. The toxins pose a health hazard to human consumers and the monitoring programmes are designed to ensure that no contaminated shellfish, from inshore and offshore fishing and aquaculture areas are placed on the market for human consumption.

The monitoring programmes provide information on the potential and actual occurrence of Paralytic Shellfish Poisons (PSP), Diarrhetic Shellfish Poisons (DSP) and Amnesic Shellfish Poisons (ASP). The programmes are operated through the year, although more intensively during the peak toxin production period of April to September. Flesh testing of shellfish is undertaken primarily on all commercial species of bivalve molluscs but if toxin levels in any area are found to exceed permitted levels then gastropods and edible crustaceans may also be examined.

During the period 1 January to 31 December 2000, 646 phytoplankton samples from 28 inshore sites around Scotland and a number of selected offshore areas were examined; 3,675 shellfish samples from 38 primary and various secondary sampling sites were assayed, 1,674 for PSP, 886 for DSP, and 1,025 for ASP toxins. Where flesh samples were found to be toxic, additional samples from both primary and secondary sites in the affected areas were examined.

Results of the 2000-2001 Monitoring Programmes

Phytoplankton

The principal toxin producing species of phytoplankton found in Scottish waters are the dinoflagellates *Alexandrium* spp.which causes PSP, *Dinophysis* spp. which causes DSP, and the diatom *Pseudonitzschia* spp. which causes ASP.

Alexandrium spp. were recorded at all 28 sites, and in 30% of all samples. The species was first detected in February in a sample from Loch Ewe on the west coast at a concentration of 20 cells l^{-1}. The maximum recorded concentration was 1,160 cells l^{-1} in a sample from Scapa Flow in the Orkney taken in August. Concentrations over 400 cells l^{-1} were found at three other sites, all taken from east coast sites in May: 980 cells l^{-1} at St Abbs, 520 cells l^{-1} at Elie in the Firth of Forth, and, 440 cells l^{-1} at Montrose. Concentrations exceeded 100 cells l^{-1} at eleven other sites, 1 on the east coast, 2 in Orkney and 1 in Shetland, 6 on the west coast, 2 in the Clyde and 1 in the Solway Firth. The presence of potentially toxic *Alexandrium* spp. at levels in excess of 400 cells l^{-1} often precedes detectable toxicity in shellfish flesh by about two weeks.

Dinophysis spp. were observed at 23 sites and in 43% of all samples. Five different species were identified, *D, acuminata, D. acuta, D. norvegica, D. rotunda* and *D. dens. Dinophysis* spp. were detected in 35% of all samples analysed. It was first detected in a sample from Loch Fyne at 20 cells l^{-1} in April, the same site and time as in 1999. The maximum concentration found was 8,920 cells l^{-1} in Loch Ewe in August. Recorded concentrations reached 4,800 cells l^{-1} at St Abbs in June. This was the highest level on the east coast; and at the same site as in 1999. On the west coast, concentrations of 1,660 cells l^{-1} were found in Loch Inchard in August; 3,240 cells l^{-1} in Loch Striven in September, and 600 cells l^{-1} at Largs in September. Levels in Orkney (The String) reached 600 cells l^{-1} in June, and 420 cells l^{-1} in Clift Sound, Shetland in July.

Pseudonitzschia spp. were recorded at 27 sites, and in 69% of all samples. It was first detected off Stonehaven in January at a concentration of 100 cells l^{-1}. The maximum concentration was found in Clift Sound in August at a level of 162,540 cells l^{-1}. Recorded concentrations reached 22,940 cells l^{-1} at St Abbs in August, 93,100 cells l^{-1} in Loch Roag in June, 48,360 cells l^{-1} in Loch Eishort in August, and 89,280 cells l^{-1} at Largs in July. The maximum concentration found in offshore scallop grounds was 21,260 cells l^{-1} in August.

Shellfish

Inshore Production Areas

Paralytic Shellfish Poisons presented more problems than in 1999, being detected at levels over 80 µg/100 g tissue in three east coast sites, 2 in Orkney, and 6 west coast sites.

PSP toxins were found in mussels at concentrations of 80 µg/100 g tissue from St Abbs, 160 µg/100 g tissue at Elie and 624 µg/100 g tissue at Montrose, all in May. In Orkney, PSP toxins were found in scallop, mussel and razor fish samples from Scapa Flow, and in mussel samples from Kirkwall.. The maximum concentration found was 247 µg/100 g tissue, and toxins were detected from May until August. On the west coast PSP toxins were detected in samples of mussels from four sites, and in *Chlamys opercularis* from two sites. The highest concentration (828 µg/100 g) was found in *Chlamys* taken in Little Loch Broom in June; detectable toxicity lasting here from May until August. The other incidents occurred in sites around Skye and at Ardtoe. Toxin concentrations ranged from 87 µg/100 g, to 217 µg/100 g during the period May to July.

As in 1999, toxicity caused by Diarrhetic Shellfish Poisons resulted in severe problems in several areas. On the east coast, DSP was detected at St Abbs and Elie from July until September. Toxicity was also detected at Montrose in November and December. In Orkney toxicity was found during July and August, and in Shetland ten sites were affected during the period July to October. In the Outer Hebrides, Lochs Leurbost and Roag were affected, first in May, and then again from July to October. On the west coast and in the Clyde, DSP was widespread and detected at 28 locations between May and December. The species affected included mussels, Pacific and Native oysters and queens, and the longest closures affecting shellfish farming lasted up to 24 weeks.

No ASP toxicity was detected at any aquaculture site where mussels or oysters were the cultivated species; ASP was detected at four sites where scallops were farmed, all at levels over 20 µg/g tissue of domoic acid.

Voluntary Closure Agreements (VCA) were imposed with the operators of all aquaculture sites affected by the different toxins where levels exceeded the permitted level. In the case of closures relating to ASP, an initial VCA may have been superseded by a statutory closure under FEPA if the farm site was later included in an offshore closure.

Offshore Scallop Grounds

No toxicity, other than ASP toxins, were detected in scallops from the offshore fishing grounds, where it was found in the Moray Firth, off Orkney, and throughout the west coast grounds.

On east coast areas, levels of domoic acid found in gonad tissue, although above the permitted level of 20 µg/g tissue, were relatively low; 38 µg/g in the Moray Firth and 58 µg/g in Orkney. On the west coast detected levels of domoic acid in gonad tissue were significantly higher; 73 µg/g in the North Minch, >100 µg/g in the South Minch and 140 µg/g in the Jura/Islay area.

Orders under the Food and Environment Act 1985 (FEPA) were imposed to prohibit scallop harvesting in all affected areas. The first west coast order was imposed on 1 August for the Jura area, further orders followed on 17 August by which time much of the west coast was affected. In Orkney an order was imposed on 14 June; the Moray Firth not being affected until early October. Partial revocations of these orders began in October and as toxin levels fell more areas were opened throughout November and December, and also during early 2001. At the present time no restrictions are in force.

