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CONWY MUSSELS - A HISTORY

Mark Hughes

The Pearl Fishers

At one time, two types of mussel were found in the Conwy River; *Mya margaritifera*, called Cragen y Diluw in Welsh, and *Mytilus edulis* or Cragen Las. The former, famed for producing pearls, was found higher up the river near the spa town of Trefriw. The pearls produced by these mussels were considered by some hardly inferior to oriental ones. The harvest no doubt attracted the Romans around 80 AD to this fine part of the world. The Roman writer and historian Pliny believed that pearls from Conwy were set in a breastplate dedicated to the Temple of Venus in Rome by Julius Caesar.

Conwy pearls are also mentioned in Edmund Spenser's poem 'Fairie Queene' of 1590:

> *Conway, which out of the streame doth send*
> *Plenty of pearls to decke his dames withal.*

Catherine, Queen of Charles II, was presented with a Conwy pearl by Sir Richard Wynne of Gwydir, and placed in the Royal Crown, a testimony to the loyalty of the gallant Welshman.

As early tourists visited Wales the fame of the Conwy pearls proved a draw for ladies of fashion and in the 1800's, a large sum of £80 was offered by a Duchess for a particularly fine pearl, with local fishermen employed to fish for the valuable commodity.

Blue mussels

The other variety, Cragen Las was found in higher concentrations on the bar at the mouth of the river. In the mid 1830's the blue mussel was gathered on the ebb tide in abundance by men, women and children, from beds with names such as Y Popty, Cae Conwy, Sgiaps, Y Morfa, Y Men, Westras and Cerrig Duon. The mussels, placed in sacks and baskets, were transported to Cefnro, at the northern extremity of the Morfa, or marsh and boiled in large iron pots called crochanau, or pits called 'pearl kitchens' each 5 feet square, 6 to 7 feet high and constructed of wattle and gorse. The fish was picked out and stamped to a pulp with the feet in a large tub and water added. The mussel flesh, called solach floated and was used as a food for ducks. The sand, stones and the smallest pearls, which fell to the bottom, were separated using a feather on a large wooden platter and sent to agents, with about 160 ounces of pearls collected per week.

When pearl fishers became mussel men and gatherers of mussels as food is uncertain, but different techniques were used according to the position of the shellfish beds.

Shore gathering

In a process described as 'hel ar y lan' (collection on the shore), pickers were dropped off at their stations in the estuary by the family boat. Here they used a small knife called a twca; a spoon shaped blade made by a local blacksmith to the gatherer's individual specifications, to prise the mussels away from the rocks. The length of the blade of the twca, according to one gatherer, equalled the 'length of the inside of the middle finger'. The twca was held in the right hand and three or four mussels pulled away from the rocks by the left hand and transferred to a willow or wire basket placed nearby. Three baskets constituted a bag-full and the shore gatherers, usually women, bound their hands with rags to prevent cutting from the sharp mussel shells. Before the men returned in their boats the bagged, shore collected mussels were carried to Conwy and sorted on the quayside. The women then had a meal and returned to the quay to meet them.

Fishing

Fishing for mussels from below the water was done for four hours at low tide and the departure time from Conwy arranged so the boats sailed downstream on the ebb tide and after fishing, back to the quay on the flood. Two men could be seen in each boat leaving Conwy for an area called the Deep with two mussel rakes, or crams, to fish for mussels in a process called codio'r dwfn (lifting from the deep). One rake had a 12-foot handle and another from 18 to 30 feet in length that ranged in diameter from 2 inches at the bottom to 1½ inches at the top. The rakes were made of pitch pine, with 10-12 long sharpened metal prongs of 8-10 inches length, fitted with a net on the underside (see photograph overleaf).

The rakes were thrown outwards from the boat as far as the men could reach and the poles rested on the shoulder and hand drawn along the seabed by the fishermen towards them with downward pressure applied on the handle at the same time to loosen the mussels. The poles were drawn up, hand over hand and at the same time twisted so that the mussels transferred from the prongs to the net. The catch was amassed in the boat and when nearly full, the anchors were pulled up fore and aft and the journey made back to Conwy Quay. The rakes, left

A Conwy mussel rake (Photo: the author)

on the beach when not in use, usually in the vicinity of the slipway or town wall, were made in the local boat yard and blacksmith's shop and lasted 4 or 5 seasons.

Purification

The mussels were usually sorted for size on the boats and placed in baskets, washed in the river before transfer into sacks and purified at the tanks at Benarth, Conwy. These tanks were built in 1913 as a result of an order granted by Parliament in 1912, which prohibited fishing for mussels for human consumption without being placed for an appropriate time in an approved place (for depuration).

The mussels were spread two deep on wooden grids on the bottom of shallow concrete tanks with individual family gatherings clearly marked out by stones placed around a section of flooring. The mussels were hosed thoroughly to clean the outside of the shell and sterilised seawater pumped into the tanks. For the first day the mussels opened their shells and discharged their stomach contents, the water was run off after 24 hours and replaced with a fresh solution. Final sterilisation of the mussels was carried out in a weak solution of (active) chlorinated water. The purified mussels were then bagged, tied using a continuous piece of string and sealed so that they could not be opened without breaking this seal; then sent to merchants at Sheffield or Birmingham and onto the markets. The mussels were placed in the tanks either on a Tuesday or Thursday, purified; and removed on Thursday and Saturday respectively. The tanks were used for purifying mussels for 80 years, eventually being shut down at the end of the mussel season in March, 1994 as a result of a new EC directive and the need for structural modifications, which required covered tanks to prevent vermin getting into them.

The industry today

Some mussel beds were disrupted and nearly destroyed following the construction of the Conwy tunnel. A Welsh Office grant was given to the mussel men and in 1994 a new, temporary purification centre was incorporated in an industrial unit in Conwy. This consisted of a multi-layer stack system with two stainless steel tanks with maximum capacity of 750 kg, fitted with ultra violet sterilisers. Due to increased productivity and as a condition of the grant a new, larger purification centre with four tanks was built on the quay at Conwy. This was given approval in January 1998. Today two Conwy men, Trevor Jones and Martin Parry, run the Conwy Mussel Company on the Conwy quay, employing approximately 10 men who still fish traditionally using rakes, although typically individually rather than in pairs, as in days gone by. The mussels are sorted for size on a platform near the quay, bagged and transported to the centre for purification and sent to merchants in the Midlands, other parts of the country as well as local fishmongers, hotels and restaurants.

Bagging up the purified mussels in the Benarth Tanks (Photo: CEFAS)

A Conwy mussel fisherman at work (Photo: the author)

The Conwy mussel centre on the quay. (Photo: Dr. Eric Edwards O.B.E.)

Further information

The above article is taken from information to be published in a book to be called CONWY MUSSEL HISTORY. This will be available locally in all good book shops, early in 2004, price £4-95, or direct from the publisher Gwasg Carreg Gwalch (Tel: 01492 642031, e-mail books@carreg-gwalch.co.uk or web site www.carreg-gwalch.co.uk). The author can be contacted on 01492 585176 and by e-mail at mark@golf050.freeserve.co.uk

TOO CLOSE A SHAVE FOR RAZOR CLAMS?

S.D. Muir and P.G. Moore, University Marine Biological Station, Millport (UMBSM), Isle of Cumbrae, Scotland KA28 0EG

Background

Razor-clams harvested by SCUBA diver-fishers in Scotland are supplied live to markets abroad, mostly in Europe and the Far East. At present, market preference is for the large pod razor clam (*Ensis siliqua*) which can reach up to 240 mm in length. However, larger individuals of the smaller, curved razor clam (*Ensis arcuatus*), which reaches a maximum of 180 mm, are also favoured. 'Size matters' since these razor clams are often served whole in restaurants as a delicacy. The market for smaller razor clams used in mixed seafood dishes in Europe was previously supplied by dredge-caught animals, primarily from Ireland. The large quantities caught by the dredges that have flooded this market have significantly reduced prices, making these smaller individuals an unprofitable catch for diver-fishers. Present EU legislation requires a minimum landing size (MLS) of 100 mm for all *Ensis* spp., however, there is a significant size difference between the species. To ensure reproductive success, and therefore recruitment, the slowest growing *Ensis* spp. would need to be allowed to reach sexual maturity before being harvested. The present 100 mm MLS does not ensure that this can happen and needs reviewing.

Methods

To investigate the length/age at maturity and the early growth of *Ensis siliqua* and *E. arcuatus* the following procedures were undertaken:

1. Samples of small razor clams were collected from the Clyde Sea area during April-June 2002, a time when sexually mature individuals would be full of ripe gonads. The razor clams were collected, either by diver hand-picking, or the UMBSM toothed dredge that was used in previous razor-clam research. Small *Ensis siliqua* and *E. arcuatus*, >20 mm and <150 mm length, were dissected and examined for gonad tissue. If present, a small section of gonad was excised and the stage of gametogenic development was assessed using standard histological techniques. The individuals were considered sexually mature if the gonads were full of ripe gametes (Figure 1).

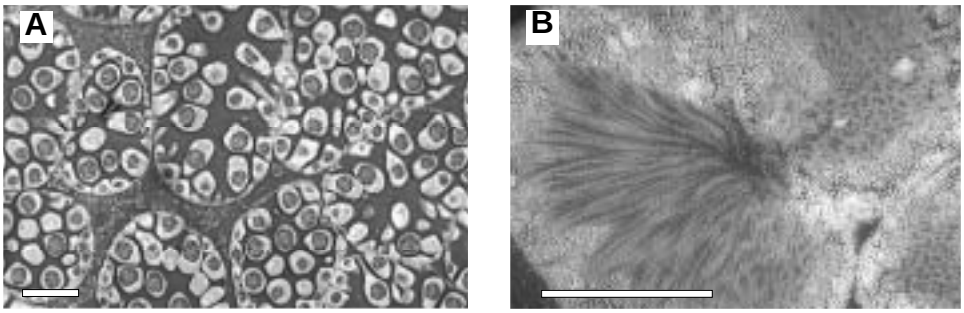

Figure 1. Ensis siliqua ripe gametes: A=♀, B=♂, scale bar ≈ 100 µm

2. The growth of juveniles was monitored by regularly measuring the lengths of juveniles that were collected in the field, brought back to the laboratory and kept in sand-filled aquaria with constant running, unfiltered sea water. Juveniles were collected between August 2000 and April 2002. The spawning of adult *Ensis siliqua* in outside tanks at UMBSM at the end of May 2001 resulted in settlement within these sand-filled aquaria. The length of these recruits was also regularly measured from when they were first discovered in August 2001 until April 2002.

Results

The smallest *Ensis arcuatus* that was found to be sexually mature was 73 mm in length. At length category 81-90 mm, 51% of *Ensis arcuatus* were sexually mature but 100% maturity did not occur until length category 121-130 mm. For *Ensis siliqua*, 100% sexual maturity did not occur until length category 131-140 mm, with the smallest sexually mature individual found being 118 mm. The percentage of small *Ensis siliqua* and *E. arcuatus* that were mature in each length category examined are shown in Figure 2.

The lengths of juveniles located *in situ* and transferred to the laboratory tanks were recorded approximately monthly (Figure 3). The laboratory-reared recruits were first measured in August 2001 and were approximately 11 mm length, i.e. 3 months after spawning. Growth was negligible during the winter and did not begin again until early spring. It is likely that recruits located *in situ* in August 2001 at mean length 33 mm were recruits from the previous year, i.e. they were approximately 1 yr 3 months old. Two years after spawning juveniles were approximately 40 mm length. It can, therefore, be deduced that juveniles would take at least four to five years to reach 100 mm length.

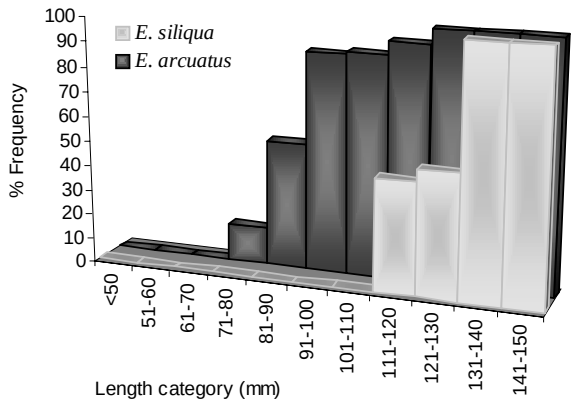

Figure 2. Length at sexual maturity for Ensis siliqua and E. arcuatus in the Clyde Sea area sampled during April-June 2002

Conclusions

The length at sexual maturity for *Ensis siliqua* and *E. arcuatus* on the West coast of Scotland was comparable with figures derived from work done in Wales that indicated that *E. siliqua* reach greater than 100 mm length before they are mature and capable of spawning. *Ensis siliqua* in Portugal were sexually mature at 60-100 mm length and reached maturity in the first year of life. From the laboratory growth of juvenile *Ensis siliqua* and *E. arcuatus* in this study, it could be deduced that they are at least four to five years old before they reach 100 mm length, i.e. 1-2 years older than *E. siliqua* in Wales. This could suggest that this species is slower to grow and mature at more northerly latitudes. Many factors can influence size at first maturity, including food availability and water conditions.

The current MLS of 100 mm length, therefore, does not ensure that all razor clams will have had a chance to spawn prior to harvesting. At present, in Scotland,

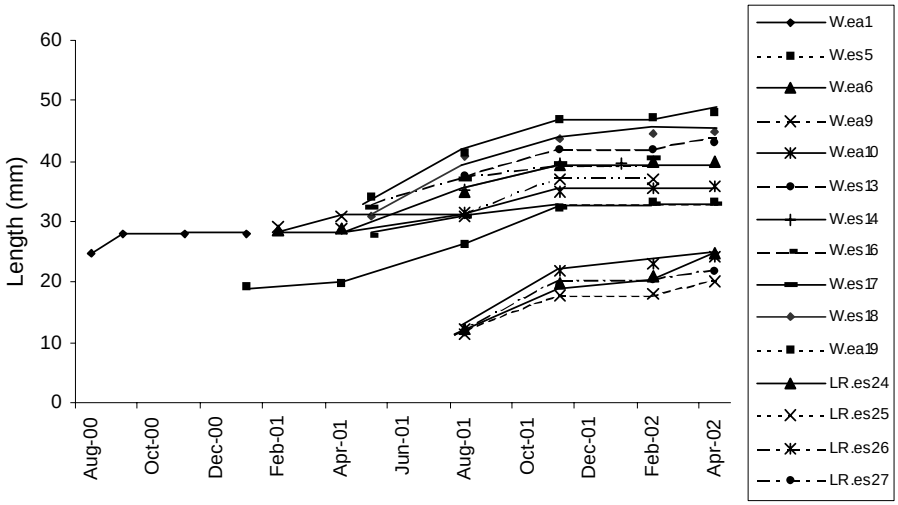

Figure 3. Juvenile Ensis growth from August 2000 to April 2002. LR.es are laboratory-reared E. siliqua, W.es are wild-caught E. siliqua and W.ea are wild-caught E. arcuatus. All razor clams were kept in sand-filled aquaria at UMBSM in outside tanks with unfiltered, running sea water

diver razor-clam fishers voluntarily concentrate their efforts on larger razor clams. This voluntary selectivity in the fishery is allowing *Ensis* spp. to become mature and spawn at least once prior to capture (assuming that successful spawning later takes place annually). As stocks decline, however, smaller razor clams are going to be captured. The largest razor clams can reach 35 years-of-age and, with probable low fecundity in the smaller individuals combined with highly variable recruitment with only occasional years showing good recruitment, the stock of larger-sized razor clams may decline.

To protect the sustainability of the fishery and the razor-clam stocks it would be sensible to adjust the minimum legal landing size in the UK to take into account the sexual maturation length discovered here and in Wales. A distinction between the MLS for the two razor-clam species would also allow the earlier maturing, smaller *Ensis arcuatus* to be fished sooner in the life history than the larger, later maturing *E. siliqua*.

Acknowledgements

This work was done as part of a PhD awarded to S.D. Muir, funded by the University Marine Biological Station Millport, the Shellfish Association of Great Britain, the Highlands Council and the Highlands and Islands Enterprise. The divers and boat crew at the University Marine Biological Station, Millport are thanked for their assistance and special thanks are due to the razor-clam diver fishers on the West coast of Scotland, without whom much of this work would not have been possible.

Further information

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TECHNOLOGICAL ADVANCES IN FISHERIES MONITORING: ELECTRONIC LOG BOOKS IN THE CRAB FISHERY

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Better advice

The Shellfish Team at CEFAS, Lowestoft, are continually looking at ways in which they can improve the advice they give on how best to manage the various shellfish stocks exploited in English and Welsh waters. With the increased pressure on shellfish stocks as a result of declining fishing opportunities elsewhere, the quality of the advice offered becomes even more important.

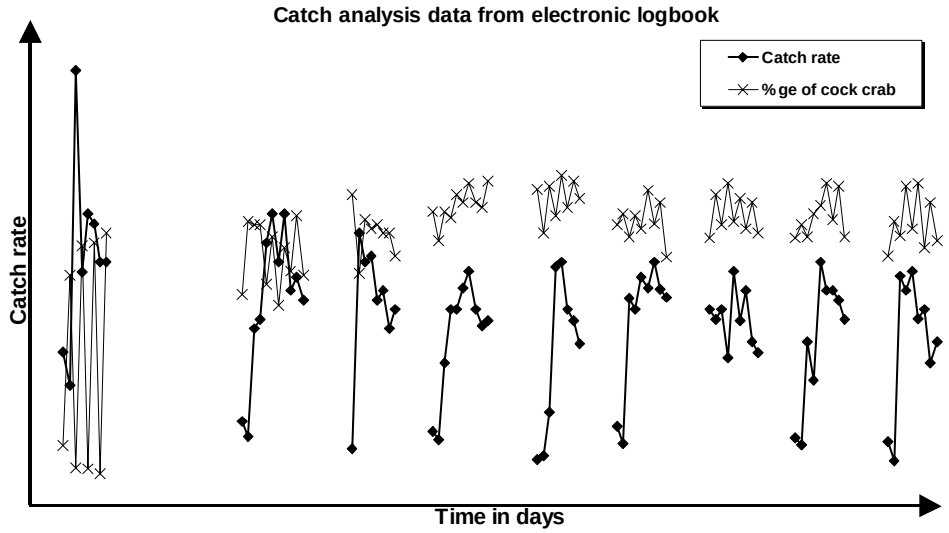
To this end a new project is beginning at Lowestoft which aims for an improved understanding not just of the dynamics of exploited shellfish stocks, but also how this is reflected in the monitoring and the application of stock assessment methods.

Fishing effort data

In the crab fisheries, for example, one of the problems for scientists is obtaining good quality catch and fishing effort data at the appropriate temporal and spatial scale. Whilst many inshore crab vessels still undertake daily trips to sea and land their catch at the end of the day, the larger offshore crab vessels have developed a wide variety of fishing practices. These often fish for ten or more days on a single trip, transferring their catch directly onto vivier trucks for onward transport. This can make it extremely difficult for scientists to get even a single estimate of total catch and number of pots hauled from the whole ten days fishing, let alone catch rate information for each ground fished during the trip.

Electronic catch recorder

One aspect of the new project will involve the use of an electronic catch recorder linked to the GPS aboard the fishing vessel (see photograph below), which the skipper will use to enter details of his catch on a haul by haul basis. At the end of each trip it is possible



to download the information directly to the CEFAS Laboratory simply by connecting the unit to a normal telephone line. The data will be automatically encoded before transmission and is completely confidential. The units are robust and easy to use and are not PC-based as is the case with many commercially available vessel management systems. The unit has already been successfully trialled aboard a commercial vessel.

The type of data collected is illustrated on the figure above. The basic information provided by the skipper was an estimate of catch (boxes) for each string hauled, the percentage of cock crabs in the catch and the soak time. (Actual catch rates and dates of fishing have been removed to ensure confidentiality.) The end positions of the string, date and time are all collected automatically by the unit via the GPS.

In this example, detailed information about the catch rates throughout the trip shows various interesting features such as the change in catch per effort over the course of the trip and how. on the first trip recorded, the changing of grounds on a daily basis resulted in a very different catch composition with cock crabs predominating in one locality and hen crabs in the other. None of this very detailed and useful information can be collected by fisheries scientists, other than by direct observation aboard the fishing boat. Perhaps in the future methods such as this could even replace the old paper logbook system.

Can you help?

The shellfish team at Lowestoft are hoping to install at least two of these units later this year aboard large (>10 m) crabbers working in the English Channel. Instructions in their use and all necessary equipment will be provided and we will carry out the installation. If you can help us with this project please get in touch by ringing the CEFAS Laboratory on 01502 562244 and asking to speak to a member of the shellfish team dealing with crabs.

SCALLOP SHUCKING METHOD CAN REDUCE GONAD ASP LEVELS

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Background

The king scallop, *Pecten maximus*, is an economically valuable shellfish species in the UK. An estimated 95% of king scallops are processed as an adductor muscle and gonad 'roe-on' product for the continental market.

During amnesic shellfish poisoning (ASP) events there can be high variation in the amount of toxin in individual scallops and particularly in the amount of domoic acid (DA) in the gonad, which is sometimes at levels above the statutory action limit (20 µg DA g^{-1}). This situation complicates the management of the fishery.

Concentrations of DA in the normally discarded scallop digestive gland routinely exceed 200 µg DA g^{-1} (levels above 1000 µg DA g^{-1} have been reported) and this therefore presents a considerable source of potential contamination of the edible parts. Furthermore, in *P. maximus*, a loop of intestine travels through the gonad, and can represent up to 6% of the gonad volume. Potentially toxic, viable cells of *Pseudo-nitzschia* spp. have been observed intact, within the contents of this loop, even when routine plankton monitoring has not detected *Pseudo-nitzschia* cells in the water column. As a consequence the toxicity of the digestive loop contents can correspond directly to the high toxicity levels of the stomach and digestive gland. The question is, can the toxin burden of the gonad be reduced by appropriate preparation of this tissue? To answer this, we examined the effect of professional processing and of differing laboratory preparation techniques on toxin levels in the gonad and assessed the significance of the toxin content in the digestive loop running through the scallop gonad, and scallop mucus on final gonad DA levels.

Trials

Adult *P. maximus* were collected from 3 fishing boxes on the West Coast of Scotland (one from Jura and two in the Sound of Mull) that consistently give high DA levels (Food Standards Agency Biotoxin Monitoring Program). Upon collection, scallop gonads from each of the 3 sites were prepared by 4 different methods. These were

1. Laboratory treatment 1: gonad dissected, digestive tissue completely removed from the top of the gonad, digestive loop rinsed out with fresh distilled water (see Figure 1) and the gonad washed and blotted dry to remove surface mucus.
2. Laboratory treatment 2: as treatment 1, but the gonads were finally dipped into mucus exudates of the same individual.
3. Laboratory treatment 3: as treatment 1, except that the digestive loop content was left intact.
4. Professionally processed treatment: professional staff shucked, washed and rinsed adductor muscle and gonad as a 'roe on' product. The gonad was subsequently removed for analysis.

Each of the above treatments was carried out on twenty scallops from each of the three fishing areas.