THE *BONAMIA* AND *MARTEILIA* SAMPLING PROGRAMME IN ENGLAND AND WALES FOR 2000

This programme is being carried out in support of the application by the UK for approved zone status in respect of the two oyster diseases Bonamiosis and Marteiliosis (EU Directive 91/67).

For *Bonamia*, Table 1 gives a summary of the results for all sites from which samples of native oysters (*Ostrea edulis*) were taken in autumn 2000. The usual sample size at each site was 30 oysters. Sites in the unrestricted areas (i.e. those free from *Bonamia* and *Marteilia*) were also sampled in spring 2000. No cases of *Bonamia* were detected in these samples.

All samples were also examined for *Marteilia*. This was not detected in any samples. In addition, all oysters were routinely examined for evidence of any other clinical disease

In Table 1 the results for 2000 are compared with those for the previous 3 years. The level of *Bonamia* infection remains generally low, and the disease has not spread outside of the restricted areas in which it has been recorded in previous years.

Shellfish farmers should note that if they have a mortality problem with their stock then they are legally obliged to report it to the appropriate Fish Health Inspectorate (Weymouth or Aberdeen) for investigation. The Inspectorate will then identify the causes and where appropriate take any legal action to limit the spread of disease and minimise economic losses to the industry. If you have any problems occurring on your site in England and Wales, contact the Fish Health Inspectorate at the CEFAS Weymouth Laboratory on 01305 206711/ 206673.

Table 1. Summary of results of native oyster sampling for Bonamia 1997-2000

Year	**Restricted Area 1** The Lizard to Start Point		**Restricted Area 2** Portland Bill to Selsey Bill		**Restricted Area 3** Shoeburyness to Landguard Point		**Unrestricted Areas**	
	Sites	% infected (range)	Sites	% infected (range)	Sites	% infected (range)	Sites	% infected (range)
1997	10	0-16	30	0-30	14	0-53	8	0
1998	12	0-23	31	0-17*	13	0-47	8	0
1999	5	6-13	21	0-16	16	0-34	8	0
2000	8	0-13	24	0-27	14	0-50	6	0

* *Apart from one on-growing area where prevalence was 63-80%. This area was de-stocked and de-registered.*

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. Cryopreservation of oyster embryos

The possibility of cryopreserving oyster (*Crassostrea gigas*) embryos was investigated. Cryopreservation of shellfish embryos allows for gene bank establishment and manipulation of spawning programs. Several critical variables associated with successful cryopreservation of embryos were examined. These were embryo developmental stage, kind and concentration of cryoprotectant, equilibration time, and freezing rate. Percentage survival was scored as the number of recovered embryos that swam actively 12 hr after thawing and had developed into the veliger stage.

The oyster embryos became increasingly susceptible to the cryoprotectants as the concentration was increased and the equilibration time was lengthened. The stage of development appears to be a critical factor for survival of oyster embryos. Trochophore stage embryos are more resistant than morula and gastrula stages embryos to cryoprotectant exposure and have better survival after freezing. The optimum cryoprotectant concentration for the trochophore embryos differed markedly from the morula stage. Cryopreservation of fertilized eggs (2-8 cells) was unsuccessful. Varying degree of success was achieved using gastrula and trochophore stage embryos. Maximum survival was obtained when trochophore embryos incubated in 10% propylene glycerol-artificial

seawater were cooled at -2.5 degree C /min to -30 degree C and then directly placed into liquid nitrogen. The results showed a clear effect of the stage of development on survival.

Reference

Gwo, Jin Chywan (Department of Aquaculture, National Taiwan University Keelung 20224 Taiwan). 1995. Cryopreservation of the Pacific oyster *Crassostrea gigas* embryos. In:Kuo, Ching Ming, Wu, Jen Leih, Hwang, Pung Pung (editors), Proceedings of the International Symposium on Biotechnology Applications in Aquaculture, December 5-10th, 1994: Taipei, Taiwan, ROC.

2. Image analysis for oyster embryo bioassay

This study shows the feasibility of using the latest image capture, processing, and analysis techniques in the oyster embryo-larval development (OEL) test.

Initially, it was shown that the OEL test could be carried out in multiwell plates (which would assist in the application of the image analysis technique) based on data from tests with the reference toxicant zinc and industrial effluents. The study then ascertained which of the 31 image analysis parameters of the Image Pro Plus software used was most appropriate for differentiating between the D larvae and non-D larvae at the end of the test procedure in a manner similar to that of visual observations. The use of image analysis parameters area and size (length) in combination gave test results which were not significantly different from corresponding values derived using visual observations. Discrimination using the area and length parameters may be improved by the inclusion of other parameters in a suite of measurements that would reduce interference from extraneous material or lighting artefacts.

Reference

Johnson, I. (johnson_i@wrcplc.com), Harman, M., Forrow, D., Norris, M., 2001. An assessment of the feasibility of using image analysis in the oyster embryo-larval development test. Environmental Toxicology, Vol. 16, pp 68-77.

3. Oyster aromas

In contrast to many foods, very little is known about the aroma of fresh oysters. This study deals with the relationship between extracted volatiles of oysters and their olfactory properties.

Nearly 50 volatiles were identified: most of them were principally related to fatty acid oxidation (86%) and particularly to n-3 polyunsaturated fatty acid oxidation (66%). Only one volatile arose from amino acid degradation. Panellists detected 42 odours by sniffing. Among them, only 12 odours were definitely attributed to identified volatiles. These odours were green/sulphur/crustacean, mushroom/citrus, and marine/cucumber and were attributed to dimethyl sulfide, 1-penten-3-one, hexanal, (2,4)-E,E-heptadienal, 1-octen-8-one, 1-octen-3-ol, 6-methyl-5-hepten-3-one, octanal, (E,Z)-2,6-nonadienal, (E)-8-octenal, and decanal, respectively.

Reference

Piveteau, F., Le Guen, S., Gandemer, G., Baud, JP., Prost, C., Demaimay, M. (demaimay@entiaa.nantes.fr), 2000. Aroma of fresh oysters *Crassostrea gigas*: Composition and aroma notes. Journal of Agricultural and Food Chemistry, Vol. 48, pp 4851-4857.

4. Oyster Herpesviruses

Sporadic high mortalities were reported in France in May 1994 among batches of hatchery-reared larval Pacific oysters and European flat oysters in 2 hatcheries, and in June and July 1994 among batches of cultured spat of both species in a shellfish nursery. Histological observation showed the presence of cellular abnormalities in moribund animals. Transmission electron microscopy revealed the presence of herpes-like virus particles in infected larvae and spat of both oyster species. This is the first description of a herpes-like virus infection in larval flat oysters. Viruses observed in diseased larvae and spat of both species are similar and were detected simultaneously in both Pacific and flat oysters (larvae and spat), indicating possible inter-specific transmission. Moreover, these viruses are associated with high mortality rates in both oyster species.