All DA analysis of gonad tissue was conducted using a LC-MS/MS procedure.

Results

The results showed that DA contamination of gonad tissue might be higher when the digestive loop contents were not flushed (Treatment 3). The mean level of gonad toxicity attributed to the digestive loop contents was estimated at 4.7 - 24.7 µg DA g^{-1}. In scallops with

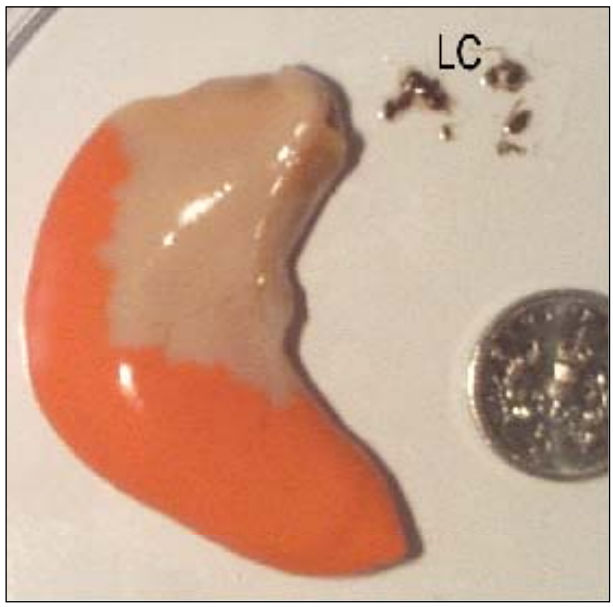

Figure 1. P. maximus gonad with digestive loop contents (LC) flushed out

elevated toxicity levels in the gonad, resulting from higher digestive loop content toxicity (sites 1and 3), flushing out the contents of the digestive loop decreased the gonad DA toxicity by 87%, and lowered the frequency of individuals harbouring levels above the 20 µg DA g^{-1} statutory limit.

The methods applied by the processor (Treatment 4), of washing and agitating an adductor muscle and gonad 'roe on' product was also able to remove the contamination effect caused by contents of the digestive loop, to a standard comparable with that of a laboratory technique.

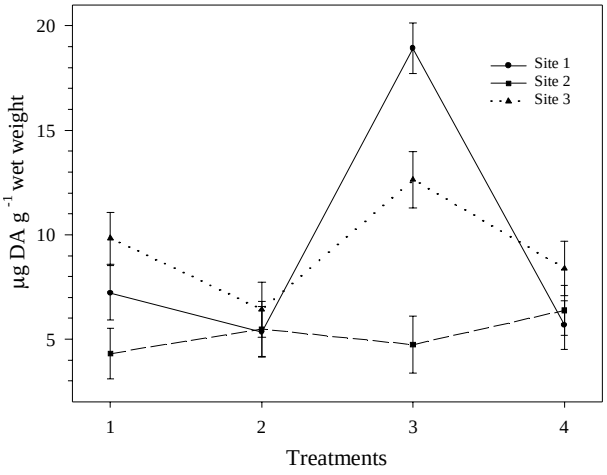

Figure 2. Mean and standard error DA levels (µg DA g^{-1} wet weight) in the gonad of P. maximus for each treatment and site

Deliberate re-contamination of the gonad by mucus exuded from the shucked scallop did not increase the DA toxicity level in the gonad (Treatment 2). Interestingly, individuals subjected to mucus showed the least variation in DA toxicity with respect to sites, and thus give inference to alternative solutions to reduce surface contamination of tissues at the processing stage. The potential to develop chemical washes that either directly break down DA or possess a greater affinity to bind and remove DA more efficiently than water, and the practical use of DA utilising bacteria in bivalves to eliminate the toxin should be looked at. Such applications may prove more practical than artificially depurating live scallops harbouring DA.

Conclusions

The extent of toxin variation resulting from the different gonad preparatory methods emphasises the need to standardise scallop tissue preparation techniques during ASP events. Consequently, detailed protocols aimed at minimising the contamination of edible components, for both processing facilities and monitoring bodies to conform to, should be developed.

- All individuals involved in handling toxic scallops should be informed of the anatomical distribution of DA within the scallop and the potential sources of and procedures to minimise contamination.
- Processors and monitoring bodies should avoid rupturing the digestive sac and exposing the edible parts to highly toxic exudates, and these toxic tissues should be discarded immediately upon removal.
- During the process of 'trimming', all traces of digestive gland from the gonad digestive gland interface, and digestive tract such as the anal tube around the adductor muscle should be removed.
- The roe on product should be washed and agitated in continuously running water to aid the clearance of the digestive loop contents.
- Protocols should also be implemented to minimise the risk of cross contamination to maintain the integrity of the product and samples for end product testing.

These measures are closely in line with current industry practises and their implementation should prove straightforward. Standardisation between industry and regulatory bodies will allow for more confident comparisons between processor produced end product samples and samples collected as part of the bio-toxin monitoring program. Public knowledge that all processors meet an approved standard, with regard to handling toxic scallops, will ultimately support consumer confidence in the scallop product. Furthermore, if contamination rates can be minimised to a known efficiency, this would facilitate the development of risk assessment models to assess scallop toxicity with respect to rate of consumption by humans.

Further information

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TOWARDS SUSTAINABLE MUSSEL CULTIVATION

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Background

In 2001 the UK mussel cultivation industry harvested approximately 14,000 tonnes of mussels with a value of over £4.5 million (Defra, 2003). The Menai Strait in North Wales has been the source of over 75% of the UK mussel production for the past decade, where mussels are cultivated directly on the seabed. At present little management is used in this cultivation technique to optimise mussel seed stocks. Survival of these seed mussels is therefore poor as many die from either starvation or are eaten by predators. Furthermore, wild seed settlement is unpredictable such that years of very abundant seed fall can be interspersed with lean years with little or no seed fall.

LINK project

A LINK-Aquculture project was set up in 1999 and competed in 2002, involving partners from the University of Wales – Bangor, Centre for Ecology and Hydrology, Dorset and the mussel industry in North Wales (Myti Mussel Ltd and Deep Dock). The project aimed to recommend a management plan to improve mussel productivity by determining stocking density and management strategies that would maximise mussel growth rate and reduce predation losses, while minimising ecological effects on bird and invertebrate communities. The project objectives were achieved through large-scale field experiments to provide data relevant to commercial cultivation.

Sampling mussels at the experimental site in the Menai Strait

Mussel growth

Both the density and shore height at which mussels are cultivated were shown to affect mussel growth. This study provided clear evidence of reduced growth rates, in terms of mussel shell length and flesh weight, with increasing shore height and initial stocking density.

Mussel growth also displayed a distinct seasonal pattern with higher growth over the summer months compared to the relatively food depleted winter months. For the experimental sites, statistical models were developed of seasonal mussel growth as a function of initial stocking density and shore height and these models predicted mussel growth with a high level of precision (Figures 1 and 2).

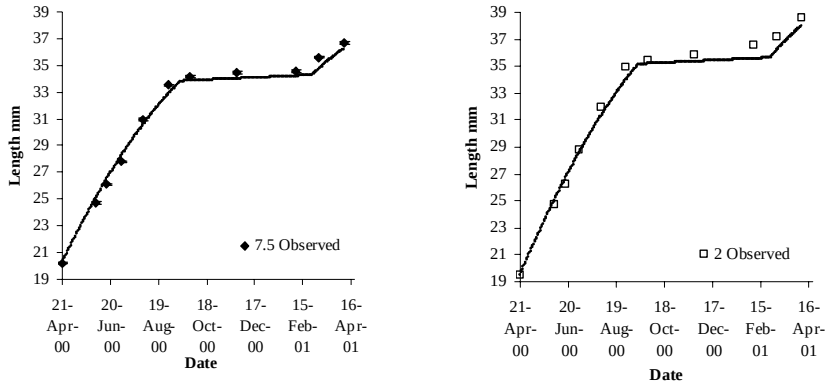

Figure 1. Predicted (solid lines) and observed (symbols) shell length of mussels grown at highest and lowest initial experimental seeding densities (7.5 and 2 kg m^{-2})

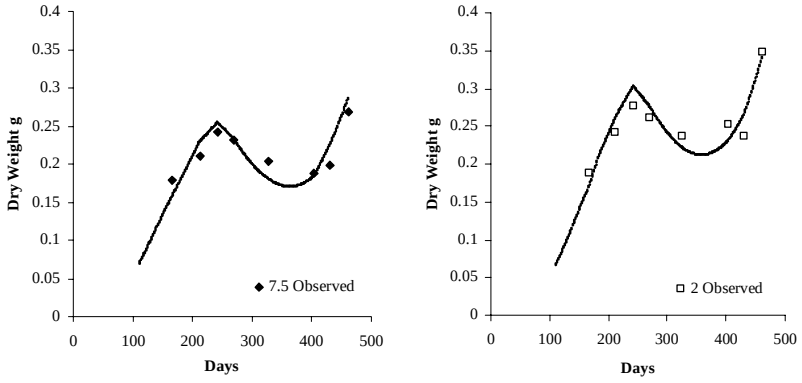

Figure 2. Predicted (solid line) and observed (symbols) flesh dry weight of mussels grown at highest and lowest initial experimental seeding densities (7.5 and 2 kg m^{-2}). Day 1 is 1 January 2000

The advantage of using such statistical models is that it allows mussel production, using several different management scenarios, to be predicted enabling informed judgements to be made in the commercial cultivation of mussels on the seabed. A better understanding of the relationship between stocking density and shore height should result in a more sustainable approach to mussel cultivation.

Mussel mortality

Food and space limitation can ultimately cause increased mortality and this was demonstrated at the high experimental densities. Mortality rates were found to change between the summer and winter on the main experimental site. However, in a caged experiment where predators were excluded, a seasonal change was not detected in the mortality rate. Additionally, the mortality rates at the caged mussel site were found to be much lower than on the main site, which suggested that the higher mortality rates on the main site could have resulted from high crab predation pressure. However, crab predation accounted for only a relatively small proportion of the total mortality on the main site (Figure 3). Over this period total losses to oystercatcher predation was approximately only 1%, due to the small sizes of the mussels.

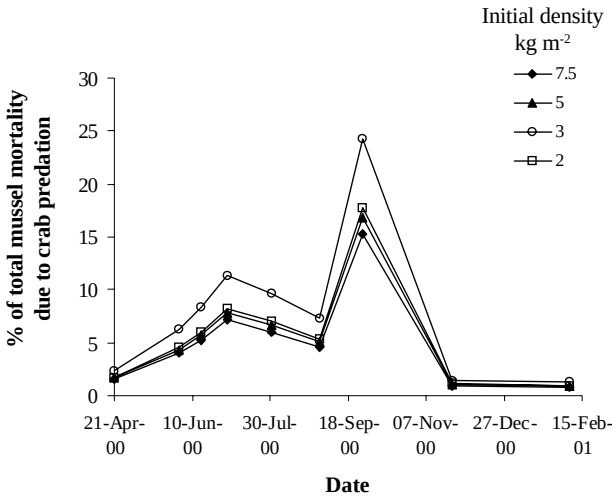

Figure 3. Predicted percentage of total mussel mortality due to crab predation for mussels grown at four initial seeding densities (7.5, 5, 3 and 2 kg m^{-2})

Mussel 'banking'

A relaying strategy of 'banking' mussels was investigated. This strategy involves banking seed mussel in times of abundant spat fall in relatively high shore areas. In subsequent years when spatfall is low these mussels can be moved down shore where they can on-grow at a faster rate to marketable size. A further advantage of growth in these high shore areas is the development of a thicker shell, which aids resistance to predation. An experiment was conducted to compare the shell thickness of banked mussels to those grown in lower intertidal and subtidal areas. Mussel shell thickness was compared directly (mass to shell surface area) and indirectly (compressive strengths and crab preference experiments).

The inter-tidally grown mussels had thicker shells than the subtidal mussels. This was maintained with on-growing and corresponded with shell compressive strength. Crab preference was shown towards the mussels with thinner shells and lower compressive strength. Over the period September 2000-March 2001, oystercatchers appeared to have very little interest in these banked seed mussels, even though they were available to them for a longer time per day than mussels growing at lower shore-levels. This probably reflects their small size, low flesh content and relatively thick shells. Banking seed mussels at high shore levels would seem to carry little risk of significant oystercatcher predation.

A novel management plan for mussel cultivation was formulated from the results of this study by manipulating shore position according to the attainment of these predator resistant shell attributes and the spatial distribution of the main natural mussel predators (crabs and birds) in order to reduce losses to predation. Additionally through 'banking' of seed mussels the unpredictable supply of seed mussels for on-growing could be evened out from one year to the next.

Conclusions

This study indicates that there is considerable potential for the improved management of cultivated mussels with respect to the factors that control mussel growth and mortality. There is the potential to both improve the mussel yield and provide a more sustainable approach to mussel cultivation by reducing the amount of seed mussels that are required to yield similar returns at harvest as presently achieved.

Together with complimentary work that was carried out on bird (carried out by CEH Dorset) and invertebrate communities the project has also provided information on the environmental impacts of seabed mussel cultivation.

HIGH PRESSURE PROCESSING

Donald E. Johnston and Margaret F. Patterson
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Processing foods using very high pressures is a concept that generates excitement and debate among food scientists, yet mystification and disbelief in the general public. Even more startling is the fact that the first research on high pressure food processing was reported over 100 years ago. Unfortunately, the considerable engineering problems involved in repeatedly generating and containing the immense pressures meant that the technique languished as a scientific curiosity until the late 1980s. By then, wider availability of specialist high pressure pumps and vessels, built for routine use in producing polymers, ceramics, artificial diamonds and metal forming, reopened the way for modern research on high pressure processing of foods.

Perspectives on pressure

Scientists measure pressure using a basic unit called called a Pascal. This is quite small, about 1/100,000 of atmospheric pressure, so a mega Pascal (MPa), which is a million Pascals, is more commonly found. This makes it difficult for the general public to envisage the pressures involved in high pressure processing. The older imperial unit of pressure, pounds per square inch (p.s.i.) is probably more familiar to those aged over 30. One atmosphere (At) (about 14.5 p.s.i.) is more easily envisaged. A typical family saloon car would have a tyre pressure of 2 At and industrial hydraulic power is about 200 At. Foods are processed using 1000 - 9000 Atmospheres. However such pressures are so extreme that they are difficult to appreciate. The Titanic wreck site is at a depth of 2.5 miles. At this depth the pressure would crush a normal submarine like an empty drinks can. Food processing would require more than twice the pressure at the Titanic wreck site.

A processing pressure of 100MPa would be about 14,500 p.s.i. or over 6 tons per square inch – equivalent to a stack of 5 family saloon cars bearing down on a postage stamp!

Effects on Foods

So why are the scientists so interested? Consumers today demand food that is more natural, minimally processed, additive free and above all, safe to eat. High pressure appears to offer particular potential in these aspects. How can exposing food to pressures greater than at the bottom of the deepest ocean improve food quality? It can reduce the number of microorganisms present in a food, deactivate many natural enzymes that could lead to quality deterioration, change the foaming, gelling and emulsifying behaviour of proteins or carbohydrates and beneficially control phase changes such as fat melting or ice formation. Many of these effects can be achieved by heat but high pressure has important differences. With heating, the interior temperature of a piece of food is often lower than at the surface because it takes time for the heat to be conducted inwards from the surface. This can lead to overcooking at the surface if the centre is to be properly cooked. In contrast, with pressure processing, identical pressure is experienced simultaneously at the surface and interior of the food. This results in minimal change to sensitive food components like flavour, vitamins and many colours as a result of pressure treatment.

Why is food not squashed to mush? Most foods have high water content and water is very difficult to compress. High pressure compresses the food equally from all sides, so it simply contracts slightly under pressure. When pressure is released the food recovers its original shape.

The innovative Japanese led the way to bring the technology to market, launching a range of speciality jams with unique fresh fruit taste, sauces, salad dressings, ready to eat desserts, and grapefruit and mandarin juices during the 1990's. Various fishery products including surimi were also investigated. Since then other countries have launched fresh citrus juice products. Pulped avocado (guacamole) products have been successfully launched in the US and also cooked ham in Spain. Of greatest interest to the shellfish trade has been the launch of high pressure treated oysters on the US market, where the level of demand has surprised and delighted the company involved.

DARD research

Scientists at the Food Science Division of the Department of Agriculture and Rural Development (DARD) in Northern Ireland were among the first in Europe to begin research on high pressure processing of foods, over a decade ago. Their ongoing programs include evaluating the ability of high pressure processing to improve the microbiological safety of various foods, including shellfish. Recently they carried out a preliminary evaluation of high pressure processing of some shellfish species, funded by DARD Fisheries Division.

Pressure Treatment of Shellfish

Improved food safety: Results so far indicate that many food poisoning bacteria, such as *Salmonella*, *Campylobacter* and *Vibrio* are killed at the pressure proposed for shelf-life extension. Other recent work from America shows that some viruses, such as Norwalk, which can be associated with shellfish are also destroyed by pressure. Therefore it appears that the technology can offer real advantages in improving food safety as well as extending shelf life.

Improved ease of shucking: One observation made during the DARD work was the fact that opening the shells of shellfish and removing the meat was much easier after pressure treatment. This observation has also been reported by other scientists and is used to commercial advantage in America, where one company is routinely using high pressure to treat oysters. To keep the shells shut, a gold coloured band is placed around the shell prior to treatment. The company reports increased quality and weight from the pressure treated oysters and reduced industrial injuries from staff stabbing themselves while attempting to open the shells.

Mussels Oysters and Prawns

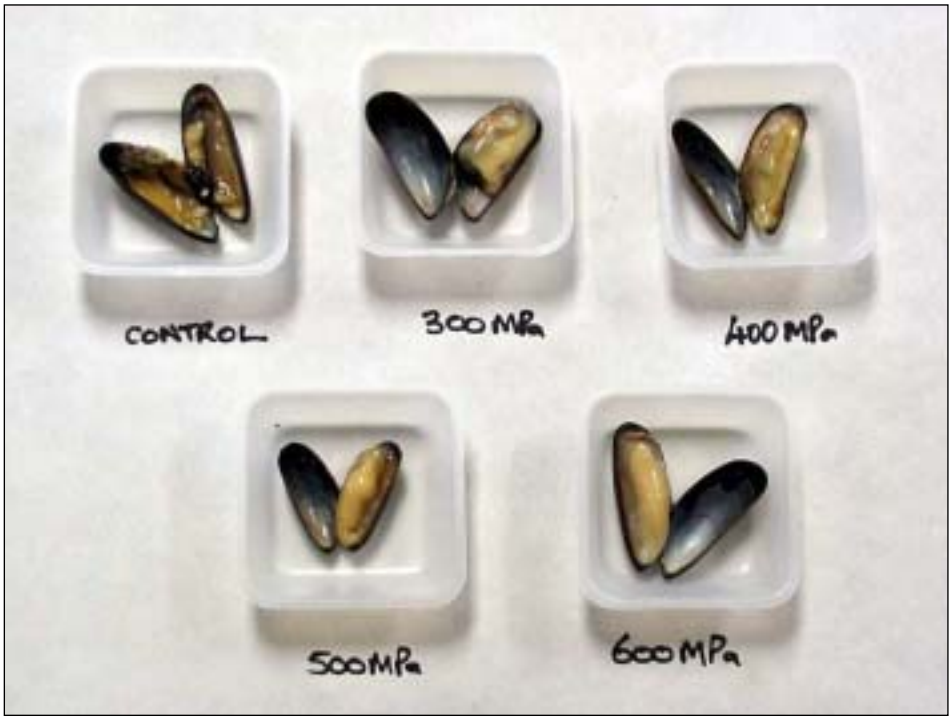
The DARD study looked at the effects of high hydrostatic pressure on mussels (*Mytilus edulis*), oysters (*Crassostrea gigas*) and prawns (*Nephrops norvegicus*) and assessed their shelf-life after high pressure treatment, using sensory evaluation panels and microbiological counts.

Mussels: Moisture content of raw mussels was increased by pressure treatment. Sensory panel results suggested that while initial odour differences were not significant, over a 2 week period pressure treated raw mussels retained their odour better than the control. The microbiological counts supported these observations. Numbers of bacteria, including those usually associated with causing spoilage and off odours, were greatly reduced by the pressure treatment and remained low throughout storage.

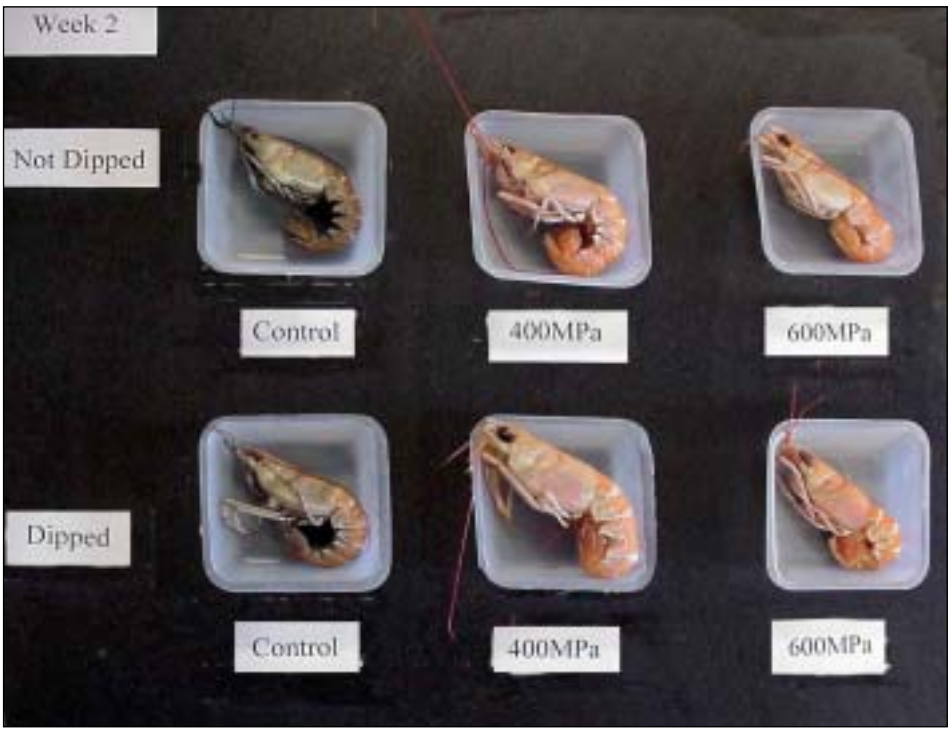
The panel also found the appearance of pressure treated samples less acceptable than untreated, probably due to pressure treatment causing their shells to open (see photograph).

Oysters: The moisture content of raw oysters was increased by pressure treatment, making them appear plumper. Pressure treatment caused their shells to open and the meat was released cleanly from the shell. The sensory panel found the appearance of the pressure treated samples to be more acceptable than control samples and that raw odour was not changed significantly by up to 2 weeks storage. Thereafter a deterioration was noticed although the samples remained acceptable. The microbiology results again supported these observations. The pressure treatment greatly reduced the number of bacteria and the numbers remained low even after 21 days storage.