Reference

Renault, T. (trenault@ifremer.fr); Le Deuff, R.M., Chollet, B., Cochennec, N., Gerard, A., 2000. Concomitant herpes-like virus infections in hatchery-reared larvae and nursery-cultured spat *Crassostrea gigas* and *Ostrea edulis*. Diseases of Aquatic Organisms, Vol. 42, pp 173-183.

5. Vibrio contamination of oysters in the USA

The first reported outbreak of *Vibrio parahaemolyticus* (serotype O3: K6) infection in the United States was investigated.

Between May 31 and July 10, 1998, 416 persons in 13 states reported having gastro-enteritis after eating oysters harvested from Galveston Bay. All 28 available stool specimens from affected persons yielded *Vibrio parahaemolyticus* isolates. The oyster beds met current bacteriological standards during harvest and faecal coliform counts in water samples were within acceptable limits. Median water temperature and salinity during May and June 1998 were 30.0 degrees C and 29.6 parts per thousand (ppt) compared with 28.9 degrees C and 15.6 ppt for previous years. The elevated seawater temperatures and salinity levels may have contributed to this outbreak. Bacteriologic monitoring at harvest sites did not prevent the outbreak, suggesting that current policy and regulations regarding the safety of raw oysters require re-evaluation. Consumers and physicians should

understand that raw or undercooked oysters could cause illness even if harvested from monitored beds.

Reference

Daniels, N.A. (ndaniels@medicine.ucsf.edu), Ray, B., Easton, A., Marano, N., Kahn, E., McShan, A.L., Del Rosario, L., Baldwin, T., Kingsley, M.A., Puhr, N.D., Wells, J.G., Angulo, F.J., 2000. Emergence of a new *Vibrio parahaemolyticus* serotype in raw oysters - A prevention quandary. Journal of the American Medical Association, Vol. 284, pp 1541-1545.

6. Safer oysters

Vibrio vulnificus and *V. parahaemolyticus* are natural inhabitants of estuarine environments and may be transmitted to humans by ingestion of raw oysters. This study focused on the use of low temperature pasteurization, to reduce these Vibrios to non-detectable levels, thus reducing the risk of infection associated with raw oyster consumption.

Artificially inoculated *V. vulnificus* and *V. parahaemolyticus* and naturally contaminated *V. vulnificus* in live oysters were pasteurised at 50 degrees C for up to 15 min. Numbers of vibrios and of aerobic spoilage bacteria were counted in samples of processed and unprocessed oysters for 14 days. Low temperature pasteurisation was effective in reducing these pathogens from more than 100,000 to non-detectable levels in less than 10 min of processing. Spoilage bacteria were reduced by 2-3 orders of magnitude, thus increasing the shelf life for up to 7 days beyond live unprocessed oysters. *V. vulnificus* was not detected even when pasteurisation was followed by a temperature storage abuse study (24 h at 22 degrees C). However, during this storage period spoilage bacteria exceeded 1 million per g oyster meat.

Reference

Andrews, L.S. (lsandrews@email.msn.com), Park, D.L., Chen, Y.P., 2000. Low temperature pasteurisation to reduce the risk of vibrio infections from raw shell-stock oysters. Food Additives and Contaminants, Vol. 17, pp 787-791.

7. Tetraploid Pacific oysters

Tetraploid *Crassostrea gigas* were first successfully produced in 1993 by inhibiting the first polar body of eggs from triploids that had been fertilized with sperm from diploids (Guo and Allen method). However, attempts to repeatedly produce high yields of tetraploids were inconsistent. Because of these uncertainties, we examined some of the fundamental aspects of tetraploid production in an attempt to optimize tetraploid induction using the Guo and Allen method.

Varying the duration of the treatment to inhibit polar body 1 (PB 1) of triploid eggs had clear effects on ploidy of progeny. Short treatments (15-35 min after fertilization — about half the period of meiosis 1 in triploid eggs) yielded tetraploid and heptaploid cells. Long treatments (7-43 min — about three quarters of the period of meiosis 1 in triploid eggs) yielded only heptaploid cells among the embryos. Tetraploid induction was most consistent when treatments were accomplished on eggs from individual triploid females rather than pooled from a number of females, and when treatments were metered according to biological landmarks. That is, eggs from individual triploids were fertilized and 0.5 mg/l cytochalasin B (CB) added after 10 min. A subsample of the fertilized eggs was kept aside untreated. When 50% of the untreated eggs showed PB 1 extrusion (as judged by microscopic examination of dividing, untreated eggs), the CB treatment was discontinued. In eight treatments based on these 'biological criteria', proportions of tetraploids ranged from 13% to 92% after 8 days for an average of 55%, and seven of eight replicates went through metamorphosis and settlement. At settlement, the percentage of tetraploids ranged from 7% to 96%, averaging 45%. Average survival in all the replicates at 8 days was 4.4%, which is acceptable considering tetraploid progeny are destined solely for use as brood stock.

Reference

Eudeline, B., Allen S.K. (Virginia Institute of Marine Science, Aquaculture Genetics and Breeding Technology Center, College of William and Mary Gloucester Point, VA USA), 2000. Optimization of tetraploid induction in Pacific oysters, *Crassostrea gigas*, using first polar body as a natural indicator. Aquaculture, Vol. 187, no. 1-2, pp. 73-84

8. PSP depuration in oysters

Experimental PSP contamination of adult Pacific oysters (*Crassostrea gigas*) with the toxic dinoflagellate *Alexandrium minutum* Halim was carried out in a recirculated seawater system to obtain toxin levels above the safety threshold. In these conditions, toxin levels of shellfish tissues corresponding to field values observed along French coasts were produced within 8 to 15 days at 16 degree C.

Diets based on non-toxic flagellates or diatoms were then used to detoxify the contaminated oysters. Despite large individual variations in toxin levels at the end of the contamination period, detoxification to a level equal to or less than the safety threshold always took 3 to 4 days. No significant differences in detoxification rates were found when oysters were fed non-toxic algae diets *Isochrysis galbana*, *Tetraselmis suecica*, *Thalassiosira weissflogii*, or *Skeletonema costatum*. These results do not suggest any bioconversion of paralytic toxins.

Reference

Lassus, P. (IFREMER, Rue de I'lle d'Yeu, BP 21105, 44311 Nantes cedex 03, France), Bardouil, M., Masselin, P., Naviner, M., Truquet P., 2000. Comparative efficiencies of different non-toxic microalgal diets in detoxification of PSP-contaminated oysters (*Crassostrea gigas* Thunberg). Journal of Natural Toxins, Vol. 9, pp. 1-12.

9. Biotoxins in Ireland

Since the mid 1980s the Marine Institute's Fisheries Research Centre has carried out a monitoring programme in Irish Coastal waters involving both the identification and quantification of phytoplankton species present in near surface waters and the detection in shellfish of toxins of algal origin. The monitoring programme is carried out under EU Directive 91/492.