Prawns: The most noticeable effect of pressure treatment was inhibition of head blackening during storage in both raw prawns and raw prawns dipped in sodium metabisulphite solution.



The effects of high pressure treatment at 300 – 600 MPa (3,000 – 6,000 Atmospheres) on the appearance of raw mussels (Mytilus edulis)



The effects of high pressure treatment at 400 – 600 MPa (4,000 – 6000 Atmospheres) on the appearance of raw prawns (Nephrops norvegicus) either dipped in sodium metabisulphite solution or non-dipped, after 2 weeks storage at 2°C

Increased treatment pressure gave better appearance. Pressure treated prawns also had significantly lower bacterial counts (see photograph).

When cooked after 2 weeks storage, dipped prawns with the higher treatment pressure had acceptable odour, appearance, flavour and texture although they were not as well accepted as cooked, fresh samples. Some issues may require further investigation, nevertheless, pressure treatment offers encouraging prospects of extending acceptable shelf life.

Future Prospects

Many interesting phenomena are reported to occur as a result of high-pressure processing but if new products are to be brought swiftly to the marketplace, a clearly focused programme of development will be required. Fundamental knowledge and applied know-how will need to be blended together.

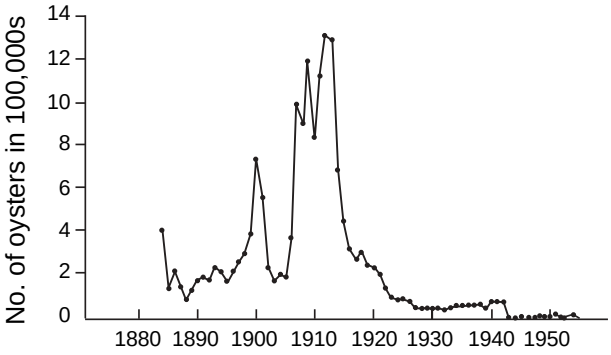
The Japanese have demonstrated what can be achieved by having industry and academia working together. If other countries can achieve a similar degree of collaboration and commitment then success will be gained more rapidly.

THE LOCH RYAN NATIVE OYSTER FISHERY

Tristan Hugh-Jones, Rossmore Oysters Ltd

History

The largest fishery for native oysters in Scotland is situated in the southwest of the country, in Loch Ryan, near Stranraer. The fishery was given to the Wallace Family in 1702 by William III and it has remained with them ever since. In around 1910 it was producing about 130 tonnes of *Ostrea edulis* supporting up to 30 boats, but generally the Loch has had a history of boom and bust (see figure overleaf). The boom of the 1913 era only lasted for about 10 years before the catches fell to about 20 tonnes per year and these quickly fell to 10 tonnes from 1930. It was not viable to fish from about 1957, when the bed was handed over to the Scottish Marine Biological Association to carry out research to see if it would be possible to bring back the fishery.



Oyster landings in Loch Ryan from 1880-1950

In 1976 the Colchester Oyster Fishery, started to fish the Loch, catching up to 61 tonnes per year using 4 boats. In 1987 B and B Shellfish began to farm the Loch and were restricted in their catch to 15 tonnes per year, mostly harvesting the larger oysters for the London market and relaying the small ones. In 1998 Loch Ryan Shellfish began to harvest about 10 tonnes per year of the larger oysters, and relaying the smaller ones, with one boat and three men. Last year, harvesting increased to 17 tonnes, approximately 98% of the official Scottish production.

Loch Ryan is unique

Loch Ryan is privately owned and managed and provides a vast growing area, one of the largest in Scotland. There is no evidence of algal toxins (DSP, PSP, ASP, AZP) in the area and the water is classified Grade A from February to April (Class B for rest of the year). Natural spatfalls of oysters occur every year.

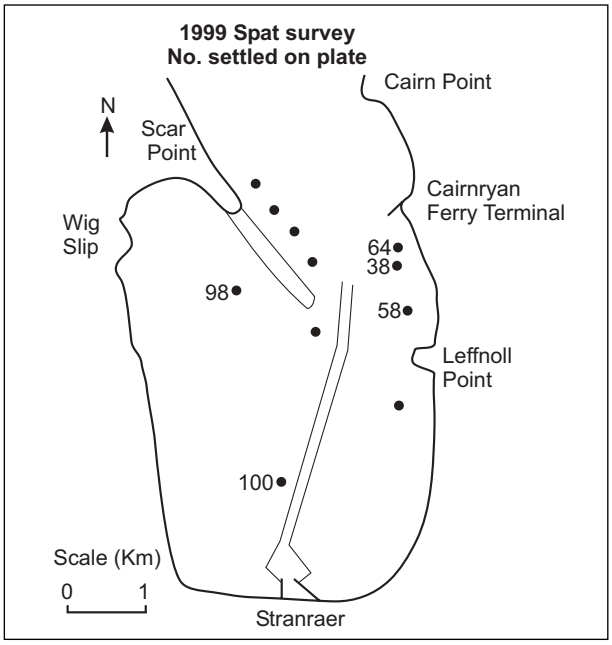
Surveys

An extensive survey has shown that the bottom is mostly silty mud, or muddy sand, with very little shelly material present. The tidal movements are generally small with the largest water movement being to the eastern side of the Loch near Cairnryan, where the water is pushed around a spit. There is a deep channel for the ferries that runs down the middle of the loch and this is filled with small *Turitella* shell. This is the only source of shell in the loch, although unfortunately it appears to be of no use for oyster spat collection.

Surveys by the Scottish Environmental Protection Agency (SEPA), and the Marine Lab in Aberdeen have investigated TBT levels in the Loch. It has been found that levels are high near Stranraer, and fall near the mouth of the Loch. With a ban on TBT and the ferries moving to Cairnryan, it is hoped that levels in the Loch will reduce further.

Estimating spatfall

In 1999, 36 small, unglazed plates were placed in the loch at 12 sites to sample the spatfall. Next to each site a mixture of shell was placed to catch the larvae. It was found that there was good recruitment near Cairnryan, and also in the middle of the loch to the south, where 100 spat were recorded on one 150 mm plate (see figure). Oyster shell was best for settlement, followed by whelks. No spat were caught on scallop and *Turitella* shell.



Some results from the 1999 spatfall survey

An earlier survey was carried out in 1998, when 100 pieces of natural cultch (shell) were fished from 12 sites and examined for spatfall from previous years. This showed that the 1995 and 1997 spatfalls were greatest, and on average every piece of cultch in the loch had spat on it. It seems, from our survey, that greatest spatfall can occur in markedly different parts of the Loch in different years.

The oysters from the above survey are now nearing marketable size. The oysters in Loch Ryan grow slowly, averaging about 11 g per year. The one advantage of this is that each oyster that remains on the bottom provides a perfect surface for the settlement of larvae, whilst it grows to a marketable size.

The future of Loch Ryan is dependent on the size of the spatfall and how the spat are captured. There is a huge lack of any shell in the loch, and if the loch is to be brought back to its former peak of production, the natural spatfall must be used to the greatest extent.

Further information

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NATIVE OYSTER BEDS IN WALES

Aethne Cooke, Countryside Council for Wales

History of the native oyster in Wales

In Wales, the native oyster (*Ostrea edulis*) industry thrived up until the end of the 19th century, where it was an important economic activity in Swansea Bay and the Gower, Milford Haven, Tenby, Stackpole, Cardigan Bay and the Menai Strait. Then the advent of the railways allowed perishable goods to be transported cheaply and easily to large population centres. A rapid increase in demand boosted the fishing industry and quickly brought heavy pressure on the oyster grounds in Wales, as was the case elsewhere around the British coast. The native oyster fishery in Wales declined rapidly due to this intense exploitation, combined with poor recruitment. Significant oyster beds are now restricted to Milford Haven, Swansea Bay and Porthcawl, although these remaining beds are of a much reduced scale to what was previously present.

Biodiversity Action Plan

Because of the sharp decline in oysters at the turn of the 20th century, the National Assembly for Wales and UK Government has selected the native oyster as a priority Biodiversity Action Plan (BAP) species. One of the first data requirements in Wales was to determine the status of the native oyster beds. To this end, the Countryside Council for Wales commissioned research into the remaining known oyster beds in Wales - in Swansea Bay and in Milford Haven, Pembrokeshire.

Research survey results

Dive surveys were employed to gather information on oyster abundance at selected sites and also the marine biodiversity associated with oyster beds. Oysters were successfully located in Milford Haven, but none were recorded in Swansea Bay. However, it is known that oysters occur inter-tidally in Swansea Bay and Swansea Port Authority carries out positive dredge sampling. Low numbers of oysters and the few dives undertaken are the most likely reasons for not finding oysters in Swansea Bay. In Milford Haven, the abundance at most sites was < 0.2 oysters/m^2.

All observed oysters in dive transects were collected and sent to the University of Wales, Bangor for age analysis using acetate peel replicas. This involves a microscopic examination of the umbo region of the flat shell valve to count annual growth lines (see figure below).

Of the oysters that were aged in this way, 21% were between 10 and 20 years old, and 76% were between 0 and 10 years old. A single old timer was aged at 34 years of age. Most of the oyster populations at the sites in Milford Haven contained a cohort of small oysters (<15 mm) attached to the shell surfaces of the larger individuals. However, there was no evidence of spat settlement on oysters from some sites in the upper sections of the estuary.

Data on the marine biodiversity associated with native oyster beds indicate that they form a flourishing part of the ecosystem. Over a hundred species were recorded from native oyster beds, including anemones, sponges, brittle stars and various crustaceans. The non-native slipper limpet *Crepidula fornicata* was recorded in all of the native oyster beds surveyed.

Information gained from this study in Wales will improve our ecological understanding of native oyster

Photomicrographs of acetate-peel replicas of shell sections of Ostrea edulis showing the appearance of 15 umbo growth lines (thick arrows). Curved arrows show small depressions associated with the growth lines. The position of each line can be followed through the umbo region (thin arrows).

The hermit crab Pagurus bernhardus with the hydroid Hydractinia echinata, and the anemone Urticina eques on mixed muddy substrates

beds and contribute to the management advice for the remaining native oyster beds in Wales. This research contributes to UK-wide action for the native oyster. A similar survey of native oyster beds has been commissioned by Scottish Natural Heritage in Scotland.

Further Information

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OYSTER RESTORATION IN CHESAPEAKE BAY

The Virginia Marine Resources Commission has recently approved plans to introduce one million non-native Suminoe oysters (*Crassostrea ariakensis*) to Chesapeake Bay on the U.S. East Coast. This article has been prepared from information in the document (Economic analysis and pilot scale field trials of triploid *C. ariakensis* aquaculture) drawn up in support of this proposal by the Virginia Seafood Council.

A declining industry

The primary aim is to carry out an economic appraisal of the aquaculture of this introduced species. This is part of an attempt to halt the decline in the oyster industry in the two states (Maryland and Virginia) that border Chesapeake Bay. In the 1950s there were almost 200 seafood businesses dealing in native oysters (*Crassostrea virginica*) that were fished from the bay. Today there are only 21, a decline that mirrors the loss of oysters from the area. This has been due mainly to disease, which has exacerbated problems of lack of recruitment and some environmental changes. Various attempts to restore the native oyster population have failed in the light of these difficulties. Diseases kill the vast majority of any seed planted before it reaches market size. Many of the grounds have silted over and would be very difficult to recover. A couple of disease-resistant strains of *C. virginica* are available, but are of limited value, performing moderately in certain areas only. Annual harvests have dropped considerably since the 1950s, when the introduction of non-native oysters initially introduced diseases that ravaged the native *C. virginica* population. The stock is currently estimated to be at only 1% of historical levels.

Pilot studies

The proposals follow research at the Virginia Institute of Marine Science (VIMS) in which triploid Suminoe oyster larvae were reared in the hatchery. Triploid oysters should be sterile and thus unable to recruit naturally in the bay. This species was chosen as it had previously given indications that it has disease resistance. Field trials were conducted at low, medium and high salinity sites between June 1998 and September 1999. At low salinity sites mortality of Suminoe oysters was 14%, compared with 81% for *C. virginica*. At medium and high salinity sites, mortality of *C. ariakensis* was less than 15% compared with the death of all *C. virginica*. Industry field trials carried out in 2000 and 2001, in which over 50,000 triploid seed oysters were reared, gave very promising rates of growth and survival, and a high level of consumer acceptance of the final product. This has led to widespread commercial interest in this species.

Suminoe oysters kept in tanks at Virginia Institute of Marine Science (Photo: Jodi Dew)

Environmental concerns

However, there are significant concerns and objections over the introduction of a non-native species. There is especially a risk of reversion of some cultured oysters to a fertile, diploid state, with the potential for unintentional establishment of populations of this non-native oyster. There are some suggestions that because more disease-resistant oyster populations would produce substantial economic and ecological benefits the intentional establishment of self-sustaining *C. ariakensis* populations should be encouraged. Others, however, argue that such an introduction should not be pursued or risked because of the history of undesirable consequences of many introductions of alien marine organisms.

Triploids

A major feature of the plan is that it will use 100% triploid oysters, produced from crossing normal diploids with newly available tetraploids, rather than triploids induced by chemical methods that do not guarantee 100% polyploidy. Ten participants, all of whom have some experience with growing *C. ariakensis* in the pilot studies, will each receive 100,000 oyster seed from the hatchery at about 20 mm size. These will be grown to market size (9-18 months, depending on growth rate) and an economic appraisal made. A project manager will be appointed to oversee the programme. Four methods of seed deployment will be used. Oysters will mainly be grown in traditional type bags either in cages, on racks or secured on the bottom. The fourth method involves suspending the trays containing the oysters from a raft. The longer-term aim is to re-establish the oyster industry in the area through aquaculture of this introduced oyster, rather than as a managed fishery of the native oyster, as in the past.

Further information

A copy of the report can be found on http://www.mrc.state.va.us/pdf/vsc_economic_analysis.pdf

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AN EVALUATION OF THE LOBSTER FISHERY IN SUSSEX - THE EFFECTIVENESS OF CURRENT STOCK PROTECTION MEASURES

R.W.E Clark (Senior Fishery Officer) and T.M. Dapling (Chief Fishery Officer and Clerk)
Sussex Sea Fisheries District Committee

Introduction

The Sussex Sea Fisheries Committee estimated the value at first sale of lobster (*Homarus gammarus*) landings at about £1 million during 2001, derived from an estimated total annual catch of 60-100 tonnes. This figure is based on inspections and voluntary return data from fishermen within the District. The lobster fishery in Sussex is mostly inshore in nature, that is, not beyond 6 nautical mile limits, with Selsey, Eastbourne and Brighton the most significant fishing stations in terms of quantity of landings. There are 96 (2002 data) registered fishing vessels with valid permits to catch lobsters in Sussex. Due to the diverse local fisheries many permit holders do not solely rely on lobster catches for their primary income, however the species plays a major role in supporting inshore fishing activity, and a reduction in the fishery could have a serious effect on the viability of vessels. Over many years there has been concern on a local and national level that the level of effort required to maintain catches has significantly risen and that this increase in effort is potentially unsustainable. Assessment of effort and catch rates has often been restricted by a lack of reliable data from which trends in the fishery can be established; this is particularly true of the under 10 metre inshore vessel fleet which represents a large proportion of the lobster fishery.

Background

An increase in the minimum legal size for lobster from 85 mm to 87 mm carapace length (CL) was introduced nationally on the 30 June 2000, and the protection of 'V' notched lobsters by means of national legislation

came into force on 17 April 2000. The purpose of these legislative measures was to improve sustainable yields in stocks and counter the adverse effects resulting from an increase in potting effort. The new minimum size legislation allowed more lobsters to reach maturity, and thereby improve stock reproductive potential. Similarly the protection of 'V' notched lobsters is intended to increase the reproductive potential, enhancing the potential yield and compensating for natural mortality. To affect a benefit for stocks both measures require that juvenile recruitment within a stock is limited by egg and juvenile production and not by a factor such as habitat availability. To evaluate these management measures an indication of size at onset of sexual maturity (SAM) and fecundity is required.

Methods

This report looks at the results of two surveys, one in 1999 and the other in 2001, investigating the population structures of the most significant lobster fisheries in Sussex. The data was used to discuss the findings with reference to management techniques available, and the available SAM data. The 1999 and 2001 data describes the results of field-sampling trips undertaken at Eastbourne, Brighton and Selsey, where measurements of the CL of all hauled lobsters were made. The 1999 and 2001 surveys describe the fishable populations of Brighton and Eastbourne before and after an increase in the minimum legal size. Where comparative population structure sampling was undertaken (Eastbourne, 1999 and 2001 and Brighton, 1999 and 2001) a Kolmogorov-Smirnov Goodness-of-Fit Test was used to compare the size frequency distributions of the lobsters and to test for a significant difference between the 1999 and 2001 lobster population structures.

An assessment of the catch per unit effort (CPUE) over the time during which the increase in MLS was introduced is also presented based on data provided from a Selsey fisherman, where monthly landings and pot lift data were made available from 1998 to 2002.

The fishing gear deployed from which comparative lobster samples were measured had not changed in design, and as far as could be established there was no changes in the grounds worked, or the methodology of fishing activity which could have a significant effect on the results.

Results

The summary statistics are shown on the following table.

Station	Brighton		Eastbourne		Selsey
Year	1999	2001	1999	2001	1999
n	384	1012	1098	689	1779
Mean CL.	82.4	82.4	79.1	86.1	77.8
SD	10.15	9.99	10.01	11.86	6.07

At Brighton (Figure 1) there was no significant difference between the 1999 and 2001 lobster population structures (K-S = 0.031, $p<0.05$) whereas at Eastbourne (Figure 2) there was a significant difference (K-S = 0.208, $p<0.01$). Relatively more smaller lobsters and fewer larger lobsters were in the hauled population at Eastbourne in 2001, compared with 1999.

Discussion

The results show considerable variation in the population structure of the fishable lobster stocks within a relatively small geographic range. The results in each instance describe a fishery with high fishing mortality. The Brighton and Eastbourne results indicate marked reduction in lobster numbers into the exploited range but greater survivorship into that range when compared to Selsey (Figure 3), indicating less reliance on the MLS alone to secure reproductive potential. The Brighton data indicated no significant change in length distribution between years. The Eastbourne data reveals a significant change in the frequency distribution between 1999 and 2001. This change is encouraging, as it reveals an increase in relative reproductive potential, especially in light of an observed increase in fishing effort. The results should however be treated with caution due to sampling error associated with unquantified changes in fishing techniques.

At Selsey fishing mortality into the exploited phase is very high. The 1999 data describes 50% of the legal catch in the 85-87 mm CL range, thus a significant initial decline in landings over the date of MLS introduction. The CPUE data (Figure 4) however demonstrated that this catch reduction was not long-term, and based on the previous study estimate of SAM at Selsey to be 82.5 mm CL. the size increase provided for significantly increased reproductive potential. The Selsey results indicate that the use of schemes to increase the biomass of the larger lobsters in the exploited phase (e.g. by V Notching) may be appropriate, and issues of high catchability of lobsters below MLS leading to in-pot mortality of juveniles should be investigated. Physical trauma and in-pot mortality issues can be reduced with the use of escape hatches. High reliance on recruitment only for egg production means the fishery is particularly vulnerable to recruitment failure. Conclusions should however consider egg dispersal patterns, and external recruitment.

These results are significant when considering the effectiveness of the various management techniques, and describe the need for local management solutions for individual population structures that exist in relatively limited sea areas. Sea Fisheries Committees are ideally placed to, and have a tradition of, tailoring fisheries management to local fisheries. When

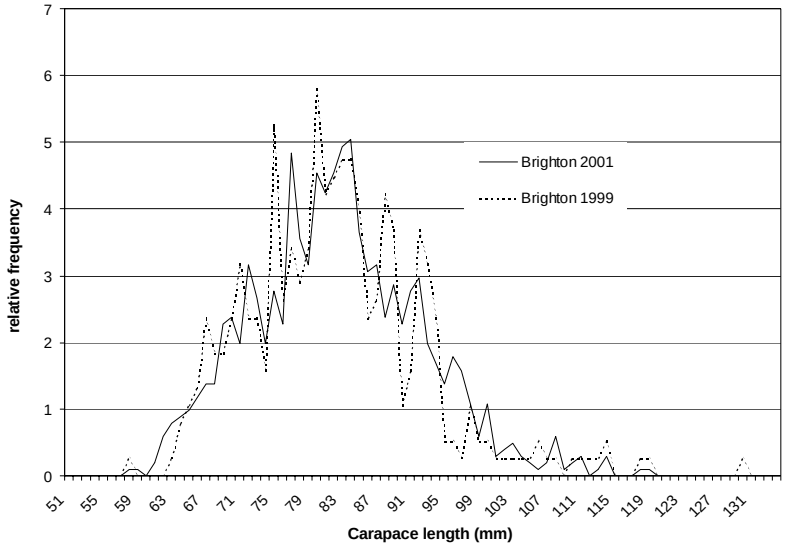

Figure 1. Length frequency distribution of (male and female) lobsters at Brighton in 1999 and 2001

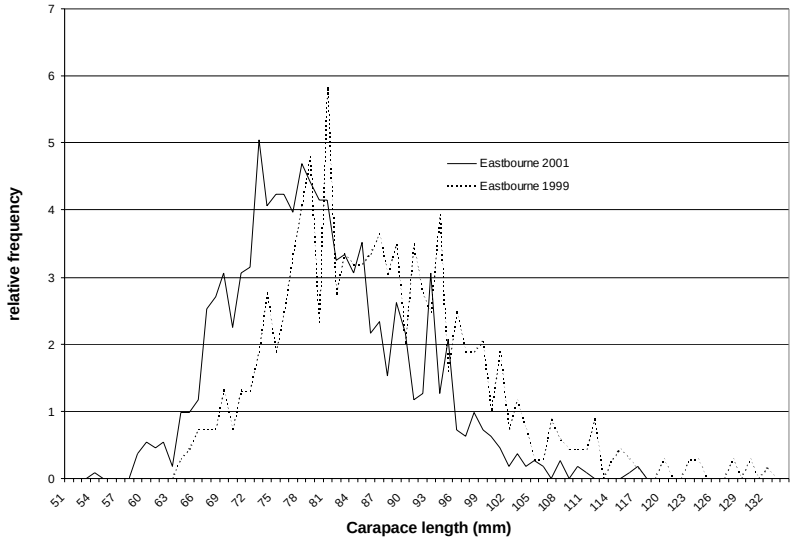

Figure 2. Length frequency distribution of (male and female) lobsters at Eastbourne in 1999 and 2001

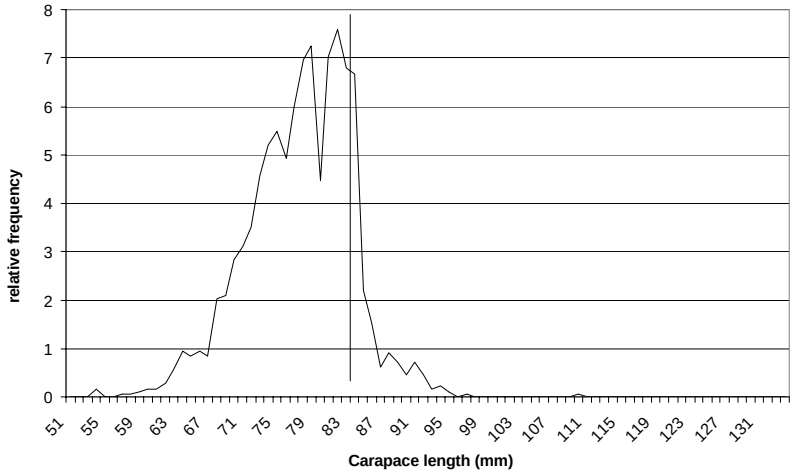

Figure 3. Length frequency distribution of (male and female) lobsters at Selsey in 1999

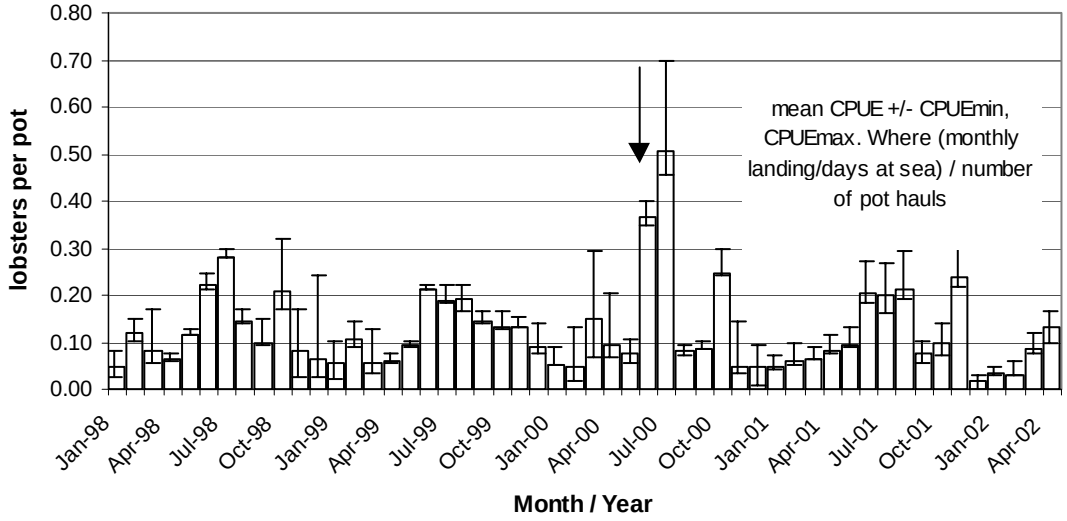

Figure 4. Catch per pot lift at Selsey from January 1998 to April 2002. The arrow represents the introduction of the increased MLS

considering the application of further management tools such as maximum legal sizes, habitat enhancement and ranching an understanding of the population structure is essential to achieve improved fisheries.

Further information

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FRENCH TURN SLIPPER LIMPETS INTO FERTILISER

The problem

The slipper limpet (*Crepidula fornicata*) has proliferated around the coast of Brittany during the last thirty years. The most significant quantities are to be found in the Normand-Breton gulf, where they amount to thousands of tons, in particular in the bays of Saint-Brieuc (250,000 tons) and Cancale (100,000 tons). It is now a significant component of the coastal ecosystems in these areas. The limpets compete for space and food with commercially exploited bivalve mollusc species (scallops and oysters, respectively). They are also spread by and interfere with dredging and trawling activities.

Restoration programme

In order to try to control this problem, a local restoration programme has been initiated. This began to operate last year (2002) and should allow the harvest and the treatment of approximately 200,000 tons of slipper limpets over the next 4 to 5 years, at a rate of 40-50,000 tonnes per year. The aim is to appreciably reduce stocks of slipper limpets at the above locations. Hopefully this will lead to increased recruitment of scallops and oysters.

Industrial exploitation

A 58 m ship (le Côtes-d'Armor) with a hold capacity of 700 m^3, able to extract 500 tons of slipper limpet daily, will be used. This ship, able to work in depths of less than 20 m, is equipped with a 36 m length trailing dredging ladder, connected to a 'hydraulic vacuum cleaner' provided with adjustable shoes, according to the nature of the environment. The unit is designed to have a minimal impact on the marine substrate. The slipper limpets are sorted and then, after washing, transferred into the hold.

As the flesh of the slipper limpet is edible, it was originally proposed that it might form a constituent of the famous 'fruits de mer' plates of seafood. However, this idea was abandoned due to the difficulties and costs associated with removing the meat from the shell. As the shell is composed of calcium carbonate, as used by the Breton farmers to neutralise soil acidity, this alternative use was favoured.

A harvest of slipper limpets (Photo G. Rocher/IFREMER)

The slipper limpets are thus taken to a factory where they are drained, introduced into a rotary drier and then transferred towards a crusher where the whole animals (shell and flesh) are transformed into powder. They are treated in this way within 48 hours following harvest, in order to avoid bacterial degradation. The storage of the finished product is carried out in silos of 2-3,000 m^3. The product obtained, called 'biocarbonate marin' has all the qualities of a traditional calcareous fertiliser.

It has been suggested that the 'biocarbonate marin' could also be used as a food supplement in the poultry industry. Research is also in hand at the Central School of Nantes for the manufacture of bio-mortar made up of concrete and slipper limpet powder, which would be heat resistant to 1,000 degrees.

The future

It is unlikely to be possible to completely eradicate slipper limpets. Future levels of exploitation will therefore need to be set to meet the requirements of both this industry and the fishermen and the oyster cultivators. Uncertainties relating to the ecological impact of such levels of exploitation require scientific study and would justify a follow-up project of the industry and its effects. This work would probably involve IFREMER, who are already co-ordinating a programme looking at the effects of slipper limpets, their interactions with commercial activities in the marine environment and the potential effects of controlling this pest species in 4 coastal areas of France, including the Normand-Breton gulf.

Further information

http://www.ifremer.fr/envlit/actualite/20020515.htm
http://www.ifremer.fr/delec/bb/crepidul.htm

ENVIRONMENTAL IMPACTS OF FRESHWATER PRAWN FARMING IN BANGLADESH

Dr Nesar Ahmed, Department of Fisheries Management, Bangladesh Agricultural University.

Introduction

Bangladesh has very considerable inland waters suitable for the growth of many species of freshwater prawns including *Macrobrachium rosenbergii*. About 23 species of freshwater prawns including 10 species of *Macrobrachium* are available in Bangladesh. However, only *M. rosenbergii* has significant aquaculture potential and is commercially cultured. The freshwater prawn farming sector plays an important role in the economy of Bangladesh, earning valuable foreign exchange and contributing to increased food production, diversifying the economy, increased employment opportunities, and maintaining rural communities. Due to the importance of freshwater prawns as an export product, the government had declared prawn cultivation to be of primary industry status and facilities, and designed a specific support programme to boost production.

Prawn farming in *gher* systems

The cultivation of freshwater prawn in modified rice fields, locally referred to as '*ghers*', has been a recent development in Bangladesh. *Gher* farming is a "quiet, indigenous technological revolution", suitable for the cultivation of prawn, fish and other crops. The practice of prawn farming in *gher* systems is currently found in Southwestern Bangladesh. The Bangla term '*gher*' is an enclosure made for prawn cultivation by modifying rice fields through building higher dikes around the field and excavating a canal several feet deep inside their periphery to retain water during the dry season. *Gher* farming can be considered as a method of combining aquaculture and agriculture on one plot. The principal water sources for *ghers* are rainfall, ground water, and sometimes river water, through canals. During the rainy season the whole water body is used for the cultivation

Harvested freshwater prawn, which are exported to the international market

of prawn and fish. However, when the weather is dry then only the trenches are used for fish and rice is planted in the central plot. At all times of year the dikes can be used for growing vegetables, fruit, wood and fodder. The *ghers* are generally situated in low-lying areas of the floodplain, which are irregular in shape and may be up to 100 hectares in area. The average *gher* size was found to be 0.23 ha, the largest *gher* size was 1.01 ha and the smallest was 0.06 ha.

The peak season of prawn farming is from May to January. Prawn post-larvae are stocked when they become available in May to June and are harvested primarily from November to January. Prawn culture in *ghers* was fully dependent on wild fry, farmers stocked these rather than hatchery produced stock as production of the latter is limited and farmers considered them to be of lower quality. Farmers also mentioned that the survival of wild post-larvae was much higher than that of hatchery-reared post-larvae. The average stocking density of post-larvae was found to be 20,680 ha^{-1} *gher*.

A typical gher for using integrated prawn farming.

Around 87% farmers are involved in rice production, and only 13% farmers could not cultivate rice in their *gher*, due to low production, infertile soil and/or saline water intrusion. In addition, farmers believe that the use of pesticides for rice negatively effects prawn growth.

A range of carp species is cultured with the prawns, but harvested throughout the year. Most (97%) farmers produce fish in their *gher*, only 3% not doing so due to low production of both prawn and fish, and/or considering that fish competes with prawn for feed, space and their limited capital.

A variety of feeds are used but the preferred feed is the freshwater snail, *Pila globosa* (Swainson). However, in the first week of post-larval stocking, 50 g of wheat flour is applied per one thousand post-larvae, and the following week a double quantity is given. When the post-larvae become juveniles the farmers start to apply snail meat. An average 66.5 kg ha^{-1} day^{-1} of snail meat is given during June to October. In general, chopped snail meat is given twice a day in the morning and in the evening.

Farmers harvest their prawns from November to January by using a cast net and barrier net, usually netting several times at a few weeks' interval. Cast nets are generally used for small *ghers* and barrier nets are used for big *ghers*. The first harvest is typically 60% of the stock, the next around 30% and the last about 10%. A few farmers harvest at the rate of 60%, 20%, and 20%. After harvesting farmers grade all head-on prawn by size and weight and sell them to the local markets. The freshwater prawn is a highly valued product for international markets, and therefore almost all prawns are exported particularly to the USA, Japan and Europe.

Environmental impacts of prawn farming

The development of *ghers* for prawn farming has brought about several environmental impacts. The major changes in the environment that have been found include problems with decomposing snail meat, water pollution, damage of drainage systems etc. Environmental impacts associated with freshwater prawn farming are likely to occur in capture fisheries, agriculture, wetland flora and fauna including local snail population. Environmental impacts may arise from - 1) *gher* construction, 2) snail harvesting and 3) wild post-larvae collection.

Gher construction

Large areas of wetlands have been used for *gher* construction. The reduction in wetland areas associated with *gher* construction is likely to have negative impacts. These include reduced wetland biodiversity, reduced fish production, reduced wildlife, loss of local varieties of rice, loss of aquatic plants, decreased soil fertility, increased flood risks due to reduced area, and the near destruction of natural reservoirs. The reduction of wetland habitat also negatively affected the population of the Indian bullfrog *Rana tigrina*, which play an important role in rice farming systems, regarded as the farmers' friend, as they consume large quantities of insects.

Construction of *ghers* has also resulted in a reduction of grazing land for livestock, especially cows and goats. This land is an important habitat for wildlife, and so wildlife and populations of livestock have considerably decreased. Rice production has fallen due to *gher* construction, and decreased rice production has meant decreased availability of paddy straw, used for both cooking fuel and as fodder for cattle. As a result of decreasing cooking fuel and fodder, people began to collect branches and sticks for cooking, and leaves and grasses as fodder for their livestock, more intensively from the smaller remaining area.

Snail harvesting

The freshwater snail *P. globosa* is traditionally and commercially used as prawn feed in Southwestern Bangladesh. The use of this snail meat as prawn feed is widespread in prawn farming areas. Snail populations have declined heavily in this area due to excessive harvesting during the monsoon when the peak season of their reproduction. Snails are now harvested from wetlands and river areas in neighbouring districts. In prawn farming areas, most of canals have become blocked with snail waste and shells due to the use of snail meat as prawn feed. The canals have suffered from abuse and were neglected (i.e. not used for fishing or other purposes), as a result of the dumping of snail shells. The disposal of snail shells after the meat has been extracted poses environmental problem - the smell of rotting snails permeates the air, and the open waterways have become polluted.

Wild prawn post-larvae collection

In Southwestern Bangladesh, many fishing people are involved in prawn post-larvae catching on the Pasur river from Mongla through to Heron Point on the coast during April to June. A huge number of other larvae are caught and discarded, and with unknown mortality effects, may have severe long term impacts on coastal fish, prawn and shrimp populations. There have been

Women and children breaking snails, which are used as prawn feed

significant decreases in *M. rosenbergii* catches in rivers in recent years. Uncontrolled fishing of large freshwater prawns (210 to 250 mm in length) may pose a threat to their natural population. Large-scale collection of post-larvae is likely to affect the recruitment of other riverine species, which migrate to spawn at the same times as *M. rosenbergii*.

Catching wild fry from the coastal area

Conclusions

In Bangladesh, freshwater prawn farming is currently one of the most important sectors of the national economy. However, in recent years there are some concerns about the long-term environmental sustainability due to unplanned construction of *ghers*, over-harvesting of snails and indiscriminately catching of wild fry. It may be necessary to establish local ingredients feed industries and prawn hatcheries for sustainable prawn farming. Hatcheries may reduce the pressure of fry exploitation and increase wild production. Development of a feed based on low-cost locally produced ingredients would reduce the negative environmental consequences of over-harvesting of snails.

Acknowledgements

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Further information

This article is based on:
Nesar Ahmed. 2001. Socio-economic aspects of freshwater prawn culture development in Bangladesh. PhD Thesis, University of Stirling, UK, 320 p. (Dr Nesar Ahmed, Department of Fisheries Management, Bangladesh Agricultural University,. Mymensingh-2202, Bangladesh; E-mail: nesar@royalten.net).

ANNOUNCEMENTS

UK MICROBIOLOGICAL LABORATORIES UNDERTAKING SHELLFISH TESTING

Resolutions of Fifth Meeting

A periodic meeting of laboratories undertaking microbiological testing of bivalve shellfish was held at Whitehall Place, London on 24 September 2002. The group comprised representatives from CEFAS Weymouth (the National Reference Laboratory), the Public Health Laboratory Service, the FRS Marine Laboratory Aberdeen and Belfast City Hospital.

The remit of the group is:

1. To provide, with reference to Council decision 1999/313, a UK technical forum for discussion of issues relating to microbiological testing of shellfish.

2. To agree, where possible, common methods and approaches relating to shellfish testing for use throughout the UK and their quality assurance.

3. To advise the central UK competent authority, and the devolved administrations, of the views of testing laboratories as outlined above.

4. To enable CEFAS Weymouth, as the UK National Reference Laboratory (NRL), to represent the views of UK testing laboratories in the European laboratory framework specified in Council decision 1999/313 and to co-ordinate with UK laboratories initiatives arising at the European level.

The group agreed the following resolutions:

1. The group undertook to produce a conclusion for the attention of the Food Standards Agency on the summary document of the results of the questionnaire sent to shellfish testing laboratories.

2. The group supported the publication in Shellfish News (Number 14, November 2002, pp 26-28) and in Communicable Disease and Public Health of ‘Advice for laboratories undertaking microbiological testing of live bivalve molluscs’.

3. The group supported the proposal to progress consideration of the UK standard method for *E. coli* in shellfish as an additional horizontal ISO method based on detection of acid.

4. The group supported the proposal to place these and future resolutions of the meeting of UK microbiological laboratories undertaking shellfish testing on to the NRL website at www.nrlcefas.org.

5. The group emphasised that laboratories returning results to CEFAS can now do so by electronic means and that instructions to help in this matter will shortly be issued by the NRL.

MORLEY ACTS TO PROTECT SHELLFISH STOCKS

New licensing scheme announced

New restrictions on fishing for shellfish will apply to over 10 metre vessels from 1 January 2004 and to under 10 metre vessels from 1 April 2004. From these dates the facility to fish freely for crabs and lobsters using pots or nets will be restricted to those vessels holding a shellfish entitlement.

To qualify for this entitlement, vessel owners will, in general, be required to demonstrate that the licence attached to their current vessel was attached to a vessel which caught more than 200 kg of lobsters or 750 kg of crabs using pots or nets in any 12 month period between 1 January 1998 and 31 December 2002. At the same time a limit of five lobsters or crawfish and 25 crabs per day is to be set on the quantities that may be landed by licensed fishing vessels which do not qualify for a shellfish entitlement.

Announcing the introduction of a licensing scheme to protect shellfish stocks, Fisheries Minister Elliot Morley said:

"For some time, scientists have been advising us that UK crustacea stocks within British waters are at risk of being exploited beyond their sustainable limit. We told Sea Fisheries Committees, shellfish interests and whitefish industry representatives last October that we would be going ahead with proposals to control effort in the shellfish sector as soon as resources became available."

"I am delighted to announce that we can now proceed immediately and address the large numbers of concerns that have been put to me about the need to protect the shellfish sector from the effects of possible displacement from other types of fishing."

"Given the very constructive and supportive responses to our consultation in early 2001, and their reactions last October, I know the industry will welcome our action."

Further information

Further guidance on eligibility for the scheme and detailed arrangements for applying for licences will be drawn up and announced later. Application forms will be sent to all licence and entitlement holders as soon as they become available.

It is envisaged that only the owners of existing licensed vessels or the holders of licence entitlements will be able to apply for a special authority to fish for lobsters, crawfish, edible crabs, velvet crabs, spider crabs and green crabs. It will be a condition of the licence that all licence holders will have to submit a monthly return of effort and catch. These will be statistically sampled by Defra to develop the data that will be needed when the scheme moves into its control phase.

STRATEGIC FRAMEWORK FOR AQUACULTURE IN SCOTLAND

The Scottish Executive's strategic framework for aquaculture was launched at the 'Sea Change' conference in Dunblane on 24 March 2003.

Deputy Environment and Rural Development Minister Allan Wilson told his audience that Ministers would bring forward legislation governing the aquaculture industry during the next parliamentary session. He also announced annual investment from the Executive of up to £100,000 to support the establishment of a Scottish Aquaculture Research Forum, which would also receive funding from other sources.

The Framework document contains a total of 33 Priorities for Action.

Of direct interest to readers of Shellfish News will be the extract:

"Expansion of the shellfish sector, including diversification of species (both molluscan and crustacean) is to be encouraged in Scotland as an environmentally sensitive activity, with support as appropriate from the relevant planning authorities and development agencies. There is scope for direct community involvement in this sector through investment or participation in small-scale crofting shellfish farming."

Other action points contained in the Framework include:

- *Steps being taken promote aquaculture's economic development* – Federation of Scottish Aquaculture Producers to prepare plan to encourage investment in industry; independent study of regulatory costs on aquaculture businesses undertaken; development of Exports Action Plan.

- *Actions to reduce the environmental impact of aquaculture* – review quality of fish farm environmental impact assessments and develop guidance for developers and regulators on minimum standards; collect environmental data to inform carrying capacity guidelines at local level; encourage companies to commit to environmental management systems; review effectiveness of voluntary sea lice management initiatives.
- *Effects of fish farming on the marine environment* – develop policy on the location/re-location of fish farms; local authorities to develop local guidance zoning the development of aquaculture in coastal areas.
- *Changes to fish farm planning policy* – extend planning authority responsibility to marine fish farming; produce Scottish Planning Policy for fish farming.

Mr Wilson said:
"The launch of this Strategic Framework for Aquaculture highlights our commitment to the development of a sustainable and competitive industry. "This Framework has been produced by various stakeholders, from industry, environmental groups, regulators, finance and retail representatives, and academics. The breadth of interests represented should ensure that this policy is successful and helps aquaculture in Scotland."

"The Framework signals the Scottish Executive's commitment to an aquaculture industry which develops sustainably, and our recognition of the important contribution the industry makes to Scotland's economy, particularly in rural areas."

"The Executive aims to bring forward new, tailor-made legislation for aquaculture, to ensure that regulations governing the industry are fit for their purpose, taking account of economic and environmental concerns."

Further information

The full report is available to read or download (as a pdf file) at http://www.scotland.gov.uk/library5/environment/sfsa-00.asp

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SCOTTISH HARMFUL ALGAL BLOOMS STUDY

The Scottish Environment Protection Agency (SEPA) has published the results of a study it commissioned into the impact of fish farming on harmful algal blooms. The main conclusion from the report is that nutrients (compounds of nitrogen and phosphorus) arising from fish farming have only a small effect on the amount and growth rate of these blooms. However, this should not be a cause for concern except in a few, enriched sea-lochs.

The blooms are groups of naturally occurring species of microscopic algae that form part of plankton (plants and animals that live in the surface layers of the sea.) Some species can lead to toxins in fish and shellfish, making them unfit for humans to eat. They can also kill fish in fish farms by choking their gills or reducing the oxygen content of the water.

The three main concerns raised against the aquaculture industry are that nutrients from fish farms have:

- led to an increased occurrence of algal blooms
- encouraged toxic species to grow in place of harmless species
- made potentially toxic algae more poisonous.

In October 2000 SEPA contracted Professor Paul Tett of Napier University to carry out this review of harmful algal blooms in Scottish waters. SEPA made particular reference to waste inputs from marine fish farms in commissioning this work.

Andy Rosie, SEPA's aquaculture specialist, said: "The review that we commissioned does not support any of these concerns. Professor Tett's report concludes that the levels of nutrients from fish farms alone appear to be too little to have significant effects on, or be the cause of, the perceived changes in algal blooms, except perhaps in a few enriched and poorly flushed sea lochs. However, we do note his comments on the lack of data. This point has also been recognised by the Ministerial working group on aquaculture, which has identified it as a priority for action. "

"Monitoring of our tidal waters has been concentrated around the industrial parts of the Forth and Clyde estuaries, but as fish farming has grown in the remote inlets of the Highlands and Islands, there is a need to increase our data set here to better inform the regulatory process which controls fish farming. This process is already underway with SEPA's programme of audit

monitoring of fish farm sites using purpose-built small survey vessels. “

“Fish farming is just one of many sources of nutrients which promote algal growth. SEPA will study the report carefully and where the review suggests there may be problems, we will look at all of the relevant factors, including aquaculture, to reduce the impact on the environment. We will also continue to restrict development in areas that may be particularly sensitive to increased levels of nutrients in line with the Scottish Executive’s locational guidelines for marine fish farms.”

The main conclusions of the report

- Modelling studies estimate that only a few sea-loch sites are strongly enriched with nutrients to such a level that they might reach or exceed environmental quality standards.
- A lack of historic environmental data over the past 30 years has made it difficult to judge whether the perceived increase in harmful algal blooms (HABs) is real and to link these with any changes, such as the expansion in the fish farming industry.
- The data that does exist does not show conclusively that there has been a wide scale increase in the abundance of organisms responsible for harmful blooms in Scottish waters. However, the number of reported incidents of toxicity (shellfish poisoning) has increased.
- The apparent spread of shellfish poisoning on the west coast and in the Northern Isles could be due to more comprehensive monitoring or as a result of the spread of toxic strains among existing populations of algal species on which shellfish feed. However, there is no evidence that organisms that cause the poisoning are becoming more abundant either at new locations or sites where there is a history of closure of the shellfishery.
- In addition, predictive models appear to indicate that the algal production apparently caused by fish farm nutrients in Scottish coastal areas is small relative to that generated by other nutrients coming in from the Atlantic Ocean or from land runoff.
- There is still much to learn about what controls the balance of organisms within the plankton. However, some types of algal bloom (*Gymnodinium mikimotoi*, *Phaeocystis pouchetii* and toxic flagellates) do seem to be stimulated by nutrient enrichment and increases in the ratio of nitrogen and phosphorus to silicon.
- Fish farm waste has a small impact on nutrient element ratios in most Scottish waters. Similarly there is no convincing evidence that changes in nutrients from fish farms makes potentially toxic species more toxic.