Recurrent blooms of the dinoflagellate *Gyrodinium aureolum* have been recorded, particularly along the southwest coast. In several cases mortalities of marine fauna, including farmed finfish and shellfish, have been associated with these blooms. Recent studies have shown that the blooms originate offshore and are subsequently advected into the bays under a particular set of meteorological conditions. Two moored instrument arrays, with near real-time data telemetry, are deployed to provide an early warning of these bloom events

The North Channel area of Cork Harbour has, to date, been the only location in Ireland where toxins causing Paralytic Shellfish Poisoning (PSP) have been detected in shellfish above the regulatory limit. During the summer of 1996, 1997, and 1998 mussels from the North Channel area were found to contain PSP toxins above the regulatory limit for a short period and a ban on harvesting was imposed. Pacific oysters remained below the regulatory threshold. The dinoflagellate *Alexandrium tamarense*, a known vector of PSP toxins, was observed in the area during each of the toxic events. The exact origin of the populations of *A. tamarense* is unknown.

Toxins causing Diarrhetic Shellfish Poisoning (DSP) associated with the presence of the dinoflagellates *Dinophysis acuta* and *Dinophysis acuminata* have been detected in many of the main shellfish production areas in the country. More recently a novel toxin, azaspiracid as well as several of its analogs, of unknown origin have been also been detected in shellfish in Ireland. Shellfish toxicity has occurred during both summer and winter months and monitoring is therefore now a year round activity.

Reference

McMahon, T., Silke, J., Cahill, B. (Marine Institute, Fisheries Research Centre, Abbotstown, Dublin 15, Ireland), 1999. Irish coastal dinoflagellate blooms and shellfish toxicity. Journal of Shellfish Research, Vol. 18, p. 722.

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10. New method for detecting Bonamia

A specific polymerase chain reaction (PCR) protocol was developed for the detection of very small amounts of *Bonamia ostreae* ribosomal DNA (rDNA) in bulk DNA from oyster gill and haemolymph. This assay is more sensitive and results are less ambiguous than when using standard histological and cytological techniques.

Oysters from Ireland, Spain, and the USA were examined. Infection was confirmed in all (100%) 'heavily' and 'moderately' infected oysters, 86.7% of the 'lightly' infected oysters, and 66.7% of the 'scarcely' infected oysters, using the new PCR protocol. In addition, 37.9% of the oysters in which *B. ostreae* was not detected using cytology were found to be positive using the PCR method. Phylogenetic analysis of DNA sequence data confirmed *B. ostreae* to be a member of the Haplosporidia.

The development of a diagnostic assay more sensitive and specific than traditional histological techniques is important for the management of bonamiasis in flat oysters.

Reference

Carnegie, R.B. (ryan.carnegie@umit.maine.edu), Barber, B.J., Culloty, S.C., Figueras, A.J., Distel, D.L., 2000. Development of a PCR assay for detection of the oyster pathogen *Bonamia ostreae* and support for its inclusion in the Haplosporidia. Diseases of Aquatic Organisms, Vol. 42, pp 199-206.

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11. Native oyster recovery in Ireland

Flat oyster production in Cork over the last quarter of a century has relied entirely on its own production of spat from shore-based breeding ponds. Over this period, selection for fast growth has led to the routine production of market-size oysters of 70-120 g in 3 years. Since the stock was almost totally destroyed by the disease *Bonamia* in 1987, the breeding objective has since concentrated on mass selection for resistance to the disease. This work, which is currently being evaluated in Ireland, France and Holland, appears to be showing promising results, with production in Cork Harbour, where oysters are exposed to the disease for their entire growing period, rising to as much as 80% of former levels.

Reference

Hugh-Jones, D. (Loch Ryan Shellfish Ltd., c/o the Thatched Cottage, Penberth St., Buryan, Penzance, England TR 6HJ, UK), 1999. Breeding ponds as a basis for flat oyster (*Ostrea edulis*) culture and their use to develop resistance to the disease *Bonamia ostreae*. Journal of Shellfish Research, Vol. 18, p. 718.

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12. Can native oysters return to Northern Ireland?

Strangford Lough in northeast Ireland supported a productive flat oyster fishery until the population crashed at the turn of the century. A survey of oyster resources in Strangford Lough has revealed that a small population still exists, although the origin of the stock is not apparent. Spatfall on natural cultch occurred at low levels in 1997. Natural recruitment of oysters in Strangford Lough may be limited by the availability of

suitable substratum. Although the hydrographic conditions in the north of Strangford Lough are ideal for oyster bed reclamation, any development programme would require a large-scale accumulation of broodstock and suitable substratum.

Reference

KENNEDY, R.J. (Queens Univ. Belfast, School of Biol. & Biochem., 97 Lisburn Rd, Belfast BT9 7BL, Antrim, Northern Ireland), ROBERTS, D., 1999. A survey of the current status of the flat oyster *Ostrea edulis* in Strangford Lough, Northern Ireland, with a view to the restoration of its oyster beds. Biology and Environment-Proceedings of the Royal Irish Academy, Vol. 99B, pp 79-88.

13. Alien oyster predator in France

A species of muricid gastropod, *Ocinebrellus inornatus*, which originates from the coasts of the Korean Sea and southern Japan, has been found regularly in the Bay of Marennes-Oleron (France) since spring 1997. It was originally reported in the bay in April 1995. It is found only in the Bay of Marennes-Oleron and has not been observed in the other areas along the Charente-Maritime coast. It lives mainly in the same habitat as the local muricid *Ocenebra erinacea* (i.e. at the level of the seaweed *Fucus serratus* between MLWN and ELWS). This alien species seems to be very well settled in the Bay of Marennes-Oleron, where it causes damage to the farmed oyster beds. In the areas of highest densities of *Ocinebrellus inornatus*, the local species *Ocenebra erinacea* is observed in reduced numbers.

Reference

PIGEOT J (Pole Sci & Technol, Lab Biol & Environm Marins, Ave Michel Crepeau, F-17042 La Rochelle 1, France), 2000. A new oyster predator, *Ocinebrellus inornatus* (Recluz, 1851), in the shellfish-culture bay of Marennes-Oleron. Comptes Rendus de L Academie des Sciences Series III - Sciences de la Vie, Vol. 323, pp 697-703.

14. A razor clam fishery in Ireland

An investigation into the biology and the fishery for razor clams (*Ensis siliqua*) on the most important bed to have been discovered to date in Ireland, at Gormanstown, provides basic information on which a management plan for sustainable harvesting of this resource might be devised.

The bed at Gormanstown has been estimated from GPS data to be 2100 hectares in extent. It is situated between the 7 m depth isopleth and runs into the intertidal area. The clams occur with a number of common interstitial invertebrate species. They range in age between 0 and 19 years. Males grow at a faster rate than females and the largest animals on the bed are males. These findings are in general agreement with what has been discovered of the biology of the species elsewhere but there are some significant differences. The Gormanstown clams appear to be slower growing than the species in Britain or in Portugal where it has been investigated in greater detail. The characteristics of the gonadal cycle are fairly similar but clams spawn later in the year at Gormanstown than off the Portuguese coast. It is reckoned to reach first maturation at three to four years of age at Gormanstown, compared with one year in Portugal. The average age of clams captured in the fishery in 1998 was 9.34 years; the following year the average age had fallen to 8.34 years and a cohort of very small individuals was encountered for the first time. The original clam biomass of the bed has been calculated at 1500 tonnes. To the beginning of July 1999 it is estimated that more than 1000 tonnes of clams have been removed. This bed is believed to have supplied virtually the whole Spanish market for razor clams during the past two years.