Further information

For more information, including a copy of the full report, visit www.sepa.org.uk/aquaculture/projects/index.htm

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SEAFOOD WEEK 2003: 3-10 OCTOBER

The Sea Fish Industry Authority (Seafish) is calling upon the seafood industry to work together to make Seafood Week 2003 a success – saying that involvement in the annual week is definitely “good for business.”

Last year, Seafood Week captured the nation’s interest. This was achieved by the huge amount of industry support, with over 10,000 different promotions, tastings, events and festivals taking place across the UK. Feedback shows that those taking part saw an increase in sales thanks to the intense marketing and promotional activity which took place during the week.

John Rutherford, chief executive of Seafish is urging the seafood industry to make this year’s event, which starts on October 3, even more spectacular. He explains: “The message we want to send out is that involvement in Seafood Week is clearly good for business, and good for sales. Seafood sales are currently buoyant and initiatives such as this show what can be achieved when a huge variety of players in the industry work together to promote awareness of seafood across the board.”

The theme for Seafood Week 2003 is currently under wraps and will focus on the romantic connotations and the healthy benefits of eating seafood. Seafish will provide promotional advice for all organisations wanting to take part.

Further information

Visit the web site http://www.seafoodweek.co.uk/ or contact Seafish, either by phone, on 0131 524 8646, or via e-mail at seafoodweek@seafish.co.uk.

SCHOOLS' SEAFOOD WEBSITE UNVEILED

A new website is being unveiled to teachers throughout the UK aiming to inform them and their pupils about fish and shellfish and the UK seafood industry. Created by the Sea Fish Industry Authority (Seafish), the site - www.seafish-education.org.uk - contains over a hundred colourful pages dedicated to the wonderful treasures of the sea and coastline.

The site has a wide range of information for primary and secondary schools including a seafood database that contains basic facts and information about seafood - type, availability, processing, preparation, recipes, cooking and nutrition. There are six main resources on the site, The Sea Fish Story; Talking Fish; Fish - a Whole New Product; The Seas Around Us; Food for Thought and Simply Seafood. Each resource contains straightforward teacher notes and pupil activities geared towards Food Technology and Home Economics, however the site is also of interest to those involved in Geography, Science and English.

A Seafish spokesperson says, "The education website is an integral part of Seafish's ongoing activity with schools. It has received excellent reviews for its design, while teachers and pupils have told us it's a great resource, which they find fun and interesting".

The site has lots of animation and visitors can have fun playing with the interactive games such as hangman with a fish twist and Sharkey's quiz.

Seafish has sent out an information postcard about the website to all primary and secondary schools in the UK as well as the specialist education media.

SEAFISH APPOINTS NEW AQUACULTURE OFFICER

The Sea Fish Industry Authority – Seafish – has appointed Martin Syvret as Aquaculture Development Officer (ADO) for England and Wales. Based in Dorset, Martin Syvret joins Seafish's Aquaculture Development Team whose role is to provide advice and assistance to the UK marine aquaculture sector to help ensure that it produces high quality seafood that will satisfy the demands and expectations of the consumer.

After completing an MSc in Aquaculture at Stirling University, Martin began his career working for CEFAS at Conwy and Weymouth. Since then he has worked as a consultant to a biotechnology company and most recently as the Farm and Restaurant Manager at Abbotsbury Oysters Ltd.

In his new role at Seafish he will be the principal contact for England and Wales. The Aquaculture Development Team offers practical advice and support to the marine fish and shellfish cultivation sectors on a range of topics, such as the economics of various production techniques, business and marketing opportunities, as well as identifying other issues that affect the sustainable development of the aquaculture industry.

Dr. Sue Utting, the Development Team Manager, would encourage producers to contact the Development Officers (see below) and discuss how Seafish can be of assistance to them.

Martin Syvret ADO (England & Wales): by e-mail at m_syvret@seafish.co.uk or Tel: 01300 342154.

Craig Burton ADO (Scotland and Northern Ireland): by e-mail at c_burton@seafish.co.uk or Tel: 01397 875402.

RESEARCHERS DISCOVER NEW AQUACULTURE ANTIBIOTIC

After 10 years of research, Galician scientists have discovered a highly effective and non-polluting natural medicine that can be used in aquaculture.

Professors José Luis Sánchez and Ricardo Riguera from Compostela University (UCS) Aquaculture Institute have succeeded in developing the sector's first natural antibiotics. The discovery - which is being patented and is not available to producers yet - is a revolutionary milestone for aquaculture.

The scientists produced the antibiotics from marine bacteria, which they found some months ago while working on a nutrition study with scallop and oyster larvae. They discovered that at certain times the cultures improved and that this improvement occurred when there were certain bacteria present.

At this point, they isolated molecules and were able to synthesise this totally natural medicine that will be used exclusively to fight some of the pathogens that affect

farmed fish and molluscs. At present, the medicines used to combat these diseases are strong pollutants and therefore banned.

In an official statement, UCS says the research findings resulted in five new molecules being patented so that they can be later sold to the public. These products, which are easily degradable, require a dose that is 10 times smaller than is currently used and are extremely effective in combating high levels of mortality in farmed fish and molluscs.

The products are easy to synthesise in the lab without any need to cultivate the bacteria, say the scientists, so the process is quick and cheap. All that remains now is to make the antibiotics available to fish farmers.

NEWS FROM THE TRADE ASSOCIATIONS

SHELLFISH ASSOCIATION OF GREAT BRITAIN (SAGB)

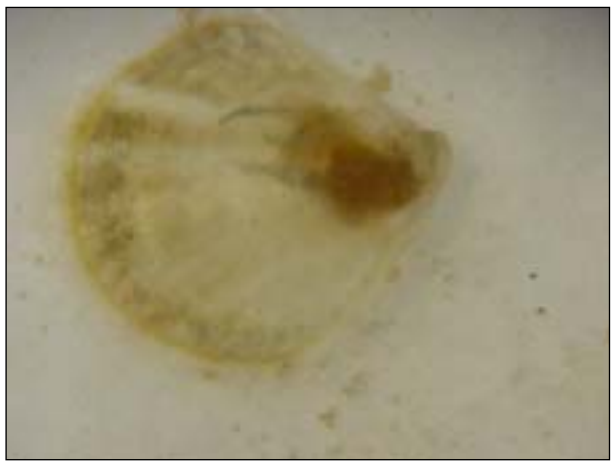
Successful Settlement of Native Oyster Spat

The major project at Southampton University being carried out under the Native Oyster Species Action Plan (NOSAP) has already yielded a very important result which will influence our thinking on the best way to proceed in bringing about an upturn in oyster stocks. For many years now, the two large co-operatives in the Solent, who between them own and manage the Calshot and Stanswood Bay Several Order Fisheries, have laid shell cultch to encourage spatfall. This is potentially the most positive way of enhancing stocks and it does have a long history of use in traditional native oyster fisheries.

The lack of spatfall in the Western Solent in recent years now seems to have spread as far east as the Co-operatives' grounds, and this has cast doubt on the effectiveness of certain types of shell as spat collectors. The problem is that some types of shell which are known to attract oyster larvae and to work well as collectors, such as cockle and mussel shell, are unlikely to remain in place in exposed sites such as the Solent grounds. Scallop shell has been used in recent years, as this has been thought more likely to remain in place. The cupped shells of scallops find a ready market as serving dishes, once they have been thoroughly cleaned. The flat shell does have other established uses, but can still be obtained for use as cultch. Coombe Fisheries of Barnstaple now sell crushed scallop shell, and a coarse grade, with pieces about 1" across, was used last year in the Solent. Some 20 tonnes of shell were laid from a barge. It was hoped that shell pieces of this size would stay in place well on the ground. The cultch was laid in April, to give time for it to acquire a bio-film to encourage spat settlement, but the result has not been encouraging.

Following this experience, considerable doubt began to set in about both the usefulness of scallop flat shell as a collector and about the timing of cultch laying, especially whether it should be laid so early in the year.

In preparation for the experimental work at Southampton, the Association used part of its funding from Defra to commission Seasalter Shellfish to produce a batch of native oysters in their hatchery at Reculver, Kent. This opportunity was used to test the suitability of various shell types for cultch and also to see if new shell, not pre-conditioned by long soaking in seawater would serve in attracting larvae. The result was very clear-cut. Both flat and curved scallop shells from Coombe Fisheries were used as well as pacific oyster shells. At Southampton, Dr. Lawrence Hawkins' team also used cockle and slipper limpet shell.



A 2 week post-set native oyster

The spat settled on all surfaces, with most being on the upper horizontal surface. They have been reared at 20°C on a mixed live algae diet. Survival to date has been good and the Southampton team are now setting up the main experiment, looking at the fitness of the oysters' immune system if retained on cultch and if 'challenged' by being close to live slipper limpets.

Spat settlement on a scallop shell

The first stage of this work has been a very simple and straightforward trial, but it has produced a very clear result that will be of great use for the future.

FSA Valentine's advice enflames oyster lovers

After a year with only one shellfish related public health outbreak reported, and that not attributed to UK oysters, producers and chefs alike were aghast at the FSA's advice in a special Valentine's Day website page warning people not to eat raw oysters.

The Shellfish Association took up the issue with the FSA, who have since agreed to remove the advice. However, an article in the Observer on 23 March said that the FSA was 'sticking to its line', so the Agency's policy is unclear at the present time.

The Shellfish Association does encourage people to try cooked oysters and agrees that this could further reduce the small residual risk of viral infection from oysters. The Association believes that improvements in shellfish water quality, together with better depuration has actually reduced the risks to a random 'residual' level in most producing areas and that oysters from reputable producers are as safe as they can be. They do believe there is room for improvement in operating procedures by the water companies and that HACCP should be put in place in sewage treatment works now that water quality is increasingly dependent on sophisticated treatment plants. A rapid response system should be put in place to notify shellfish producers when systems fail of are overloaded.

The Environment Agency is now into the planning stage for the next 5-year programme of improvements to discharges. The Shellfish Association is trying to assist by pinpointing any identifiable remaining problem areas.

Further information

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ASSOCIATION OF SCOTTISH SHELLFISH GROWERS (ASSG)

VIEWS FROM THE ASSG

'Strategic Framework' for Scottish aquaculture

There must be very few members of the Scottish aquaculture community who are not aware of the SEERAD-led efforts of the past 18 months to create a 'stakeholder' driven 'Strategic Framework for Aquaculture' for Scotland, through a Ministerial Working Group consisting of representatives from all the interested parties. This exercise culminated in the distribution of the final draft on Christmas Eve, for a more comprehensive public consultation exercise.

I hope that all those who had the opportunity to read and comment on that document have done so before the 'closing date' for submissions.

As I understand it, this document is intended to establish the outline constraints for development policy at the start of the process of future aquaculture expansion, ie industry has to develop its own strategies "within the compass of the Strategic Framework". As such, it has both helpful aspects and unsatisfactory elements from the standpoint of the shellfish cultivation sector.

The extensive structure of 'command and control' parameters referring to fin-fish farming gives a security blanket for other users of the marine environment, real or perceived depending on whether or not you believe the industry does cause significant environmental change. However, in my view, (unless there have been substantial changes between the Draft and the Final document) there is a significant downside. This lies in the lack of reference to the specific 'parameters' of the shellfish cultivation environment. These include the minimal references to the FSAS and its classification and control regimes, achievement of Water Framework

Directive objectives, water quality standards for treatment plant and agricultural discharges and Shellfish Waters Designations, all of which are central policy issues for the future development of our sector.

By all appearances the outcome of the Working Group exercise is probably a 'Strategic Framework for Marine Fin Fish Farming' rather than for aquaculture as a whole.

However, it does represent a significant improvement over the previous disjointed situation, where there was an absence of coherence in the 'command and control' structure – so as a first step in the process of rationalising the policy framework for aquaculture, we should welcome the document.

Scallop research

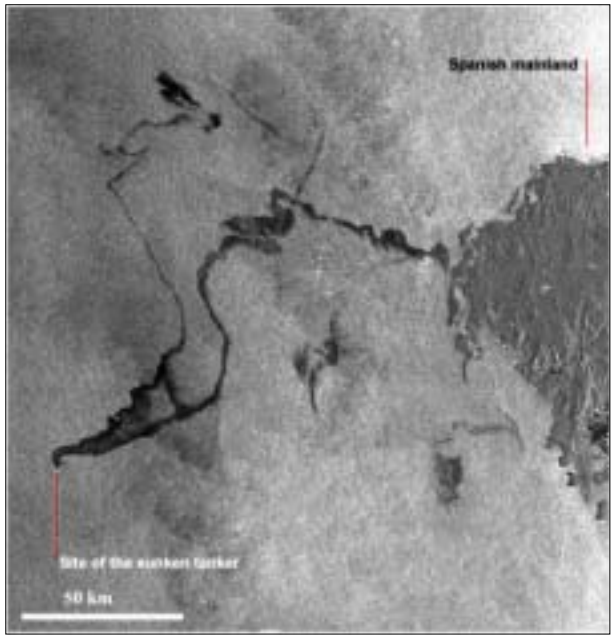
We should also welcome the progress achieved over recent weeks in securing funding for the research study into scallop 'portion size', an essential step in leading to a reconsideration of the introduction of the excessively low level 'Trigger Value' of 4.6 micrograms of ASP for scallop meats. This level threatens to decimate the scallop production sector and render stillborn the embryonic scallop cultivation sector in Scotland. However, some final contributions are still required from some Local Authorities in order to achieve the total funding required for the project, which will carry out consumer research across the restaurant and domestic sectors in the five main European markets for scallops. But I am hopeful that the final elements of the funding will be found within the near future.

Depuration

Proposed changes in depuration plant operating criteria, to ensure removal of bacteriaphage (human/animal bacteria which act more like viruses than *E. coli*) are causing some concern to European shellfish producers. Not only is there significant doubt within the scientific community that bacteriaphage is an appropriate indicator, but a potential requirement for the operation of depuration equipment at temperatures of 20°C, for extended periods of 5 days, sounds close to economic meltdown. The 'European Mollusc Producers Association' (EMPA) is in close liaison with member national associations and sympathetic scientific advisers over the issue, and fully intends to press the case in Brussels with appropriate DG SANCO officials.

Oil pollution

Although we have had our own oil tanker incidents in the UK (the 'Braer' and the 'Sea Empress' immediately come to mind), the current situation relating to the 'Prestige' exhibits a particularly powerful hypnotic horror. This springs partly because of the specific impact upon fellow shellfish farmers in both Spain and France, and partly because of the 'torture' of the continuing pollution – most incidents occur over a short time and are then followed by an extended clean-up and recovery period. This one is characterised by on-going leakage from the sunken wreck.



Satellite image of oil spreading from the stricken tanker 'Presige'

The 'Prestige' situation has also been characterised by reports of official incompetence, high level disagreements and a conspicuous failure of so-called experts' predictions, most notably the claim that the combination of pressure and low temperature in the sunken vessel would virtually solidify and immobilise the heavy fuel oil. Instead, a 'black tide' has continued to ooze from the wreck and encroach on shellfish cultivation operations from Galicia through to the Ile de Re in western France.

The long-term effects of this fuel oil pollution are likely to include positive measures, such as acceleration in the phasing out of single hulled tankers and more efficient and effective anti-pollution planning by the authorities. However, the greatest impacts will probably be negative, such as reduced demand for mussels and oysters, particularly in France and Spain, as consumers fear contamination of these products, as well as forcing a number of shellfish operators to close down permanently. These effects were seen after the 'Erika' pollution incident of a few years ago – even though the tanker foundered off the Atlantic coast, consumption of Mediterranean shellfish declined significantly.

Also, the well publicised effects of the oil on the shellfish, beaches and birds has made the public and the authorities here in Scotland even more aware of the fragility of the coastal zone environment and the ease with which a similar tanker incident could significantly effect the West Coast and the islands.

DSP in Southern France

I hope that those ASSG members who sometimes feel that we are the only industry in Europe who suffer from closures as a result of over-enthusiastic application by the food safety authorities of EU Directives relating to biotoxin events will feel some sympathy for the oyster growers of Leucate in southern France (some 50 kilometres from the Spanish border). The season for oyster sales in France is largely around the 'Festive Season', with the traditional Christmas Dinner and Hogmanay meals enjoying a strong oyster presence, so being closed on account of DSP for most of December has been a significant blow. The growers estimate a financial hit of some 600,000 Euros with Leucate producers left holding 300 tons of oysters in stock with no apparent market for them.

However, in typical French fashion, the relevant public sector organisations (department, region and national) and trade representatives are joining together in the preparation of a rescue plan. This will assist in developing a marketing effort for the Leucate oysters, including an effort to sell the stockpile of oysters into the Spanish market. If only we could enjoy a little more co-ordination along these lines when our industry suffers from 'acts of God' like biotoxin events! Both the 'Prestige' effect and the DSP event will have a negative impact on the market, and as a result I would not be surprised to see lower oyster prices in the spring marketplace across Europe.

Training Exemplar

To finish on a positive note, I recently visited 'The Sound School', a vocational training and education facility in Connecticut, based on the north shore of Long Island Sound, where teenagers were learning a broad spectrum of aquacultural competences, including marine sciences and boating skills. The School is a public high school, offering the usual curriculum of academic subjects, plus courses in the practical aspects of aquaculture, which students from in and around New Haven have elected to study.

Not only do I believe that this is an excellent approach to training a skilled workforce for the aquaculture industry, it introduces the students to aquaculture at a sophisticated level, as well as training them on state-of-the-art equipment. Topics range from biology and

Tim Visel and Carl Harvey of 'The Sound School', with Dr Inke Sunila, with the new school building behind

chemistry through hatchery science, oceanography and navigation to fisheries management and seafood science. Shellfish and finfish pathology is also taught, with a significant and enthusiastic input from Dr Inke Sunila, pathologist with the State of Connecticut, a good example of 'joined up support' for the facility.

The support of the State is clear, as shown by a $34 million investment in the construction of a new facility with classrooms, laboratories, etc, while the enthusiasm and dedication of the teaching staff was equally impressive. I was amazed at the scale of the achievement, for a student population of around 300, and could only reflect that 'The Sound School' appeared to better equipped than most of our Colleges that offer aquaculture qualifications!

With backing like this, its no wonder that the aquaculture industry in Connecticut is one of the more optimistic examples I've come across in recent years! If only we could transfer this level of commitment to Scotland, and deliver high quality training to youngsters, the industry would enjoy a more positive and robust outlook for its future prospects.

Further information

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MONITORING REPORTS

THE MARINE BIOTOXIN MONITORING PROGRAMME FOR ENGLAND AND WALES: 2002-2003

Summary

This report on the progress of the marine biotoxin monitoring programme for England and Wales covers the period April 2002 to March 2003. During this time 534 water samples were analysed from 23 harvesting areas, and 1,529 flesh samples were analysed from 139 sites in 66 harvesting areas. On these samples, a total of 981 tests for PSP, 1,342 tests for DSP and 902 tests for ASP were carried out, giving a total of 3,225 tests undertaken during this period. PSP toxins were found in 8 samples from 2 areas, two samples were above the Maximum Permitted Level (MPL) of 80 µg/100 g, one in the north-east at Holy Island, the other at Salcombe in the South-west. This was the first recorded incidence of PSP in this area, and further investigation showed that toxicity was present in all species harvested in the area until November. DSP tests were positive for 203 samples from 20 areas, the most significant ones again being the Thames (including Pegwell Bay and the Blackwater) the Burry Inlet and the Wash. The other affected areas were Holy Island, Lymington River, Salcombe, Bigbury and Avon, River Dart, Fowey, Fal estuary, Camel estuary, Taw Torridge, Milford Haven, River Dee and Ravenglass. The Thames was affected by closures in several areas from April 2002 through to February 2003. The Burry Inlet cockle fishery had closures in every month except May and November 2002, however new zoning proposals allowed harvesting to take place within areas of the Burry at all times. The Wash was found to be positive during January 2002, and remained closed into March 2002.

ASP toxins (domoic and epi-domoic acid) were found in 10 samples from 7 areas: Holy Island, The Fleet, The Dart, Plymouth, The Fal estuary, Taw/Torridge and Conwy. Concentrations in these samples were below the MPL of 20 µg/g, the highest level (2.77 µg/g) being found in a sample of scallops from Area EC49, landed at Plymouth on 22 July 2002.

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.

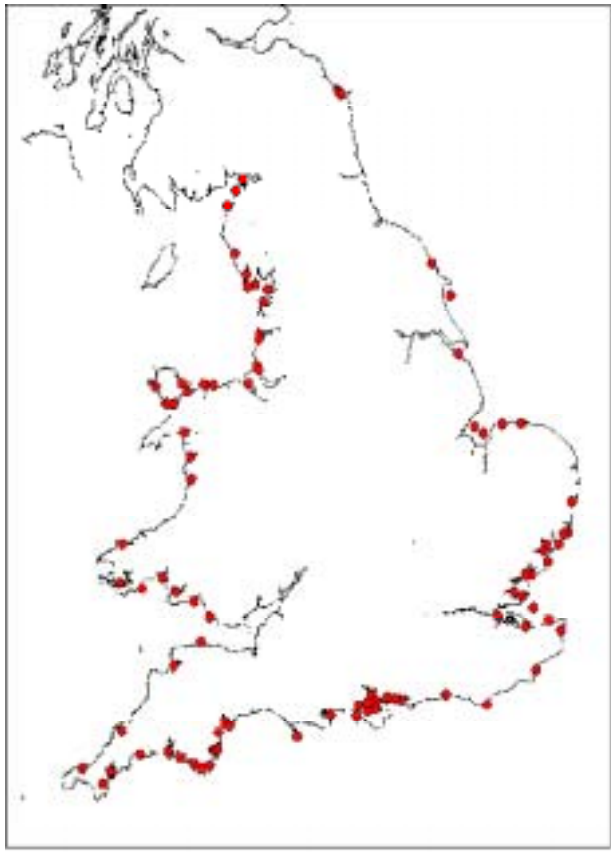

Figure 1. Shellfish Harvesting Areas in England and Wales

Within England and Wales monitoring for algal biotoxins is divided into two programmes, the flesh monitoring programme where samples of commercially harvested shellfish are tested from each harvesting area, and the water monitoring programme where fixed water samples are collected from selected harvesting areas. The monitoring year runs from April to March and wherever possible the flesh and water sampling points correspond with well-defined microbiological sampling points.

The flesh monitoring programme includes all areas in England and Wales where commercial harvesting takes place (Figure 1). Samples are collected on a monthly basis except in areas with a history of PSP in the shellfish or associated toxic algae where samples were collected fortnightly during weeks 14 - 39 (1 April to 28 September). Where MPL are exceeded or positives occur the affected sites continue to be tested on a weekly basis with seven days between samples until two consecutive negatives are obtained.

The water monitoring programme for 2002 - 2003 continued as a rolling programme, where samples were collected from selected shellfish harvesting areas and these included all sites with a history of algal toxicity.

The Food Standards Agency (FSA) as the competent authority has overall responsibility for ensuring that this monitoring programme is effectively carried out, and the CEFAS Weymouth Laboratory is responsible for identifying the sample areas and co-ordinating the programme. The local Food Authorities are responsible for collecting the water and shellfish samples from the designated sites. The samples are then sent to the relevant testing laboratory. For the period this report covers these were the CEFAS Weymouth laboratory for flesh analysis for PSP, DSP and ASP, and the CEFAS Lowestoft laboratory for the water sample analysis.

Where biotoxin MPL's are exceeded, the FSA advises the necessary course of action and the final decision on implementing the decision lies with the relevant Food Authority. The action limits used for water samples and the MPLs used for shellfish samples are listed in Table 1.

Table 1. Action limits and maximum permitted levels (MPL)

Water		Shellfish flesh	
Algal group	Action Limit(cells/l)	Toxin	Maximum Permitted Level
Alexandrium spp.	Presence	PSP	80 µg per 100 g
Dinophysis/ Prorocentrum spp.	100	DSP	Presence
Pseudonitzschia spp.	150,000	ASP	20 µg per g

If water samples exceed the specified action levels, then samples of shellfish within the same harvesting area are collected for biotoxin screening. This occurred in 10 samples for PSP *(Alexandrium*), 23 samples for DSP (*Dinophysiales* and *Prorocentrum*) and 50 samples for ASP (*Pseudo-nitzschia* spp.) during the period April 2002 - March 2003, although none of the follow up flesh samples showed evidence of toxin above the MPL. If MPL's for ASP or PSP toxins are exceeded, 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.

Results of the 2002/2003 sampling programme

Shellfish Collection and Analysis

For the monitoring year commencing 1 April 2002, 66 harvesting sites have been included in the primary shellfish testing programme, and 20 harvesting areas in the primary water testing programme. Additionally, there were 2 ports where samples of scallops were obtained. In total, shellfish from 153 sampling locations were tested in the 66 harvesting areas. During the year a total of 534 water samples have been tested for the presence of potentially toxic algae as part of the water testing programme. The flesh testing programme analysed 1,529 shellfish samples, carrying out 981 flesh tests for Paralytic Shellfish Poison (PSP) 1,342 flesh tests for Diarrhetic/Diarrhoeic Shellfish Poison (DSP) and 902 flesh tests for Amnesic Shellfish Poison (ASP). This gives a total of 3,225 test results for shellfish samples in the year, an increase of 508 from the previous year. Positive areas are shown in Figure 2.

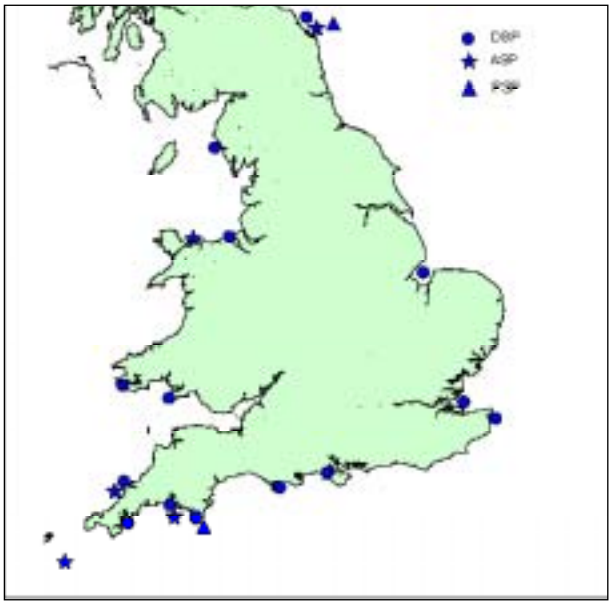

Figure 2. Algal biotoxins detected in shellfish flesh in England and Wales during 2002 - 2003

Summary of Algal Biotoxin Toxicity in Shellfish

PSP Results

A total of 981 tests for PSP have been carried out during this monitoring year, an increase of 205 over the previous year. PSP toxicity was detected in 12 samples of shellfish from 2 areas: Salcombe estuary in the South-west of England and Holy Island in the North-east of England. PSP has been identified at Holy Island for many years, but this was the first recorded toxicity in shellfish from Salcombe (a new sampling site added in 2001), and the toxicity occurred in cockles, Pacific oysters and scallops from July through to November. The highest level detected was 101 ugSTX/100g in a sample of cockles from Salcombe in South Devon collected in August. The only other sample to be above the MPL was a sample of mussels collected in May from Holy Island. Warning notices were posted at both

sites and voluntary closures were observed until the toxicity passed. *Alexandrium* sp. were found in water samples from 5 sites during July, August and September, but no associated toxicity was detected within shellfish from these areas.

DSP Results

A total of 1,342 tests for DSP were carried out this monitoring year, an increase of 169 over the previous year. Toxicity was detected in 203 samples from 20 areas, showing a small increase in prevalence over the previous year, the earliest detection occurred at the start of the monitoring programme in April, and continued throughout the year. The prevailing number of positives were in cockles as in the previous year and were not caused by known DSP toxins and were atypical, these atypical positives were also found in mussels and oysters but in much lower numbers. The Holy Island site on the NE coast of Northumberland was the only location exhibiting typical DSP toxicity. DSP was detected at this site during the period from August to October, and shellfish from here were found to contain not only okadaic acid but also pectenotoxin, the first time these two toxins have been co-extracted from this site.

Over the last year the atypical DSP closures caused a significant effect on three areas in particular: the Burry inlet, the Thames estuary and the Wash. The Burry having closures in place in every month except May and November, and the Thames being affected throughout the monitoring year. The Wash was affected by closures in every month except September, October and February. Closures in all of these three areas were ameliorated compared with 2001 by the introduction of zones within each of the harvesting areas.

Although there have been a large number of atypical DSP positives, these have occurred in only 19 of the 66 harvesting areas tested, despite monthly sampling of shellfish from all 139 sites. Of particular note is that where these positives have occurred they have an incidence of 35% in cockles, and only 1% in other species.

In contrast to the high number of flesh samples which were positive for toxicity, there were only 23 water samples in which algae associated with DSP were identified. The highest levels were recorded off Blyth in Northumberland during July when a count of 5,500 cells/l was recorded, this event preceded DSP toxicity in shellfish from this area in August.

ASP Results

A total of 902 tests for ASP have been carried out so far this monitoring year an increase of 134 over the previous year. Toxicity was detected in 10 samples from 7 areas (Holy Island, The Fleet, The Dart, Plymouth, The Fal estuary, Taw/Torridge and Conwy). However, none of the samples exceeded the MPL for ASP. The highest level recorded was 2.7 µg/g in whole scallops from EC49 (off the SW coast) landed at Plymouth. Again, the majority of samples where ASP was detected were whole scallop samples (54% of ASP positives). Cells of *Pseudo-nitzschia* spp., the organism responsible for ASP, were found in 50 water samples at levels up to 80,000 cells/litre, below the action limit.

THE MARINE BIOTOXIN MONITORING PROGRAMMES FOR SCOTLAND: 2002-2003

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Introduction

Fisheries Research Services (FRS) has conducted an extensive monitoring and surveillance programme for marine biotoxins in bivalve mollusc flesh in Scotland since 1991, and for the causative phytoplankton since 1995. The monitoring programmes are operated to comply with the requirements of the shellfish hygiene directive, 91/492/EEC, and with the current UK implementing legislation, The Food Safety (Fishery Products and Live Shellfish) (Hygiene) Regulations 1998, as amended. The programmes are undertaken on behalf of the Food Standards Agency (Scotland) (FSAS).

Marine biotoxins are produced by certain species of phytoplankton and can accumulate in the tissues of filter feeding bivalve molluscs. The toxins pose a health hazard to human consumers, and the monitoring programmes are designed to ensure that no potentially hazardous shellfish are placed on the market for human consumption.

The monitoring is carried out on bivalve mollusc samples from classified harvesting areas, and from offshore scallop fishing grounds. The sampling frequency is based on a risk assessment of each site and fishing area, and takes account of the shellfish production and the historical occurrence of toxins.

Samples are taken from sites around Scotland throughout the year, but more frequently during the spring, summer and early autumn, and less often during the winter. Sampling frequency at individual sites is normally increased if toxins are detected; species other than bivalve molluscs may be tested.

During the period 1 April 2002 to 14 March 2003, 363 water samples were analysed from 14 inshore sites around Scotland, and 97 samples from offshore scallop fishing areas for the presence of toxin producing phytoplankton. A total of 5,059 shellfish samples were analysed, of which, 1,581 were analysed for Paralytic Shellfish Poisons (PSP), 864 for Diarrhetic Shellfish Poisons (DSP), and 2,614 for Amnesic Shellfish Poisons (ASP).

A further 649 samples were analysed for DSP by liquid chromatography – mass spectroscopy (LC-MS).

Results of the 2002 – 2003 Monitoring Programmes

Phytoplankton

The recorded levels of toxin producing dinoflagellates were much reduced this year when compared to previous years. The maximum numbers of *Alexandrium* spp. recorded was 600 cells.l^{-1} at Scapa Bay in Orkney, compared with a more usual 2,000 cells.l^{-1} recorded from the same location in 2001. Similarly, the maximum number of *Dinophysis* spp. recorded was 1,600 cells.l^{-1} at Stonehaven during August 2002, which contrasts to a maximum number of 33,000 recorded from Loch Inchard during 2001. In contrast, the maximum number of *Pseudo-nitzschia* spp recorded during 2002 (1 million cells.l^{-1} from Loch Spelve) was much greater then levels recorded in 2001.

One hundred samples were analysed using transmission electron microscopy (TEM) so as to identify *Pseudo-nitzschia* cells to species level. Nine species were recorded: *P. americana*, *P. australis*, *P.* cf. *delicatissima*, P. *fraudulenta*, *P.* cf. *heimii*, *P. multiseries*, *P. pungens*, *P.* cf. *pseudodelicatissima*, and *P. seriata.* With the exception of *P. americana* and *P.* cf. *heimii*, the species observed are potential ASP toxin producers. However, no experiments were performed to examine if any of these species taken from Scottish waters were producing the ASP toxins.

Shellfish

Inshore Harvesting Areas

The incidence of PSP toxins this year, was one of the lowest on record. Although PSP toxins were recorded at St Abbs on the east coast site, in Busta Voe and Vaila Sound in Shetland, and at nine west coast sites including Loch Dunvegan, Loch Harport, Loch Greshornish, Loch Spelve and Loch Scridain, the aquaculture sector was not badly affected. Only two samples were found to be above the action level of 80 μgSTX/100g tissue and only two harvesting areas, Loch Eishort in Skye (100 μgSTX/100g tissue) and Loch Hourn (98 μgSTX/100g tissue) were closed in June and July. The toxins were found mainly in mussels, but one scallop sample and two Pacific oyster samples both contained low toxin concentrations.

Following the general trend of recent years, DSP toxins again proved the more troublesome. They were first detected early in May, and at some sites were contemporaneous with PSP toxins. DSP was first detected on the west coast in Loch Eishort in May, followed in June at Loch Dunvegan, Loch Greshornish, Scalpay, and Loch Hourn, and at St Abbs and in the Dornoch Firth on the east coast. By July, further sites in Skye, sites on the north–west coast at Loch Laxford and Loch Inchard, and in Loch Fyne and Loch Striven were affected. Other sites in Loch Scridain, Loch Spelve, in Shetland and in the Western Isles were affected later in the summer. DSP was also detected in Lamlash Bay in the Clyde in November and December. Samples shown positive by bioassay were confirmed by LC-MS, and the maximum levels of DSP toxins found in the different areas are shown below.

Table 1. Maximum levels of DSP toxins found by LC–MS

Area	Species	Okadaic acid μgOA/g tissue	DTX-1	DTX-2
St Abbs	Mussels	0.06		
Dornoch Firth	Mussels			
Ronas Voe	Mussels	0.22	Present	
Loch Laxford	Mussels	0.22	Present	Present
Loch Inchard	Mussels	0.13		Present
Kylesku	Mussels	0.77	Present	Present
Loch Dunvegan	Mussels	0.19	Present	Present
Loch Greshornish	Mussels	LOD	Present	Present
Loch Harport	Mussels	0.27	Present	Present
Loch Bracadale	Mussels	0.19		Present
Loch Eishort	Mussels	0.15	Present	Present
Loch Hourn	Mussels	0.16	Present	Present
Scalpay	Mussels	0.26		Present
Loch Scridain	Mussels	0.16		Present
Loch Fyne	Mussels	0.43	Present	
Loch Striven	Mussels	0.29	Present	Present
Lamlash Bay	Mussels	LOD		Present

Note: LOD = Limit of detection. Specific concentrations of DTX were not reported.

The primary species affected was mussels, but queens, *Chlamys opercularis* were affected in two areas, and Pacific oysters in one area.

The FSAS implemented harvesting restrictions and Voluntary Closure Agreements (VCAs) where appropriate. The closures remained in force until samples tested clear of the toxins; in the majority of cases closures lasted for periods of four to six weeks, but some closures lasted for up to seven months. These extended closures were the result of a failure by the aquaculture sector to provide further samples for testing.

At inshore aquaculture sites, ASP did not pose any problems, except in two areas, Loch Ewe and the Kyle – East Skye region, where scallops were farmed. Low levels of domoic acid were found in a variety of bivalve molluscs, including mussels, queens, Pacific and Native oysters, cockles and surf clams all around the Scottish coast throughout the year. The maximum level found in mussels was 13 μgDA/g tissue, at Dales Voe, Shetland in September; in Pacific oysters it was 10 μgDA/g tissue, in Loch Moidart during July, and in queens was 7 μgDA/g tissue, during July in Broadford Bay. Levels in all other species were at the limit of detection.

Harvesting restrictions were imposed as necessary, but in cases where whole scallops were affected, if gonad and adductor muscle tissue levels were below the regulatory limit of 20 μg DA/g tissue, FSAS allowed shucked and processed material to be placed on the market.

Offshore Scallop Grounds

During the year, monitoring detected all three of the toxin groups in scallops from offshore fishing areas. PSP toxins in whole scallops, above 80 μgSTX/100g tissue were found in the waters around Orkney, in the Moray Firth and in the North Minch from May to September. The highest levels recorded being 247 μgSTX/100g tissue in the Moray Firth and 111 μgSTX/100g tissue in the North Minch in July, and 115 μgSTX/100g tissue in Scapa Flow in May. Toxin concentrations below the action level were found in gonad tissue, and in whole scallops in the same areas, and in the Sound of Jura and off the east coast throughout the year. Levels ranged from 29 to 77 μgSTX/100g.

Positive DSP results from whole scallops were found in the Moray Firth in July, and in Shetland waters in September and October, when tested by bioassay. However, subsequent chemical assays found no trace of the specific DSP toxins in those from Shetland, but the Moray Firth samples showed traces of okadaic acid and both DTX-1 and DTX-2.

ASP toxins continued to cause problems in scallop fisheries, and were detected continually throughout 2002, and early 2003.The toxins affected all major scallop fishing grounds during the course of the year. Scallop samples were obtained on a regular basis throughout the year from al grounds by fishing vessels specifically chartered for this task by the FSAS. Of the scallop samples analysed, 88% of gonad tissue samples had a toxin content of <20 μgDA/g tissue, while 12% had >20 μgDA/g tissue Of the whole animal samples, 19% had <20 μgDA/g tissue, 38% had between 20 and 99 μgDA/g tissue, and 43% had >100 μgDA/g tissue. The maximum and minimum levels of domoic acid found in whole scallops and in gonad tissue from each of the main fishing areas is shown below.

FSAS imposed fishery closures under the Food and Environment Protection Act 1985, in areas affected by PSP, and where ASP toxins in scallops' gonad tissue exceeded the permitted level of 20μgDA/g tissue. In areas where ASP toxins in gonad tissue were below this level, but the total toxin loading in the whole animal was above it, then a requirement was imposed that scallops harvested from such areas must be processed before being placed on the market for human consumption. These restrictions were revoked whenever levels fell below the permitted limit. At the time of writing, mid-March, no areas are currently closed by FEPA Order, but shucking/processing requirements are in place for 105 whole or part boxes.

Table 2. Maximum and minimum levels of domoic acid found in scallops

Area	Gonad – max. μgDA/g tissue	Gonad – min. μgDA/g tissue	Whole – max. μgDA/g tissue	Whole –min. μgDA/g tissue
East Coast	6	3	134	3
Moray Firth	17	3	334	3
Orkney	140	3	537	3
Shetland	20	3	160	3
North Minch	89	3	460	3
South Minch	47	3	646	16
Hebrides	40	3	532	18
Sound of Jura	45	3	449	14
Clyde	4	3	54	3

Acknowledgements

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Further Information

The Food Standards Agency (Scotland) will publish a summary of the annual reports for the Shellfish and Phytoplankton Monitoring Programmes in Scotland on their web site later in 2003, and full reports will also be available on request from the FSAS for a small administration fee.

THE 2002 BONAMIA AND MARTEILIA SAMPLING PROGRAMME IN THE UK

Ian Laing, CEFAS Weymouth Laboratory

Introduction

A programme of sampling and testing of samples of native oysters from fisheries and farm sites around the UK has been carried out since 1993 in support of the application for approved zone status in respect of the two oyster diseases Bonamiosis and Marteiliosis (EU Directive 91/67). In 2002 (Commission Decision 2002/300/EC) the UK achieved approved zone status for the whole coastline for *Marteilia* and approved zone status for the whole coastline for *Bonamia* except in the three restricted areas where the disease is found. These areas are (1) from the Lizard to Start Point; (2) from Portland Bill to Selsey Bill and (3) from Shoeburyness to Felixstowe.

Approved zone status enables us to operate import controls aimed at preventing the introduction of these diseases from elsewhere in the EU, where they are known to occur, or where no sampling and testing is carried out. Movements within the UK are also controlled according to the health status of these areas. Anyone wishing to deposit or relay molluscan shellfish taken from the controlled (restricted) areas listed above must apply for permission to the Fish Health Inspectorate at the CEFAS Weymouth Laboratory (for England and Wales) or the Fisheries Research Services at the Marine Labroatory, Aberdeen (in Scotland). Addresses are at the back of this issue of Shellfish News.

Sampling results for England and Wales in 2002

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 2002. 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 2002. 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 2002 are compared with those for the previous 4 years. The level of *Bonamia* infection remains generally low, and results for 2002 appeared to be slightly lower than in previous years. The average for all the sampled farm sites was 12.8% of oysters infected, compared with 21.30% the previous year and 16.96% in 2000. The average for all the fishery sites sampled was 2.90%, compared with 4.99% the previous year and a 10-year average of 4.32%. The disease has not spread outside of the restricted areas in which it has been recorded in previous years.

Table 1. Summary of results of native oyster sampling in England and Wales for Bonamia 1998-2002

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**	
Year	Sites	% infected (range)	Sites	% infected (range)	Sites	% infected (range)	Sites	% infected (range)
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
2001	11	0-30	22	0-26	15	0-60	5	0
2002	11	0-10	23	0-29	12	0-46	6	0

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

Sampling results for Scotland in 2002

All 8 farms sites holding native oysters in Scotland were sampled and tested twice (spring and autumn) for *Bonamia* and *Marteilia* (30 oyster sample in each case). All tests confirmed the absence of these disease organisms.

Further information

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 action to limit the spread of disease and minimise economic losses to the industry.

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 larvae

Cryopreservation of shellfish embryos allows for gene bank establishment and manipulation of spawning programs, as well as the potential for supplying a regular and reliable supply of animal material for bioassays for aquatic toxicological testing. Various conditions were examined in an attempt to develop a stepwise cryopreservation technique for larvae of the pacific oyster, *Crassostrea gigas*.

Initially, larvae at 9, 12, 15, 18 and 21 h after fertilisation were cooled at a rate of 1°C per minute (seeding at -8°C for 15 min). They were then plunged into liquid nitrogen at -35 or -40 °C using 1.5-M dimethyl sulfoxide (DMSO) and 250 mM trehalose as cryoprotectants. Larvae cryopreserved 15 h after fertilisation (equivalent to the trochophore stage before formation of the shell gland) showed the highest motility and the best external appearance after thawing.

Trochophore larvae were cryopreserved in media containing different dilutions (1/4, 1/6, 1/8, 1/10 and 1/30) of seawater. Larvae preserved in the 1/4 dilution seawater medium gave the highest number of shelled larvae 4 days after thawing.

Trochophore larvae reared in seawater at 21, 25 or 29°C were cryopreserved using the above methods and then stored for 8 months before thawing and rearing at 26°C. Larvae reared at 21°C prior to cryopreservation showed the highest survival rate and percentage of normal larvae up to day 4 after thawing. However, larvae reared initially at 25°C gave better results at day 6 after thawing. One larva from the 25°C treatment was reared through to settlement.

Reference

USUKI, H. (usuki@fra.affrc.go.jp), HAMAGUCHI, M., ISHIOKA, H., 2002. Effects of developmental stage, seawater concentration and rearing temperature on cryopreservation of Pacific oyster *Crassostrea gigas* larvae. Fisheries Science Vol 68, pp 757-762.

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2. Identifying pathogenic Vibrios

French mollusc production is based mainly on the Pacific cupped oyster, *Crassostrea gigas*. Since 1991, mass mortality of juveniles has been reported every year, during the summer months. These recurring episodes concern professionals who fear that, like the Portugese oyster before it, *C. gigas* could in turn disappear following one of these epizooties.

Previous bacteriological analysis of moribund oyster juveniles yielded an isolate of a *Vibrio splendidus* biovar H strain, named TNEMF6. This isolate was demonstrated to be pathogenic to *Crassostrea gigas* spat by experimental challenge. To study the association between summer oyster mortality and presence of TNEMF6 cluster strains, Vibrios were isolated from infected spat along the French Atlantic coast between 1997-1998. Strains related to *V. splendidus* biovar II were selected. Comparisons with the strain TNEMF6 were made using various biochemical and molecular biological methods. Only one strain out of the 14 selected, named TNNIII7, was found to be closely related to the pathogenic bacteria.

None of the markers used in this study were able to distinguish pathogenic from non-pathogenic strains of the widespread *V. splendidus*. However, it is believed that future genetic comparisons of TNEMF6 and TNNIII7 are likely to reveal genes involved in pathogenicity.

Reference

Le Roux, F. (fleroux@ifremer.fr), Gay, M., Lambert, C., Waechter, M., Poubalanne, S., Chollet, B., Nicolas, J.L., Berthe, F., 2002. Comparative analysis of *Vibrio splendidus*-related strains isolated during *Crassostrea gigas* mortality events. Aquatic Living Resources Vol 15, pp 251-258.

3. Anti-bacterial agents for oyster larvae

Eight antimicrobial compounds were examined to evaluate their therapeutic effects against experimentally or naturally induced vibriosis in larvae of the pacific oyster *Crassostrea gigas*.