Reference

FAHY, E. (Marine Institute, Fisheries Research Centre, Abbotstown, Castleknock, Dulbin 15, Ireland), 1999. A new fishery for razor clams (*Ensis siliqua*) on the east coast of Ireland. Journal of Shellfish Research, Vol. 18, p. 715.

15. Shellfish culture in the Netherlands

Shellfish culture in the Netherlands consists of bottom culture of mussels (*Mytilus edulis*) and oysters (*Crassostrea gigas, Ostrea edulis*) and fisheries and experimental relaying of wild cockles (*Cerastoderma edule*). Annual surveys show high densities of shellfish in the cultivation areas Wadden Sea and Oosterschelde estuary. The fishery board records annual yields of shellfish culture and fisheries and detailed long-term data are available of shellfish condition and annual yield from the various production areas.

The 'exploitation' carrying capacity of the Oosterschelde ecosystem - defined as the standing stock of the exploited species at which the yield is maximised - was evaluated before and after completion in 1987 of a large scale coastal engineering project consisting of the construction of a storm-surge barrier. This project resulted in decreased current velocities, increased water residence time, decreased nutrient loads and increased water transparency. The phytoplankton population showed a resilient response by maintaining primary production while species composition adapted to the changes in light and nutrient conditions. Phytoplankton turnover increased significantly.

Shellfish culture has adapted to the new conditions in the Oosterschelde estuary. Mussel lease sites were relocated in response to changed hydrodynamic conditions, cultivation techniques have evolved and lease sites are now used in a more extensive way. Although the standing stock has been maintained, the annual yield has increased, residence time of mussels on the lease sites has decreased, hence the turnover has increased. Yet, the condition of market delivered

mussels has not changed. Apparently, the mussel farmers made the choice to increase yield rather than quality. Total standing stock of shellfish has furthermore shown a decrease of cockle densities due to a lack of spatfall, and a dramatic increase of Pacific oysters. The latter has spread from lease sites to virtually everywhere in the estuary, and is now considered a threat to other shellfish.

Reference

Smaael, A., Van Stralen, M. (Netherlands Institute for Fisheries Research RIVO-DLO, Centre for Shellfish Research, PO Box 77, 4400 AB Yerseke, The Netherlands), 1999. Shellfish carrying capacity and ecosystem processes. Journal of Shellfish Research, Vol. 18, pp. 728-729.

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16. The future for scallop culture

World scallop landings increased dramatically in the last 20 years and in 1996 were about 1.7 million tonnes (whole weight). This increase was due to aquaculture, which accounted for about 90% of landings in 1996. Most production of scallops from culture operations was from China and Japan (88% of world production) and to a much lesser extent from Chile. A consistent 1000 tonne annual production from culture operations in other countries has rarely been met. The potential for scallop culture remains high in many countries but it will require a firm commitment by governments and industry to achieve this goal.

Reference

Bourne, N.F. (Fisheries & Oceans Canada, Pacific Biol Stn Pacific Reg, Nanaimo, BC, V9R 5K6, Canada), 2000. The potential for scallop culture - the next millenium. Aquaculture International, Vol. 8, pp 113-122.

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17. Scallop enhancement in the USA

There is good potential for using aquacultural methods for enhancement of bay scallop populations when natural recruitment is poor and habitat and environmental conditions are not limiting.

The Niantic River estuary supports only a small bay scallop population that is harvested recreationally. An assessment of natural bay scallop recruitment in the Niantic River indicated that few spat were found, they were widely dispersed within the river, and peak spawning occurred in late July. Direct re-seeding was evaluated as an enhancement measure by planting hatchery-reared scallops (38 mm shell height) in small-scale (100 square metre) plots at different times and densities. Time of planting and the inferred predation intensity were major factors affecting survival. Planting density had no significant effect. Also, approximately 9,000 scallops (35-45 mm shell height) were broadcast within an eelgrass bed in November. These had high over-winter survival and underwent gametogenesis and spawning during the following year. An additional enhancement method was also tried by over-wintering 26,000 bay scallops (45 mm shell height) in suspension culture. Approximately 60-80% survived, and these scallops spawned in mobile sanctuaries during the following summer.

Reference

Goldberg, R (ronald.goldberg@noaa.gov), Pereira, J., Clark, P., 2000. Strategies for enhancement of natural bay scallop, *Argopecten irradians irradians*, populations; A case study in the Niantic River estuary, Connecticut, USA. Aquaculture International, Vol. 8, pp 139-158.

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18. Not enough scallop spat from Bantry Bay?

In Ireland a reliable source of king scallop spat needs to be found in order to support a stable scallop aquaculture industry. The aim of this study was to investigate whether Bantry Bay was a suitable site for the collection of scallop spat using artificial collectors. The study was conducted over a three-year period (1995-7), comparing sites within the bay, types of collectors and depths. Overall the amount of spat collected was not economically viable and varied between sites and between years. The most effective collector had the largest surface area. Depth was also an important factor since collectors must be placed at least 2 metres above the seabed to avoid heavy fouling, siltation and predation by crabs.

Reference

Maguire, J.A. (National Univ. Ireland Univ. Coll. Cork, Dept Zoology & Animal Ecology Aquaculture Dev Centre, Cork, Ireland), Burnell, G.M., 1999. The potential for scallop spat collection in Bantry Bay, Ireland. Biology and Environment-Proceedings of the Royal Irish Academy, Vol. 99B, pp 183-190.

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19. Survival of scallops out of water

The results from this study suggest that air exposure greater than 12 h should be avoided. At temperatures greater than 9 degrees C, behavioural responses may be a simple and effective method to assess vitality, which can assist in the management of scallop culture.

Scallops of 40-55 mm shell height were exposed in air for time intervals up to 24 h and their behaviour examined once re-immersed. Scallops were placed upside-down and the number of movements and the cumulative numbers righting in 5 min time blocks were recorded. The greatest frequency for all behavioural responses was found at 15-17 degrees C in August. Responses were reduced in November and June (9-11 degrees C) and least at 5 degrees C in January. All effects of treatment, temperatures and season, and increases in air exposure were significantly different. Following the treatments, mortalities after 10 days in culture was about 10-30% for scallops exposed for 18 and 24 h in August and June. Scallops did not show significantly different behaviour whether they were

exposed upright or inverted. However, scallops exposed at 15 degrees C had fewer responses than scallops held at less than 10 degrees C, so chilling during transport may prolong scallop vitality.

Reference

Minchin, D. (minchin@indigo.ie), Haugum, G., Skjaeggestad, H., Strand, O., 2000. Effect of air exposure on scallop behaviour, and the implications for subsequent survival in culture. Aquaculture International, Vol. 8, pp 169-182.

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20. Artificial reefs

Artificial reefs are used world-wide in a variety of roles: promotion of fishery catch, habitat protection and recreation being the most common. In Europe the majority of artificial reefs have been placed for habitat protection (*Posidonia* and other seagrass meadows) and developing finfish fisheries yield.

The use of artificial reefs for shellfish culture/ranching is in its infancy in Europe. Mussel and oyster cultivation has become possible in the Adriatic Sea, because of artificial reef deployment, and proposals for ranching in Northern Europe have developed as several strands of the knowledge needed to promote lobster ranching have been established, but these still require some further research. In the Adriatic Sea the combination of eutrophic, shallow water and significant natural mussel larval production have provided the conditions which have facilitated development of mussel and oyster cultivation in association with Italian 'pyramid reefs'. In northern Europe the deployment of artificial reefs, development of lobster hatcheries and research showing the effective survival of hatchery reared lobsters and inclusion in a fishery are the basis for further work to make lobster ranching a reality.

Japanese workers have pioneered the use of artificial reefs for abalone habitat and developed coastal structures to influence larval settlement. In order to make artificial reefs an economic reality in Europe, we must learn from their example, particularly in the large scale of their operations.

Reference

Jensen, A. (School of Ocean and Earth Science, University of Southampton Oceanography Centre, Southampton, England, UK), 1999. Artificial reefs for shellfish habitat: Results and ideas to date. Journal of Shellfish Research, Vol. 18, p. 718.

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21. Lobster stock enhancement in Ireland

Depletion of stocks and increasing market prices has lead to a number of stock enhancement programs in Northern Europe. One such method utilised for the enhancement of European lobster *Homarus gammarus* involves the release of hatchery-reared juveniles onto the seabed. Due to the lack of information on the habitat requirements of wild juvenile lobsters, animals are reared to stage V and then released into habitats similar in characteristics to those occupied by adults.

Juvenile lobsters were released at high density into enclosed and unconfined experimental plots containing existing wild fauna within a commonly utilised release ground. Twelve percent of the initial seeded lobsters were recovered from enclosures after one month, compared to a one percent recovery from unconfined plots. The overall density of 4.8 individuals per square metre may represent a rough approximation to the saturation density of juvenile lobsters, although wild densities are unlikely to reach this level. Enclosure and/or the presence of juveniles reduced the abundance of young of the crab *Pisidia longicornis*, but did not affect any other species, or community structure as a whole. The influence of dispersal may become less important for species below saturation density resident in physically complex habitats with a plentiful food supply. Movement in densely populated areas, subject to losses to predators, may result in increased mortality. The numbers of released lobsters that survive to recruit to the fishery, and the resultant financial viability of this enhancement method, remains unclear.

Reference

Robinson, M., Tully, O. (Zoology Department, Trinity College Dublin, Dublin 2, Ireland), 1999. Mortality and dispersal in a benthic subtidal decapod community and of hatchery reared lobster *Homarus gammarus*. Journal of Shellfish Research, Vol. 18, p. 727.

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22. Where do small lobsters like to live?

The results from this study show the importance of shelter-providing habitat such as cobble or crevice-type substrata to small juvenile European lobsters. They also confirm that for a shelter-dwelling animal such as a lobster, the physical structure of the habitat is a key factor in determining both the size and number of its inhabitants.

The natural substratum preferences of very small juvenile European lobsters (*Homarus gammarus*) remain largely unknown. This study utilised a large-scale mesocosm experiment to determine if the animal favours cobble ground, similar to its American counterpart (*Homarus americanus*), or if it has other substratum preferences. Postlarvae were provided with the choice of settling on four natural substrata: sand, coralline algae, mussel shell and cobble. The number and size of juveniles on each substratum was recorded, over a nine-month period, with loss of chelipeds used as an indication of social interaction. After 30 days juveniles were more abundant in substrata which provided pre-existing shelter in the form of interstitial spaces, i.e. cobble and mussel shell, than in sand or coralline algae. The survival of individuals from postlarvae to 30-day old juveniles ranged from 5 to 14% with survivors showing a clear mode at 6-8 mm carapace length (CL) in size distribution. The density of lobsters per square metre of cobble remained relatively constant

(18/m^2) throughout the study period while the density of juveniles on mussel shell decreased significantly (35 to 5/m^2). The size distribution of lobsters on each substratum also varied with time. By the conclusion of the trial, lobsters found in mussel shell were on average of 8-10 mm CL, within a range of 6-14 mm CL, while those in cobble were slightly bigger at 10-12 mm CL, within a range of 8-24 mm CL.

Reference

LINNANE, A., MAZZONI, D., MERCER, J. P. (National University of Ireland, Galway, Shellfish Research Laboratory, Cama, Galway, Ireland), 2000. A long-term mesocosm study on the settlement and survival of juvenile European lobster *Homarus gammarus* L. in four natural substrata. Journal of Experimental Marine Biology and Ecology, Vol. 249, pp 51-64.

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23. Position important in raft mussel culture

Mussels located at the inflow of a raft grew significantly better than those at the outflow.

One-year-old rope-grown blue mussels were placed in experimental lantern nets at two depths (2 and 6 m below the surface) in two different positions (inflow and outflow) off a raft in Loch Etive on the west coast of Scotland. Shell and tissue growth and mortality were recorded. Water temperature, salinity and food availability were also monitored over the experimental period. There were no significant differences in the length, live weight, wet meat weight, dry meat weight and ash-free dry meat weight between depths. However, position had a significant effect on these parameters, with better growth at the inflow. This was linked with food availability, measured as particulate organic matter and chlorophyll *a*, which were significantly higher at the inflow than the outflow of the raft. Depth had no effect on food availability.

Reference

KARAYUCEL, S., KARAYUCEL, I., 2000. The effect of environmental factors, depth and position on the growth and mortality of raft-cultured blue mussels (*Mytilus edulis* L.). Aquaculture Research, Vol. 31, pp 893-899.

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24. Mussels culture does not encourage toxic algae fouling

Mussel culture provides a microenvironment that favours the colonisation and growth of macroalgae, but the growth and colonisation densities of the epiphytic toxic dinoflagellate *Prorocentrum lima* are not directly dependent on that fouling biomass.

Six miniature live-mussel (*Mytilus edulis*) socks (30 cm long) and 6 dummy socks (created with empty mussel valves) were hung along a horizontal long-line at a sheltered coastal site in Nova Scotia, Canada. After 4 and 9 weeks, 3 socks of each treatment were harvested and the biomass of fouling macroalgae and the cell concentration of the toxic dinoflagellate *P. lima* were determined.

Macroalgal fouling was greater on the live-mussel socks than on the dummy socks after 9 weeks. Densities of *P. lima* cells were higher on the dummy socks than the live-mussel socks during the entire experiment. The epiphytic material contained the diarrhetic shellfish toxins DTX1 and okadaic acid, which had been previously identified in cultured mussels from this site.