In experimental infections with a strain of *Vibrio splendidus* biovar II, a causative agent of bacillary necrosis of cultured triploid oyster larvae, chloramphenicol exhibited complete protection against challenges at 10^5 or 10^6 Colony Forming Units per ml. Erythromycin, novobiocin, gentamicin and streptomycin gave reduced mortality, but nalidixic acid and oxytetracycline had no effect. Chloramphenicol and Erythromycin were also highly effective against experimental infections with six other strains of Vibrio species that had been isolated from oyster larvae or rearing water, but novobiocin and streptomycin were less effective in these cases.

Chloramphenicol, erythromycin, novobiocin and streptomycin all gave enhanced protection against natural infections.

Reference

Matsubara, D. (matubara@hiroshima-pffa.or.jp), Tanaka, M., Soumyou, Y., Hirakawa, K., Doi, R.J., Nakai, T., 2002. Therapeutic effects of antimicrobial compounds against bacillary necrosis of larval pacific oyster. Fish Pathology Vol 37, pp 183-188.

4. Fitness test for oysters

A new tool, designed to measure the adductor muscle strength in juvenile pacific oysters, is described in this paper. This instrument has been used to demonstrate relationships between muscle strength and (shell-free) dry weight, shell length and width, and diameters of the opaque and translucent portions of the adductor muscle.

The results have also established a link between muscle strength and summer mortality in juvenile oysters. The relationship between muscle strength and dry weight was linear in healthy oyster samples. It was not linear, or correlation coefficient was lower, in samples presenting high mortality. During a 3-year survey in the Bay of Morlaix, France, more than 40 different stocks of oysters were tested with this tool, which can be used for the diagnosis of healthy, resistant juveniles and recognition of weak specimens.

Reference

Poulet, S.A. (poulet@sb-roscoff.fr), Lennon, J.F., Plouvenez, F., Jalabert, F., Correc, G., Cueff, A., Lacoste, A., 2003. A nondestructive tool for the measurement of muscle strength in juvenile oysters *Crassostrea gigas*. Aquaculture Vol 217, pp 49-60.

5. Pacific and Portuguese oysters - a comparison (1)

At present, the existence of natural populations of the Portuguese oyster *C. angulata* in the north Atlantic would appear to be limited to the Spanish and Portuguese coasts. All the taxonomic studies comparing this oyster with the pacific oyster, *C. gigas*, consider these two taxa as belonging to the same species. Indeed, morphological studies made on the larval or adult stages show no difference between the two. Earlier genetic studies also showed a very close proximity of the two taxa. However, recent work revealed significant genetic differences between these cupped oysters both in the mitochondrial genome and in the nuclear genome. It also supported the hypothesis of the introduction of *C. angulata* from Asia (and more precisely Taiwan) to the Portuguese coast during the 16th century.

Various studies have compared the Portuguese and Pacific oysters in terms of their yield in the natural environment. The overall results of these studies established that growth of the Pacific oyster is twice that of the Portuguese oyster. Other experiments showed that the Pacific oyster had higher clearance and oxygen consumption rates than the Portuguese oyster. Nevertheless, it would appear that until now, no study has been published that would allow a comparison of the scope for growth between these two taxa.

Spat were obtained by crossing parent oysters that had been previously identified using a diagnostic mitochondrial genome marker. Thus, two pure offspring lines were obtained by crossing within *C. angulata* parents or *C. gigas* parents. Two other progenies were produced by hybrid crossing of *C. gigas* females with *C. angulata* males and *C. angulata* females with *C. gigas* males. Individual physiological measurements of 35 animals from each brood were carried out at 19±1 °C. The oysters were fed *Skeletonema costatum*. The means of clearance and oxygen consumption rates obtained from continuous data recording over 3 h did not reveal differences between the four lines. However, the feeding time activity results showed significant differences. The average feeding time activity of the pure Portuguese oysters was 73%, which was significantly lower than that for the other three broods (85-89%) This could account for observed differences in growth.

Reference

Haure J. (jhaure@ifremer.fr), Huvet, A., Palvadeau, H., Nourry, M., Penisson, C., Martin, J.L.Y., Boudry, P., 2003. Feeding and respiratory time activities in the cupped oysters

Crassostrea gigas, Crassostrea angulata and their hybrids. Aquaculture Vol 218, pp 539-551.

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6. Pacific and Portuguese oysters - a comparison (2)

A comparative study of the pacific (*Crassostrea gigas*) and Portuguese (*C. angulata*) oysters and their hybrids was carried out, under normal farming conditions. The oysters were reared in the Marennes-Oleron Sound (France), Growth, survival and reproduction, three major consideration for oyster farmers, were measured. On the whole, *C. gigas* of French origin gave the best results. However, several episodes of severe *C. gigas* mortality have been observed in France in recent years, indicating that this species might not be entirely suitable for sustained oyster farming in this country. This is why these alternatives are being investigated.

Four populations were examined (*C. gigas*: Japan and France; *C. angulata*: Taiwan and Spain) and each of these were used as parents to produce six different batches of spat, under common hatchery and nursery conditions. The seed oysters were transferred at 5-6 g to the on-growing site and reared in bags for 2 years. Mortality profiles differed greatly among the progenies. The *C. angulata* progeny of Taiwanese origin gave the poorest results, with 100% mortality during the second year. For the entire rearing period, the highest yield (+22%) was obtained with the *C. gigas* progeny of French origin. The sexual maturation index, lipid cycles and dry weight loss after spawning showed that spawning of *C. angulata* was delayed by about two weeks compared to that of *C. gigas*. For the hybrids, growth and reproductive characteristics were clearly related to the strain of maternal oysters used.

Reference

SOLETCHNIK, P. (patrick.soletchnik@ifremer.fr), HUVET, A., LE MOINE, O., RAZET, D., GEAIRON, P., FAURY, N., GOULLETQUER, P., BOUDRY, P., 2002. A comparative field study of growth, survival and reproduction of *Crassostrea gigas, C. angulata* and their hybrids. Aquatic Living Resources Vol 15, pp 243-250.

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7. Female oysters better than males

If the sexes are found to display asynchronous rates of growth and condition then the manipulation of sex ratio may be a means by which commercial oyster farmers can increase the performance of their stock, and thus their profitability. The recent conclusion that the sex ratio of Pacific oysters is predominantly under genetic rather than environmental control introduces the possibility of manipulating sex ratio for commercial gain in this respect. Comparative data were collected that show that the growth rate and condition of female pacific oysters is superior to that of males.

Pacific oysters (*Crassostrea gigas*) were cultured intertidally in Smoky Bay, South Australia. The observations, made over the 7-month gametogenic cycle from August to February, to ensure no sex reversal, were of growth rates of male and female oysters and ambient chlorophyll a concentrations. Mean shell growth of female oysters was significantly faster than that of males (4.5 compared with 3.8 μm per day per mm total length). Female oysters were consistently heavier, reaching a mean final total weight of 86.5 g, compared with 73.1 g for the males (from an initial 30 g).

Sex-specific asymmetries in length and weight were generally significant and increased in magnitude during the 7-month study period, suggesting potential commercial benefits from increasing the proportion of cultured female oysters. The fastest increase in the sex-specific disparity in growth and condition came after the October chlorophyll a peak, suggesting that females utilise blooms more efficiently than males. This means of increasing oyster growth would give a 18% gain, which compares favourably with other methods currently used (e.g. triploidy, which can provide growth gains of 13-51%).

Reference

BAGHURST, B.C. (ben.baghurst@flinders.edu.au), MITCHELL, J.G., 2002. Sex-specific growth and condition of the Pacific oyster (*Crassostrea gigas* Thunberg). Aquaculture Research Vol 33, pp 1253-1263.

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8. Stocking density of pacific oysters

Effects of stocking density on changes of total mass and tissue mass of the Pacific oyster (*Crassostrea gigas*) were examined at Port Stephens, an estuary 250 km north of Sydney (eastern Australia).

Three stocking densities were tested. The lowest (80 individuals/tray, similar to 50% tray-area coverage) represented a lower stocking density than that generally used by local oyster farmers. The medium density represented a stocking density generally used by local oyster farmers (120 individuals/tray, similar to75% tray-area coverage). The high density used contained 160 individuals/tray (similar to100% tray-area coverage). The experiment ran for 9 months, from September 1999 to June 2000. Oysters showed a continuous increase in total mass (shell plus soft tissues), with no effect from stocking density. Tissue (meat) growth showed a different pattern; positive growth was observed only during the autumn. Thus, shell growth and meat growth was not coupled. Density effects on the amount of meat in the oysters were significant but small. Generally, the difference in meat weight between the animals kept at a low and medium density was insignificant, but the meat weight of individuals kept at a high density was significantly smaller. Production (total biomass) of *C. gigas* was significantly different among densities, the

largest production at the high, and the smallest at the low density.

Reference

HONKOOP, P.J.C. (phonkoop@bio.usyd.edu.au), BAYNE, B.L., 2002. Stocking density and growth of the Pacific oyster (*Crassostrea gigas*) and the Sydney rock oyster (*Saccostrea glomerata*) in Port Stephens, Australia. Aquaculture Vol 213, pp 171-186.

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9. MSX disease in Japan

One hundred pacific oyster spat obtained from a coastal area in north-eastern Japan were examined for the protistan parasite *Haplosporidium nelsoni*, the causative agent of MSX disease. Haplosporidium-like plasmodia were observed histologically in two spat and the sections reacted positively with a molecular probe specific to this species in an in-situ hybridization analysis. Four spat, including the two in which the plasmodia were found, showed positive reaction in PCR analysis for the detection of *H. nelsoni*. The small subunit ribosomal RNA sequence amplified from the spat was virtually identical (99.7%) to the sequence of *H. nelsoni* previously reported. These results demonstrate that *H. nelsoni* is distributed in Japan.

Reference

KAMAISHI, T. (kamaishi@fra.affrc.go.jp), YOSHINAGA, T., 2002. Detection of *Haplosporidium nelsoni* in Pacific oyster *Crassostrea gigas* in Japan. Fish Pathology Vol 37, pp 193-195.

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10. Mussel spat collectors

Collection of natural spat is very important for the production of blue mussels, regardless of the type of production technology used. In Norway, long-lines are often used for mussel farming. Previously a two-step production technique was common. Separate collectors were used for spat collection. After the first growing season, the spat were collected and stripped and transferred to separate farming socks where they were grown until harvesting. Today rigs using combined spat collectors and growth bands, where the mussels remain on the same collector from spat collection to harvesting are commonly used. Such rigs increase the cost effectiveness of mussel production. A typical blue mussel farming rig in Norway, with a production potential of 100 tonnes, is 250 m long, 15 m wide and uses ten long-lines. In such a rig, the total length of the collector band is approximately 30,000 m. The design of the collectors is, therefore, very important.

An experiment with four different types of combined collectors was conducted, at two production sites, to find the most efficient.

The collectors used were Alesund band I and II, Fiskevegn stocking and Swedish band. Alesund band I and II are 5 cm wide flat bands made of a combination of polypropylene (PP) threads and polyester (PES) fibres. In Alesund band I the PP threads are grouped in seven vertical lines, whereas in Alesund band II the PP threads are spread uniformly over the width of the band. The Fiskevegn stocking is a loose crochet rope made of a combination of PP and PE (polyethylene) fibres. The Swedish band is a 5 cm wide white PP band.

The results showed that the amount of mussels that can be harvested was highly dependent on the type of collector. On both sites the amount of harvested mussels was greatest for the Swedish band, which averaged between 25 and 30 kg mussels per collector of length 6.1 m. The average amount of harvested mussels on the other collectors was between 14 and 18 kg. Both shape and surface structure of the collector seems to be important. A dense structure, such as in the Swedish band, provided several attachment points for the byssal threads. The attachment between the mussels and the collector surface was also stronger. In the experiment, the mussels showed no preferences for collectors with filamentous surfaces (Fiskevegn stocking). A collector band must be stiff enough to prevent folding of the band as the weight of the mussels increases. Folding occurred on both Alesund band I and II, but not on the Swedish band. Poorer structure and surface quality of the collectors may still result in large initial attachment of spat, but this will be followed by excessive losses as the mussels become detached later in the growth period. There was also less fouling on the Swedish band. In the experiments, the number of spat was over 4500/m after the first growing season. At harvesting, the mussel densities had been reduced to 600-800 mussels per m of the collector.

Reference

LEKANG, O.V. (odd-ivar.lekang@itf.nlh.no), STEVIK, T.K., BOMO, A.M., 2003. Evaluation of different combined collectors used in longlines for blue mussel farming. Aquacultural Engineering Vol 27, pp 89-104.

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11. Mussel and salmon polyculture

Intensive marine salmonid cultivation can introduce significant quantities of nutrient wastes from uneaten feed, faeces and excretory products into the local environment. Along with the growth of the salmon aquaculture industry, so too have concerns regarding the environmental impacts from aquaculture wastes. One of the major challenges for the sustainable development of salmonid culture, and the aquaculture industry generally, is to minimise environmental degradation. The salmon aquaculture industry has adopted a number of strategies to reduce nutrient wastes and its impacts on the local environment, including improved feed formulations and digestibility, improvements in feed/waste monitoring and feeding techniques, site rotation and fallowing, and reduced stocking densities. Integrating the culture of filter-feeding bivalve molluscs (e.g. mussels, oysters, and scallops) with salmon farms has long been advocated as another potential strategy

to alleviate waste loadings and environmental impacts associated with open-water salmon culture.

In a field experiment, Tasmanian blue mussels (*Mytilus planulatus*) were cultured within an Atlantic salmon (*Salmo salar*) farm in North West Bay, Tasmania to see if there would be enhanced mussel performance and reduced organic enrichment from integrated mussel–salmon culture.

The performance of mussels grown within the fish farm lease (70 and 100 m from the fish cages) was not appreciably different from that of mussels grown distant to the farm (500 and 1200 m from the fish cages). Growth of mussels cultured within the fish farm was not enhanced due to several contributing factors. These were: (a) solid wastes (feed particles and faeces) from the farm did not significantly increase particulate food concentrations above ambient levels, (b) phytoplankton production within the farm was not enhanced, (c) mussels were cultured too distant to intercept settling particulate wastes emanating from the fish cages, and (d) ambient seston concentrations were consistently above the pseudofaeces threshold concentration, thereby limiting ingestion of fish farm particulate wastes.

In summary, it is our opinion that some of the potential benefits from integrated bivalve–fish culture, which have been championed in the past, may have been overestimated. The primary benefits of culturing bivalves and fish together, which are increased bivalve growth and reduced fish farm waste, may not be achievable in all instances. An enhanced algal food supply within a fish farm for integrated bivalves seems unlikely. Further, particulate wastes may be too diluted, or released in pulses of short duration to significantly increase the long-term quantity or quality of food available for the bivalves. Retention of solid wastes, with significant reductions in particulate waste, is limited when ambient particulate concentrations are above the pseudofaeces threshold. Integrated suspended bivalve–fish culture may only be applicable for enhancing bivalve growth under certain conditions.

Reference

CHESHUK, B.W. (Brian.Cheshuk@dpiwe.tas.gov.au), PURSERA, G.J., QUINTANA R., 2003. Integrated open-water mussel (*Mytilus planulatus*) and Atlantic salmon (*Salmo salar*) culture in Tasmania, Australia. Aquaculture Vol 218, pp 357-378.

12. Sea lice treatment and mussel farming

Wild and farmed mussels, *Mytilus edulis*, coexist with salmon farms in Scottish sea lochs. A synthetic pyrethroid chemical called cypermethrin is used as a medicine on fish farms to control sea lice infestations. It is licensed as a formulation called Excis®. It is important to know if this chemical has any effect on farmed mussels. In this study, uptake of cypermethrin from exposure to Excis® was investigated through the use of gas chromatography with mass-spectrometry. The effects of Excis® on mussels were also examined by measuring the neutral red retention time of lysosomes, aerial survival and shell closure. These are all reliable indicators of the health status of mussels. Although some responses were seen in the experiments (see below), it is thought that these are unlikely to occur in the field, even at the concentrations of cypermethrin within the fish cages, as used during treatment of sea lice.

It was demonstrated that mussels are able to accumulate cypermethrin. It is unlikely however that such accumulation will occur in the environment surrounding fish farms, because the nominal exposure concentrations used here (up to 1,000 μg/l) were considerably above the SEPA EQS of 16 ng/l. At these higher concentrations Excis® had a notable effect on mussel shell closing behaviour, giving shorter periods when the valves are open, but did not appear to influence neutral red retention time or aerial survival.

Reference

GOWLAND, B. (gowlandb@marlab.ac.uk), WEBSTER, L., FRYER, R., DAVIES, I., MOFFAT, C., STAGG, R., 2002. Uptake and effects of the cypermethrin-containing sea lice treatment Excis® in the marine mussel, *Mytilus edulis*. Environmental Pollution Vol 120, pp 805-811.

13. Tubeworm fouling on mussels

In Scotland, some 2,000 tons of mussels (*Mytilus edulis*) are produced each year from suspended rope cultures. Mussels can act as a settlement substrate for tubeworm (*Pomatoceros* spp.) and badly fouled mussels are devalued and may be discarded. The estimated cost to the Scottish rope-grown mussel industry is between £300,000 and £500,000 per annum. Established growers believe the problem is getting worse.

Collector plates were deployed at two sites in two lochs on the West Coast of Scotland to monitor tubeworm settlement. In conjunction, in situ trials at a mussel farm site assessed tubeworm settlement on rope-grown mussels. The tubeworm *Pomatoceros triqueter* was found to be the prevalent species settling on the collector plates and on the mussels. The timing of peak tubeworm settlement differed between lochs but was synchronous between sites and different depths within the same loch. Peak settlement in both lochs occurred after the highest seawater temperatures were recorded. Settlement intensity differed between lochs, sites, and depths, indicating the scale of variation in settlement within lochs. Mussel shell size was distinguished as a significant factor influencing *Pomatoceros* spp. settlement as higher numbers of tubeworm settled on larger mussels. In large (60 mm shell length) mussels tubeworm settlement was greatest in treatments where

adult tubeworms of the same species were already present and higher levels of settlement were found in mussels stocked at lower densities. In small (34 mm shell length) mussels the initial stocking density and tubing system had no effect on tubeworm settlement. Differences in the fouling intensity between mussel stocks were attributed to variation in the abundance of tubeworm larvae in the water column and the size of the mussels at the time of re-tubing. A 100% mortality could be expected in adult tubeworm after 24 hours and 35 hours when exposed to air at 7°C and 13°C, respectively. In areas where tubeworm is a persistent problem consistent annual monitoring of the tubeworm settlement is recommended as part of a management strategy to avoid heavy fouling on mussel stock.

Reference

CAMPBELL, D.A., KELLY, M.S. (mke@dml.ac.uk), 2002. Settlement of *Pomatoceros triqueter* (L.) in two Scottish Lochs, and factors determining its abundance on mussels grown in suspended culture. Journal of Shellfish Research Vol 21, pp 519-527.

14. Source of azaspiracid toxin discovered

A new human toxic syndrome, azaspiracid poisoning (AZP), was identified following illness from the consumption of contaminated mussels (*Mytilus edulis*). To discover the aetiology of AZP, sensitive analytical protocols involving liquid chromatography - mass spectrometry (LC-MS) were used to screen marine phytoplankton for azaspiracids. Collections of single species were prepared by manually separating phytoplankton for LC-MS analysis.

A dinoflagellate species of the genus *Protoperidinium* has been identified as the source of azaspiracids. Azaspiracid-1, and its analogues, AZA2 and AZA3, were identified in extracts of 200 cells. This discovery has significant implications for both human health and the aquaculture industry, since this phytoplankton genus was previously considered to be toxicologically benign. The average toxin content was 1.8 fmol of total AZA toxins per cell with AZA1 as the predominant toxin, accounting for 82% of the total.

Reference

JAMES, K.J. (kjames@cit.ie)., MORONEY, C., RODEN, C., SATAKE, M., YASUMOTO, T., LEHANE, M., FUREY, A., 2003. Ubiquitous 'benign' alga emerges as the cause of shellfish contamination responsible for the human toxic syndrome, azaspiracid poisoning. Toxicon Vol 41, pp 145-151.

15. Azaspiracids in scallops

Azaspiracids are a new class of shellfish toxins that have been implicated in several recent incidents of human intoxications following the consumption of mussels (*Mytilus edulis*). A study was undertaken to examine the distribution of azaspiracid poisoning (AZP) toxins in scallops (*Pecten maximus*).

Individual shellfish were dissected into five tissue fractions for the determination of toxin composition. Separation of the three predominant azaspiracids (AZA1-3) was achieved using reversed-phase liquid chromatography with detection by positive electrospray multiple tandem mass spectrometry. The AZP toxin composition was then determined in the adductor muscle (meat), gonad (roe), hepatopancreas (digestive glands), mantle and gill of scallops. Substantial differences in the AZP toxin levels between tissue compartments were observed and toxins were concentrated predominantly, about 85%, in the hepatopancreas. There was also a significant variation in the total toxin levels between individual scallops from the same sample batch. Interestingly, although all three AZP toxins were present in phytoplankton and mussels, AZA3 was not detected in the scallop samples examined. It was concluded that in the interests of food safety, only the adductor muscle and gonad of scallops should be permitted for sale to the public.

Reference

MAGDALENA, A.B., LEHANE, M., MORONEY, C., FUREY, A., JAMES, K.J. (kjames@cit.ie), 2003. Food safety implications of the distribution of azaspiracids in the tissue compartments of scallops (*Pecten maximus*). Food Additives and Contaminants Vol 20, pp 154-160.

16. ASP-producing diatom found in Ireland

The presence of a diatom producing the neurotoxin domoic acid (DA), responsible for amnesiac shellfish poisining (ASP), has been confirmed, for the first time, in Irish waters. The species is *Pseudo-nitzschia australis*. Results indicate that this species may have been the source of DA that has recently contaminated shellfisheries in this area.

A non-axenic isolate of the potentially toxic diatom *Pseudo-nitzschia australis* from Irish waters was tested in two separate batch culture experiments. When grown under low light and in a 16h light: 8h dark photoperiod for up to 40 days, the culture produced only trace amounts of DA, during the late stationary phase. Growth at higher light levels and with a 12h light: 12h dark cycle resulted in DA production starting during the late exponential phase and reaching a maximum concentration of 26 pg DA per cell during the late stationary phase. Liquid chromatography coupled to mass spectrometry was used to confirm the identity of DA in the culture. Irradiance and photoperiod could be important factors that contribute directly or indirectly to the control of DA production in *P. australis* in the wild.

Reference

CUSACK, C.K. (caroline.cusack@marine.ie), BATES, S.S., QUILLIAM, M.A., PATCHING, J.W., RAINE, R., 2002. Confirmation of domoic acid production by *Pseudo-nitzschia australis* (Bacillariophyceae) isolated from Irish waters. Journal of Phycology Vol 38, pp 1106-1112.