Reference

LAWRENCE, J.E. (lawrence@ocgy.ubc.ca), GRANT, J., QUILLIAM, M.A., BAUDER, A.G., CEMBELLA, A.D., 2000. Colonization and growth of the toxic dinoflagellate *Prorocentrum lima* and associated fouling macroalgae on mussels in suspended culture. Marine Ecology Progress Series, Vol. 201, pp 147-154.

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25. Mussels recover from oil pollution

The results from this study show that immuno-suppression in mussels following an oil spill are severe, but that recovery can follow a few months later, with the initial effects not permanent.

In February 1996, the oil tanker '*Sea Empress*' spilt over 70,000 t of crude oil which contaminated about 200 km of coastline around Milford Haven. The effects of the oil on immunity in mussels were investigated in parallel with the measurement of hydrocarbon contamination in the tissues. Initially, severe immuno-suppression, which is likely to have serious consequences for disease resistance, occurred in oiled mussels. This corresponded with very high polycyclic aromatic hydrocarbon (PAH) levels. As contaminant levels decreased, the immuno-suppression became less extreme and recovery was evident by May 1996. Between October 1996 and March 1997, immune activity in the previously oiled mussels was again significantly reduced; coinciding with increased PAH levels. During this latter period certain PAHs characteristically derived from combustion processes were primarily responsible for the increase, occurring at similar concentrations in the mussel tissues to those observed just after the spill. A subsequent reduction of hydrocarbons in June 1997 was followed by another, but less marked, increase in PAHs between October 1997 and March 1998, coupled with only minimal changes in immunity. These results suggest that seasonal peaks in combustion-derived PAHs may occur in the region and that these would have been greatly exacerbated early in 1996 by oil released from the '*Sea Empress*'.

Reference

DYRYNDA, E.A. (e.a.dyrynda@swansea.ac.uk), LAW, R.J., DYRYNDA, P.E.J., KELLY, C.A., PIPE, R.K., RATCLIFFE, N.A., 2000. Changes in immune parameters of natural mussel *Mytilus edulis* populations following a major oil spill ('Sea Empress', Wales, UK). Marine Ecology-Progress Series, Vol. 206, pp 155-170.

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26. How crabs prey on mussels

The foraging behaviour of shore crabs on mussels varies, depending on the manner in which the mussels are presented.

Handling techniques, breaking and handling times, percentage flesh eaten and prey value curves were compared when mussels of the following size-classes, 5-10, 10-15, 15-20, 20-25, 25-30 mm shell length, were presented singly and when they were presented as part of a group to crabs of 30-55 mm carapace width. When prey were presented singly, crabs used four opening techniques; smaller prey were attacked by outright crushing and directed crushing whilst boring and edge chipping were used on larger, more resistant mussels. However, when mussels were presented as part of a group, boring and edge chipping were never observed since larger mussels were not consumed. Handling time increased exponentially with mussel size, irrespective of how mussels were presented. However, handling times tended to be shorter when crabs preyed on mussels presented as part of a group, than when they fed on similar-sized mussels presented singly. The amount of flesh left uneaten in discarded shells from groups of mussels ranged between 10 and 25%. More of the flesh was consumed when mussels were presented singly (5 - 15% uneaten). The predicted optimal prey size altered with modifications in prey presentation. For example, when the relative number of mussels in smaller size groups was increased, so was their vulnerability, indicating that prey size preference is flexible and not fixed.

Reference

Burch, A., Seed, R. (Univ. Wales Bangor, School of Ocean Sciences, Menai Bridge, LL59 5EY), 2000. Foraging behaviour of *Carcinus maenas* on *Mytilus edulis*: the importance of prey presentation. Journal of the Marine Biological Association of the United Kingdom. Vol. 80, pp 799-810.

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27. Manila clams at reduced salinity

The oxygen consumption of Manila clams exposed to reduced salinity (20, 15, 10 and 5 parts per thousand) was measured. The results indicated that normal metabolic activity couldn't be maintained at lower than 15 parts per thousand (ppt) salinity.

The endogenous rhythm in the oxygen consumption of the Manila clam was studied using an automatic intermittent-flow respirometer. When exposed to salinities reduced from ambient (31.5 ppt) to 20 and 15 ppt under otherwise constant conditions, the clams recovered a clear endogenous circa-tidal rhythm in their oxygen-consumption rate after having dampened periods of 12 h and 48 h, respectively. At salinity less than 10 ppt, however, the oxygen-consumption rate was depressed greatly at the beginning of the experiment for about 36 h and then increased to a level higher than normal, and the rhythm of oxygen consumption did not recover. With exposure to salinity of 5 ppt, all clams were dead after 7 days.

Reference

Kim, W.S.(Korea Ocean Res. & Dev. Inst., Div Biol. Oceanog., PO Box 29, Seoul 425600, South Korea), Huh, H.T., Huh, S.H., Lee, T.W., 2001. Effects of salinity on endogenous rhythm of the Manila clam, *Ruditapes philippinarum* (Bivalvia: Veneridae). Marine Biology, Vol 138, pp 157-162.

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28. Antibiotics in cultured urchins

Previous work has shown that it is feasible to grow *Psammechinus miliaris* alongside Atlantic salmon, *Salmo salar*, in a polyculture system. The intensive nature of salmon farming demands the use of antibiotics such as oxytetracycline (OTC) administered with the feed, which have the potential to accumulate within the urchin's gonad. Two approaches were used to evaluate the persistence of OTC within urchin gonad.

Accumulation and residue depletion of OTC in the gonads of the echinoid, *P. miliaris*, following oral administration were evaluated in urchins of high and low nutritional status, under laboratory conditions. Urchins were held in 10 litre tanks in a sand filtered seawater system under ambient environmental conditions. The results demonstrated that urchins conditioned for 30 days on salmon food produced larger gonads than urchins fed macroalgae. A commercially prepared, medicated salmon food containing 29 mg g^{-1} of OTC was fed to the urchins *ad lib* for 12 days. Gonad tissue was sampled at intervals during the mediation period (5th, 8th, and 12th day) and after its cessation (20th, 40th and 70th day).

OTC significantly reduced gonadal growth rates (g d^{-1}) in urchin conditioned on salmon feed. Individual urchins demonstrated considerable variation in drug intake. No significant differences in accumulation and residue depletion of OTC in the gonads were observed between urchins of different nutritional status. On day 12 mean OTC residue concentrations were 60-70 µg g^{-1} in urchins conditioned on salmon food and macroalgae. The OTC half–life ($t_{1/2}$) of the elimination phase in gonad tissue was 5.37 days. Extrapolation indicated that a maximum residue limit (MRL) of 0.1 µg g^{-1} would be reached after a 333.5 day withdrawal period in the gonads of *P. miliaris* fed OTC (29 mg g^{-1}) for a 12 day period. These results reflect a 'worse case scenario' for the uptake and decontamination of OTC in the gonads of *P. miliaris*.

Urchins harbour symbiotic bacteria in epithelial tissue. The response of sub–cuticular bacteria (SCB) to OTC administration in urchins of different nutritional status compared to a control was determined by direct SCB

counts by using epifluorescence light microscopy, after staining with acridine orange. Mean estimated SCB loading was significantly higher in urchins of an elevated nutritional status indicating that the symbiosis between SCB and *P. miliaris* may be heterotrophic. OTC significantly reduced SCB loading in urchins conditioned on salmon food and fed OTC medicated salmon feed. Differences in SCB response to OTC as a result of differing urchin nutritional statuses were observed.

Source

Dirk Campbell, Maeve Kelly (Dunstaffnage Marine Laboratory, Oban, Argyll, PA34 4AD) and Andy Beaumont (School of Ocean Sciences, University of Wales, Bangor, Menai Bridge, Gwynedd, LL59 5EY); Campbell, D. A. (2000) The persistence and effect of oxytetracycline in the gonads, and symbiotic sub-cuticular bacteria of the urchin, *Psammechinus miliaris* (Gmelin). MSc thesis, University of Wales.

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29. New sea urchin species for aquaculture

Cultivation of sea urchins has been successful with several commercially viable species and given the continuous increase in world annual consumption, new species are being tested to assess their potentials for aquaculture. This study focused on establishing hatchery protocols for the production of common sea urchin *Echinus esculentus* as a potential echinoculture species.

In an initial trial, gravid urchins collected by scuba were induced to spawn using 0.5M KCl and larvae reared in 40 l bins at a density of 1 ml^{-1}. The larvae were maintained in a static condition with a constant supply of aeration and water change carried out every third day.

This study found a diet containing green algal species *Dunaliella tertiolecta* at an optimum ration (1000, 3000, 5000 cells ml^{-1}) to produce best growths for *E. esculentus* larvae. Diets consisting solely of *Phaeodactylum tricornutum* or of this alga mixed with *D. tertiolecta* were less suitable. Maintaining an optimum dietary requirement and rearing condition shortened the larval stage (from 21 days in first trial to 16 days in second trial) which is an advantage in aquaculture in reducing costs incurred in keeping animals in the hatchery.

Source

Robert Jimmy, Maeve Kelly (Dunstaffnage Marine Laboratory, Oban, Argyll, PA34 4AD) and Andy Beaumont (School of Ocean Sciences, University of Wales, Bangor, Menai Bridge, Gwynedd, LL59 5EY); Jimmy, R. A. (2001) The effect of diet type and quantity on the development of common sea urchin larvae *Echinus esculentus*. MSc thesis, University of Wales.

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30. Bioassay to study effect of copper on Pacific oysters

The effect of trace metals on bivalve larvae has been well documented within species. However, with the continual use of bioassays, further investigations into the physiological sub–lethal effects need to be examined. The aim of the study was to examine the effect of copper on the embryonic and larval stages of *Crassostrea gigas* (Thunberg), through static laboratory experiments. Bioassay tests were used to establish copper concentrations that would cause sub–lethal and lethal effects, to provide percentage normality and mortality of the test organisms.

Video filming techniques were developed to investigate larval swimming behaviour in water with different copper concentrations. The swimming behaviour of 24 hour post fertilisation larvae was investigated over 24 hours, and the upward swimming rate of the larvae increased significantly over 24 hours in 40 µg Cu ions l^{-1}, but not at higher or lower Cu ion concentrations.

Trials were conducted to develop a method for producing a layer of copper concentration in seawater. The perfection of such a method would enable the study of larval behaviour across distinct concentrations of copper.

Source

Danuta Kochanowska, Simon Cragg (Portsmouth Institute of Marine Science , Ferry Road, Eastney, Portsmouth, P04 9LY) and Andy Beaumont (School of Ocean Sciences, University of Wales, Bangor, Menai Bridge, Gwynedd, LL59 5EY); Kochanowska, D, (2000) Some effects of copper on the embryos and larvae of *Crassostrea gigas* (Thunberg), the Pacific oyster. MSc thesis, University of Wales.

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

Ministry of Agriculture, Fisheries and Food,
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)

Shellfish Hygiene - Food Standards Agency, Room
429E, Ergon House, same address as Nobel House
(Tel. 020 7238 5883) (Fax. 020 7238 6745)

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

Research and Development Programmes -
Chief Scientist's Group, Room 811,
1A Page Street, London SW1P 4PQ
(Tel. 0207 904 6000) (Fax. 0207 904 6013)

You can also visit the MAFF website at
http://www.maff.gov.uk/

National Assembly for Wales Agriculture Department,
Division 2B, New Crown Buildings, Cathays Park,
Cardiff CF1 3NQ
(Tel. 029 2082 3567) (Fax. 029 2082 3562)
(*http://www.wales.gov.uk*)

Scottish Executive 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/core/dard0450.htm*)

Scientific and technical advice

Cultivation techniques, health regulations and disease
control (England & Wales) -
CEFAS Weymouth Laboratory, Barrack Road,
The Nothe, Weymouth, Dorset DT4 8UB
(Tel 01305 206600) (Fax 01305 206601)

Shellfish hygiene classifications and purification plant
approvals (England & Wales) -
CEFAS Weymouth Laboratory, Barrack Road,
The Nothe, Weymouth, Dorset DT4 8UB
(Tel 01305 206600) (Fax 01305 206601)

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

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

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

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

Department of Agriculture for Northern Ireland,
Fisheries Division, Annexe 5, Castle Grounds,
Stormont, Belfast, BT4 3PW
(Tel. 028 9052 3431) (Fax. 028 9052 2394)

SEAFISH - Aquaculture Development Officers:
For Scotland; 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, Buckrose House, Commercial Street, Norton, Malton, North Yorkshire, YO17 9HX
(Tel. 01653 698219) (Fax. 01653 695953)

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

CEFAS PUBLICATIONS

The following booklets and leaflets are available:

From the CEFAS Weymouth Laboratory, Barrack Road, The Nothe, Weymouth, DT4 8UB,
(Tel no: 01305 206600; Fax no: 01305 206601):

A Guide to Importing Fish
A Guide to Shellfish Health Controls
Don't Import Disease (leaflet and poster)
Combating Fish Disease
The Fish Health Inspectorate and You - Service Standards and Code of Practice for Enforcement
SVC Alert leaflet
Marine shellfish cultivation in the UK: Background to the industry
Cultivation of Pacific oysters
Cultivation of Manila clams
Clam cultivation: localised environmental effects
Bivalve cultivation: criteria for selecting a site
The hatchery rearing of king scallop (*Pecten maximus*)
Techniques for the production of juvenile lobsters (*Homarus gammarus* L.)
Storage and care of live lobsters

From the CEFAS Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk, NR33 0HT,
(Tel no: 01502 562244; Fax no: 01502 513865):

Shellfish News (back copies of some issues. Numbers 6-10 can also be viewed and/or downloaded as .pdf files from the CEFAS web site *http://www.cefas.co.uk*)
Mussel cultivation in England and Wales.
The scallop and its fishery in England and Wales.