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17. Testing for PSP and ASP toxins

Rapid test kits (MIST Alert ™) for the detection of paralytic shellfish poisoning (PSP) and amnesic shellfish poisoning (ASP) toxins in shellfish have recently been developed. In this study, these kits have been evaluated for their potential use in shellfish toxin-monitoring programs and by the shellfish industry. These antibody-based tests were used to assess the presence of shellfish toxins qualitatively in a variety of shellfish species (mussels, scallops, oysters, cockles, and razor clams) while routine methods of detection were simultaneously used to quantify any toxin present.

All shellfish extracts found to contain PSP toxins at the regulatory limit of 80 µg saxitoxin equivalents per 100 g shellfish flesh using the mouse bioassay were confirmed as positive by MIST Alert ™ for PSP. Shellfish farmers and other professionals in the industry also used these test kits successfully, with all positive samples being correctly identified, clearly demonstrating its potential application in shellfish harvest management and end product testing. MIST Alert ™ for ASP also detected toxin in all monitoring samples containing the regulatory limit for ASP toxins (20 µg per g shellfish flesh), as determined by high-performance liquid chromatography (HPLC). In addition, among samples in which HPLC did not detect toxin, the kit agreed in 99% of tests. Overall, these results suggest that MIST Alert ™ for PSP and ASP could be used as part of routine monitoring programs.

Reference

MACKINTOSH, F.H., SMITH, E.A.(smithe@marlab.ac.uk), 2002. Evaluation of MIST Alert ™ rapid test kits for the detection of paralytic and amnesic shellfish poisoning toxins in shellfish. Journal of Shellfish Research Vol 21, pp 455-460.

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18. Testing for PSP toxins

In parallel trials with the mouse bioassay, a rapid diagnostic test (MIST Alert™) for Paralytic Shellfish Poisoning (PSP) detected all of the toxic extracts in over 2,100 regulatory samples. Toxic extracts contained at least 80 µg saxitoxin equivalents (STX equivalent) in 100 g of shellfish tissue, or more, as measured by the regulatory mouse bioassay. Only one potentially toxic sample, which contained 78 and 86 µg STX equivalent/ 100 g shellfish tissue in two different mouse bioassays, was recorded as negative in one replicate of MIST Alert™.

The MIST Alert™ for PSP also detected the majority of extracts containing PSP toxin greater than 32 µg STX equivalent/100 g, which is the mouse bioassay detection limit. The MIST Alert™ gave a false positive result compared to the mouse bioassay at an average rate of about 14% over all sites, although some differences were seen between sites. Further analysis by high performance liquid chromatography of the (false positive) extracts showed that many contained PSP toxicity in the range of 20-40 µg STX equivalent/100 g, that is below the level detectable by the mouse bioassay. The MIST Alert™ gave false positive results from extracts containing less than 20 µg STX /100 g shellfish tissue only about 6% of the time.

The PSP family of toxin analogues can occur in any combination in naturally contaminated shellfish tissue and the antibody mixture in the MIST Alert™ tests detect each of the different PSP toxin analogues with different efficacy. It is therefore impossible to provide an exact detection limit for the MIST Alert™ that would be applicable for all possible PSP toxin profiles. Through the experience of comparison testing with the regulatory mouse bioassay in many parts of the world, with over 2,100 different samples, the MIST Alert™ for PSP has proven its ability to detect all types of profiles of the PSP toxin analogues. The detection limit for MIST Alert™ for PSP was about 40 µg STX /100 g for the 'average' profile of PSP toxin analogues. Since the detection limit depends on the toxin profile in the individual extract, it will also vary depending on the profile of analogues most commonly found at each geographic location. This was observed in our study. Over all sites in the trials, approximately 5% of samples below 40 µg STX equivalent/100 g were positive, and 5% of samples between 40-80 µg STX equivalent/100 g were negative. This is a reflection of the different analogue profiles found in naturally contaminated extracts.

Reference

JELLETT, J.F. (jjellett@ns.sympatico.ca), ROBERTS, R.L., LAYCOCK, M.V., QUILLIAM, M.A., BARRETT, R.E., 2002. Detection of paralytic shellfish poisoning (PSP) toxins in shellfish tissue using MIST Alert ™, a new rapid test, in parallel with the regulatory AOAC = Association of Official Analytical Chemists ® mouse bioassay. Toxicon Vol 40, pp 1407-1425.

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19. Depuration of DSP toxins

Diarrhetic shellfish poisoning (DSP) is one of several seafood poisoning syndromes caused by marine phycotoxins. Although not a life-threatening condition, DSP is a worldwide problem for the bivalve aquaculture and fisheries industries. Closure of shellfish harvest areas for long periods due to the presence of DSP toxins are common and are causing major economical losses in some countries. For example, farmed blue mussels,

Mytilus edulis, along the Swedish west coast generally contain levels of DSP toxins above the tolerance limit for harvest of shellfish for up to 6 months each year. This is the largest impediment to the development of mussel farming in Sweden. The toxic compounds mainly responsible for DSP are okadaic acid (OA) and the structurally related DTX-1, DTX-2 and DTX-3.

Some field observations and experiments on depuration of DSP toxins in various species of bivalves have suggested that the quantity of non-toxic food available is the most important factor regulating the rate of depuration. One physiological model to explain this states that when non-toxic food cells become more abundant, ingestion rates in the mussels increase, which in turn leads to a higher digestive activity and greater metabolic faecal loss. Faecal deposition has been suggested to be the main route for elimination of DST. Thus, as a consequence of increased feeding rates, the toxins are eliminated at a higher rate in the mussels.

In Swedish blue mussels, high levels of OA are generally detected during the autumn and winter period, followed by a fast reduction during early spring. The reduction of OA coincides with the spring bloom of diatoms. This indicates that feeding on non-toxic algae may be important for depuration. This observation, of a correlation between the concentration of algae and the rate of depuration is consistent with (but not evidence for) the notion that high ingestion rates lead to high rates of depuration.

The effects of the quantity of food supplied to mussels on the rate of depuration of DSP toxins in *Mytilus edulis* L. was tested in a laboratory experiment. Mussels naturally contaminated by okadaic acid (OA) were collected from a mussel farm located on the Swedish west coast during a bloom event. Individual mussels were placed in filtered seawater and given daily rations of a mixture of non-toxic algae as follows: no food, 0.5% and 1.5% of dry weight body mass day^{-1}. Depuration was followed over 32 days. The levels of OA decreased in all treatments with time, with an average of approximately 50% reduction after 32 days. No significant differences in content of OA among food rations were detected. In contrast to predictions, there was a trend towards lower levels of toxins in the mussels receiving no food, compared to both food treatments, after 32 days of depuration. The loss of toxins in mussels that were not feeding correlated with a considerable loss in the mass of the digestive gland between 16 and 32 days. It was concluded that the rate of depuration of OA in mussels is not positively correlated with digestive activity and faecal production. Instead, it is suggested that OA may have affinity for lipid-rich cellular and intracellular components and that increased usage of these lipid stores, which occur during starvation, may accelerate the release of OA. This model could explain the observations made during the last part of this experiment. In management of toxic mussels, depuration in waters free of toxic algae is not likely to be enhanced by increasing the food supply to mussels. However, long periods of depuration in the absence of food are not recommended because of the damaging effects on the condition of the mussels.

Reference

SVENSSON, S. (susanne.svensson@zool.gu.se), 2003. Depuration of Okadaic acid (Diarrhetic Shellfish Toxin) in mussels, *Mytilus edulis* (Linnaeus), feeding on different quantities of nontoxic algae. Aquaculture Vol 218, pp 277-291.

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20. Human viruses in shellfish

Viral pollution in shellfish has been looked at simultaneously across a wide range of geographical regions.

Firstly, the participating laboratories optimised and standardised the methods for sample treatment and for the detection of human enteric viruses. The second part of this study involved using an agreed protocol for virus detection, for determining the distribution and concentration of human viral pathogens in shellfish under a range of rearing conditions during an 18-month period in four European countries (Greece, Spain, Sweden, and the United Kingdom).

Human adenovirus, Norwalk-like virus, and enterovirus were identified as contaminants of shellfish in all the participating countries. Hepatitis A virus was also isolated in all areas except Sweden. Norwalk-like virus appeared to be the only group of viruses that demonstrated seasonal variation, with lower concentrations occurring during warm months. The depuration treatments currently applied in Europe were shown to be adequate for reducing enteritic bacterial (*Escherichia coli*) levels but ineffective for the elimination of viral particles. The human adenoviruses, which can be detected by PCR, correlate with the presence of other human viruses and could be useful as a molecular index of viral contamination in shellfish.

Reference

FORMIGA-CRUZ, M., TOFINO-QUESADA, G., BOFILL-MAS, S., LEES, D.N., HENSHILWOOD, K., ALLARD, A.K., CONDEN-HANSSON, A.C., HERNROTH, B.E., VANTARAKIS, A., TSIBOUXI, A., PAPAPETROPOULOU, M., FURONES, M.D., GIRONES, R. (rosina@bio.ub.es), 2002. Distribution of human virus contamination in shellfish from different growing areas in Greece, Spain, Sweden, and the United Kingdom. Applied and Environmental Microbiology Vol 68, pp 5990-5998.

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21. High pressure treatment

The depuration treatments currently applied in Europe are generally ineffective for the elimination of viral particles in shellfish. The potential for applying high hydrostatic pressure (HPP) processing as a method

for inactivating these viruses was tested. It was found that hepatitis A virus and a Norwalk virus surrogate can be inactivated by HPP and suggest that HPP may be capable of rendering potentially contaminated raw shellfish free of infectious viruses.

Viruses in a stock of 7^{10} PFU (Plaque Forming Units) of hepatitis A virus per ml, in tissue culture medium, were reduced to non-detectable levels after exposure to more than 450 MPa of pressure for 5 minutes. Titres of hepatitis A virus were reduced in a time- and pressure-dependent manner between 300 and 450 MPa. In contrast, poliovirus was unaffected by a 5-min treatment at 600 MPa. Dilution of hepatitis A virus in seawater increased the pressure resistance of this virus, suggesting a protective effect of salts on virus inactivation. Results indicated that the viral capsids may remain intact during pressure treatment, suggesting that inactivation was more likely due to subtle alterations of the proteins in these capsids. A 7^{10} tissue culture infectious dose of feline calicivirus, a Norwalk virus surrogate, was completely inactivated after 5-min treatments with 275 Mpa of pressure or higher.

Reference

KINGSLEY, D.H. (dkingsley@dsc.edu), HOOVER, D.G., PAPAFRAGKOU, E., RICHARDS, G.P., 2002. Inactivation of hepatitis A virus and a calicivirus by high hydrostatic pressure. Journal of Food Protection Vol 65, pp 1605-1609.

22. Shellfisheries and nature conservation

In the Netherlands, wild stocks of mussel seed are fished and mussels are cultured on bottom plots. In addition, wild stocks of the edible cockle are dredged for harvest. Two of the areas where these activities are carried out are nature reserves.

In 1993, the government implemented a policy in these reserves to ensure the conservation, protection and development of natural values and processes in which human activities should fit in. Fishing for shellfish is considered a traditional activity in these waters. Therefore, it is allowed, but under the restriction that no negative effects are caused. A number of bird species are dependent on shellfish for their food requirements. Therefore, the policy makes use of a reservation system. This means that, in years when mussel and cockle stocks are low, an amount is reserved for the birds and cannot be fished. The government and shellfish industry agreed on co-management, (i.e., the fishermen are responsible for implementing the measures). This task is carried out by Producers' Organisations.

Reference

KAMERMANS, P (p.kamermans@rivo.wag-ur.nl), SMAAL, A.C., 2002. Mussel culture and cockle fisheries in the Netherlands: Finding a balance between economy and ecology. Journal of Shellfish Research Vol 21, pp 509-517.

23. Effect of dredging on undersized scallops

In Ireland, scallops are caught using a spring-loaded dredge with a toothed cross bar, a collecting bag made from case hardened steel rings and a mesh bag (mesh size, 100 mm). The inshore boats typically use two dredges and offshore boats can tow up to 14 dredges. Upon contact with the dredges, scallops are either caught or left on the seabed. A proportion of the caught scallops will be kept as catch while the remainder will be discarded, being undersized (<110 mm shell height) or damaged. Of the scallops that are not caught, a significant proportion that have come in contact with the dredge may also be damaged and subsequently die. In Ireland, local scallop stocks are often over-fished, and many boats will fish for small daily returns all year round. Therefore, many undersized scallops may be caught and returned to the seabed over and over again.

There is very little information on the effect of dredging on the vitality of discarded scallops. We simulated dredging and measured the stress in the scallops using the adenylic energetic charge (AEC) of the adductor muscle and the righting and recessing behaviour of individuals as indices.

Tow speed had an important impact on both AEC and behaviour. After 15 minutes, the AEC level decreased by more at high tow speeds (from 0.85 to 0.56) than at low speeds (0.85 to 0.70). In addition, the behavioural score declined in dredged animals only at the high tow speed.

We compared two different tow length times (15 and 30 min) and found no difference in the AEC level or behavioural score of the scallops from these two treatments. Recovery was also monitored and was rapid. Scallops from the low speed treatments had AEC levels of >0.8 after 2 h, whereas the AEC returned to this level after 6 h in the scallops from the higher speed treatments. A repeat dredging (after 24 h) at a slower speed had a significant cumulative effect on the AEC level of the animals, but no further decrease was evident after further dredging at 48 hours. Each application of an additional dredge disturbance at a higher speed did not have a significant cumulative effect on the AEC level or behavioural activity of the scallops. The period between disturbances was long enough for the scallops to significantly recover from the previous stress. However, it is not known whether a cumulative stress effect might have occurred in the test scallops if the recovery period was shorter.

Reference

MAGUIRE, J.A. (maguire_julie@hotmail.com), JENKINS, S., BURNELL, G.M., 2002. The effects of repeated dredging and speed of tow on undersized scallops. Fisheries Research Vol 58, pp 367-377.

24. Seeding king scallops in Jersey

In 1995, landings of king scallops, *Pecten maximus* (L.) increased dramatically in Jersey from around one tonne in the previous year, to 66 tonnes, and this figure continues to rise. The introduction of scallop diving permits and diversification of the fishing fleet was the cause of this rise. Due to this increase in effort it was decided that the feasibility of ranching one-year-old juvenile scallops should be investigated. One hundred thousand scallop juveniles were purchased from Ireland and seeded in specifically selected coastal sites. The scallops grew from 22.8 mm shell length (1.17 grams live weight) to 57.6 mm (23.2 grams) in the first six months after seeding, and to 93.3 mm (88.9 grams) during the subsequent 12 months. Growth rate slowed considerably during the winter months. Given these growth rates the scallops will reach market size in three years from settlement, less than the 4, 5 and 6 years taken in Guernsey, the Eastern Channel and the offshore Irish Sea respectively. Although growth rates are not unique and are comparable with other inshore sites in the UK, they are significant for scallop farming in Jersey waters. Mortality following re-seeding and predation rates by crab and starfish appears to be lower than reported in other areas. However this has not yet been quantified in Jersey.

Reference

MOREL, G.M., BOSSY, S.F., 2001. A seeding experiment of juvenile great scallops (*Pecten maximus* (L.)) off the Island of Jersey. Aquaculture International Vol 9, pp 367 - 377.

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25. Scallop cultivation research in Norway

The great scallop, *Pecten maximus* is a potential aquaculture species in Norway, but production to date has been low. Great scallop landings in 2000 were 571 tonnes, and these were exclusively from harvesting wild stocks, landed by divers. Approximately two million juveniles of 15-mm shell height have been produced annually in a hatchery since 1998, and distributed to farmers. Research projects on larvae and juveniles include studies of various antibacterial treatments, improved culture system designs and application of probiotics. Results from hanging cultures under different environmental conditions indicate a strong correlation between low temperature and poor survival, and point out the importance of careful selection of cultivation sites. Good growth potential of scallops in Norwegian waters has been shown, and it is possible to reach market size of 100-mm shell height in three to four years. Experiments with fences and other strategies protecting cultured scallops on the seabed from predation by crabs are in progress.

Reference

BERGH, O., STRAND, O., 2001. Great scallop, *Pecten maximus*, research and culture strategies in Norway: a review. Aquaculture International Vol 9, pp 305-318.

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26. Effect of low salinity on scallops

The effects of reduced salinity on small (1.7 mm shell height) scallop (*Pecten maximus*) spat were studied at 15 and 18°C. Spat were held for 25 days at salinities of 30, 25 and 20 psu and mortality, growth, byssus attachment, behaviour activity and clearance rate were measured.

At 18°C the mortality of scallops held at 30 and 25 psu was 8%, which was significantly lower than for the spat kept at the other salinity-temperature combinations. Final mortality at a salinity of 20 psu at this temperature was 26%. Mean final mortality was higher at the lower temperature (15°C). At this temperature it was 59% for spat held at a salinity of 20 psu and 25% for spat held at 25 and 30 psu. At the 20 psu salinity, the increase in mortality rate commenced 1-2 weeks earlier at 15°C than at 18°C.

Higher growth rates at temperature of 18 °C than at 15°C were observed at 25 and 30 psu. The shell of spat held at 20 psu salinity became very thin and easily damaged, resulting in negative shell growth, although ash free dry weight growth was positive.

No byssal attachments were observed at 20 psu at either temperature, and about 20% attachment occurred at 25 psu. At 30 psu salinity the attachment rate decreased from 100% to 55% at 15°C while at 18°C the attachment remained high, at 83-97%. The general activity level was affected by low salinity as the foot movements decreased, the mantle retracted from the shell margin and gaping increased.

Cultivation of scallop spat at sites influenced by brackish water (e.g., Norwegian polls) may result in high mortality when exposed to salinity lower than 25 psu and retarded growth may occur below 30 psu. Locations exposed to salinities below 25 psu for an extended period should be avoided for nursery growth of *Pecten maximus* spat.

Reference

CHRISTOPHERSEN, G. (gyda.christophersen@smr.uib.no), STRAND, O., 2003. Effect of reduced salinity on the great scallop (*Pecten maximus*) spat at two rearing temperatures. Aquaculture Vol 215, pp 79-92.

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27. Scallop and salmon polyculture

The sea scallop, *Placopecten magellanicus*, is cultivated commercially in Atlantic Canada and New England. The feasibility of polyculture of these scallops with Atlantic salmon (*Salmo salar*) was investigated. Growth and survival of sea scallops grown in suspension at two salmon aquaculture sites in north-eastern Maine (Johnson Cove (JC) and Treats Island (TI)) were measured.

The sea scallop spat were grown in pearl nets and deployed on drop-lines containing ten nets in August 1994. One drop-line of ten nets was sampled about every four months and scallops were counted, measured and weighed. After one year, shell height was 53.6 and 56.4 mm, growth rates were 0.11 and 0.12 mm per day and wet adductor muscle weights were 3.3 and 4.1 g at the two sites (TI and JC) respectively. These growth rates were comparable to sea scallops grown in suspension culture to a nearby scallop aquaculture site and other areas in Atlantic Canada. Reduced rates of survival were found during the latter part of the experiment and were attributable, in part, to heavy fouling, predators and high stocking density. It was concluded that the potential for diversification of the salmon aquaculture industry, and the feasibility of culturing scallops at sites adjacent to salmon operations does exist.

Reference

PARSONS, G.J. (jay.parsons@mi.mun.ca), SHUMWAY, S.E., KUENSTNER, S., GRYSKA, A., 2002. Polyculture of sea scallops (*Placopecten magellanicus*) suspended from salmon cages. Aquaculture International Vol 10, pp 65-77.

28. How old is that scallop?

The relationship between shell growth rate and striae deposition was investigated in a field study in which groups of juvenile scallops, *Pecten maximus*, were deployed for monthly periods over a year in the Menai Strait, North Wales. The number of striae deposited per day, inter-striae width (the increment of shell deposited between successive striae), and striae abundance (the number of striae deposited per mm of shell height) all correlated well with measured shell growth rates. During the winter months, when seawater temperatures were minimal (6°C), inter-striae width declined, whilst striae abundance increased, whereas during the summer when seawater temperatures were maximal (18°C), shell growth was rapid with maximum inter-striae width, resulting in a seasonal pattern of narrowly grouped, then widely spaced striae. This seasonal pattern in inter-striae width variation provides an accurate and reliable method for estimating the number of growth cycles and hence the age of *P maximus*.

Reference

OWEN, R. (rowen@bbsr.edu), RICHARDSON, C., KENNEDY, H., 2002. The influence of shell growth rate on striae deposition in the scallop *Pecten maximus*. Journal of the Marine Biological Association of the United Kingdom Vol 82, pp 621-623.

29. Cosmetic uses for scallop shells

In order to find ways of utilising waste scallop shells, the in vitro activities of components extracted from these shells were investigated. In particular, the scallop shell's ability to protect skin was examined. It was found that scallop shell extract inhibited generation of the superoxide anion as generated by xanthine and xanthine oxidase. Also, when scallop shell extract was supplied to culture medium for skin fibroblast cells, the cell growth rate was increased. Finally, scallop shell extract showed strong inhibitory activities for elastase. All these attributes give the possibility of using extracts of scallop shells in cosmetics.

Reference

LIU, Y.C., UCHIYAMA, K., NATSUI, N., HASEGAWA, Y. (hasegawa@mmm.muroran-it.ac.jp), 2002. In vitro activities of the components from scallop shells. Fisheries Science Vol 68, pp 1330-1336.

Shellfish in the Press

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

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

INFORMATION FILE

WHERE CAN I GET HELP OR ADVICE?

Policy Matters

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

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

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

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

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

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

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

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

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

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

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

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

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

Shellfish Hygiene

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

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

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

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

Scientific and technical advice

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

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

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

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

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

SEAFISH - Aquaculture Development Officers:
For Scotland and Northern Ireland; Craig Burton, Marine Farming Unit, Ardtoe, Acharacle, Argyll, PH36 4LD (Tel. 01397 875402) (Fax. 875001)
(email: c_burton@seafish.co.uk)

For England and Wales: Martin Syvret,
Trendleview, No. 35 Back Lane, Cerne Abbas, Dorset, DT2 7JW (Tel/Fax. 01300 342154)
(e-mail: m_syvret@seafish.co.uk)

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

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

Advice on commercial activities

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

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

Wildlife conservation and status of on-growing sites

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

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

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

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

Other Useful Numbers

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

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

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

USEFUL PUBLICATIONS

CEFAS

A variety of booklets and leaflets are available, including:

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

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

A catalogue of CEFAS publications is available from the CEFAS Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk, NR33 0HT, (Tel no: 01502 562244; Fax no: 01502 513865). Electronic copies of many of these publications can be found on the CEFAS web site at *http://www.cefas.co.uk/publications/default.htm*
Back copies of issues 6-14 of *Shellfish News* can also be viewed and/or downloaded as .pdf files from the CEFAS web site (*http://www.cefas.co.uk/publications/shellfish_news.htm*)

Seafish Aquaculture

Detailed information on the technical and economic aspects of cultivation for individual shellfish species is available from Seafish Aquaculture. They publish a series of 'hyper-books' on CD-ROM that covers all aspects of cultivation. Economic models are also available.

For further information contact the Aquaculture Development Officer for your area (see above for contact details, or *http://www.seafish.co.uk/aquaculture/development.htm* for further information).

A full list of Seafish publications can be found on the Seafish web site at *http://www.seafish.co.uk/publications/publications.htm*