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THE POTENTIAL FOR SCALLOP SPAT COLLECTION TO ENHANCE FISHERIES IN LYME BAY

Gavin Saville and Richard Stanford

Introduction

Since the mid 1990s the Devon Wildlife Trust (DWT) has been working closely with local fishermen in Lyme Bay. Due to the damaging effects of scallop dredging on sensitive reef habitats, local fishermen agreed to two voluntary no-dredging areas around the most valuable habitats. Initial monitoring studies indicate that these closed areas have been effective in promoting the recovery of reef species and scallops. Other areas in Lyme Bay had been earmarked for protection but there were concerns from fishermen that these were too economically valuable to relinquish. Hence DWT, with the support of local fishermen, decided to trial scallop spat collection. The aim of this was to enhance scallop stocks around the reefs and reduce the level of fishing effort on sensitive habitats while maintaining the income of fishermen. Initial trials in the summer of 2003 had indicated that spat collectors were effective at catching queen scallops (*Aequipecten opercularis*) in Lyme Bay and the experiment was repeated in 2004.

Spat Collection

Gear was deployed during known summer spawning and settlement periods of king scallop (*Pecten maximus*) spat in southwest England. Fishermen reported the first spawning of *P. maximus* on the 31st May 2004 and two gear sets were deployed at fortnightly intervals starting from the 15th June. Gear was deployed in approximately 16 to 18 m of water. It was intended to leave each gear in position for a period of eight weeks to allow settlement and growth of spat; however, haul dates were adjusted due to adverse weather conditions and boat availability.

Gear

Spat collectors were loosely based on Japanese designs. Commercial onion bags (dimensions 85 cm x 50 cm, mesh size 8 mm x 2 mm) were filled with 2 m² of 1 mm monofilament netting. The monofilament filler used was obtained during the normal patrol activities of Devon Sea Fisheries Committee or discarded by local fishermen. Studies on the presence of light fouling or biofilm on settlement substrate has indicated improved spat settlement rates and it was anticipated that the netting used would provide an excellent settlement substrate.

Preliminary trials with single strings of collectors were successfully carried out by DWT at various locations in Lyme Bay during 2003. To scale up the quantity of collectors for this project without incurring prohibitive expense and forming a potential navigational hazard, an arrangement of subsurface gearing was then attempted. A gear set similar to a gill net's construction was created using a floating top rope and a weighted bottom rope to produce a stable 35 m x 11 m frame with enough buoyancy to maintain an upright position. Ropes holding spat collectors at 1 m intervals were attached every 5 m within the frame. Anchor lines approximately 2 m in length were attached to the bottom corners of the gearing to provide frame flexibility, whilst surface buoys on 10 m lines were attached on the top corners of the gears frame for hauling and location. Each deployed frame produced an array of 60 collectors at depths of 1 to 10 metres above the seabed (Figure 1).



Figure 1. Ten spat collectors at one-metre intervals were deployed with the help of Devon Sea Fisheries Committee

Gear recovery

Three out of the six gears deployed were successfully hauled with three being lost to either bad weather or trawling by anonymous parties. One spat collector was damaged during hauling and is omitted from the results (height 1 m from the seabed). Similarly, two collectors from the same haul were not labelled correctly and are also omitted from the analysis.

On retrieval of gear, spat collectors were immediately labelled according to their height from the seabed and secured individually in black plastic bin liners. These were subsequently transported to cold storage in Plymouth Fish Market, Devon, where analysis and counting of biota took place over the following days. Animals were counted according to five taxonomic categories; pectinids, mytilids, gastropods, starfish, crabs. Crabs as a group were further separated into large and small; large being defined as the carapace being larger than 2.5 cm, the size of the largest recruited spat. Only scallop spat of ≥ 5 mm were counted and identified to species by shell shape.

Spat abundance

The results of this study indicated that it is possible to predict the settlement of scallops in Start Bay from the spawning of neighbouring populations. This information could feasibly be utilised to optimise timing of any spat collection performed in the area. Recruitment of both *P. maximus* and *A. opercularis* exhibited a defined temporal peak (Figure 2) in this study during the second deployment of gear, 30 to 44 days after the first reported adult spawning of *P. maximus* by local fisherman. This corresponds with the expected time frame for larval development. However, spawning of *A. opercularis* was not positively identified before deployment and reiterations of the experiment would be required to confirm that *P. maximus* spawning could be used as a surrogate index for queen scallop recruitment.

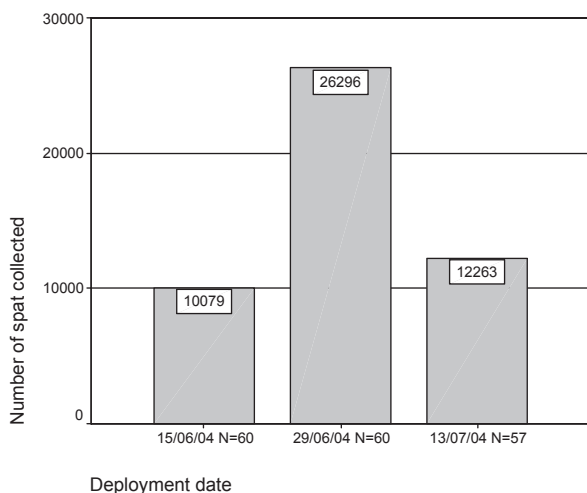


Figure 2. Spat numbers gathered from collectors during three deployments in Start Bay

The results further indicated that both species preferentially settled between 2 and 6 metres from the seabed (Figures 3 and 4). This agrees with CEFAS guidelines of collection of spat 5 metres from the

bottom to avoid benthic predators and excess wave turbulence. Figures for spat harvest per bag in this experiment are comparable to those collected in trials for successful commercial fisheries augmentation around the Isle of Man and suggest good potential for a similar programme in Lyme Bay. *P. maximus* recruitment at optimal heights from the seabed in this study is similar to all but the highest recruitment year of current Isle of Man trials, although it is slightly lower than those predicted as ideal for commercial ventures. This said, the recruitment of *A. opercularis* in this study is very high (29/06/04 mean for 3 m from the seabed = 891) and may be commercially viable for an augmentation programme, if survivorship of spat is high and recruitment can be translated to adult stock.

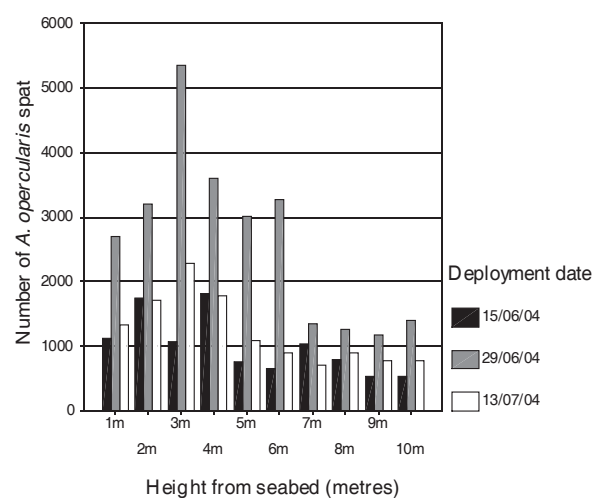


Figure 3. *A. opercularis* spat at heights from the seabed during three deployments in Start Bay

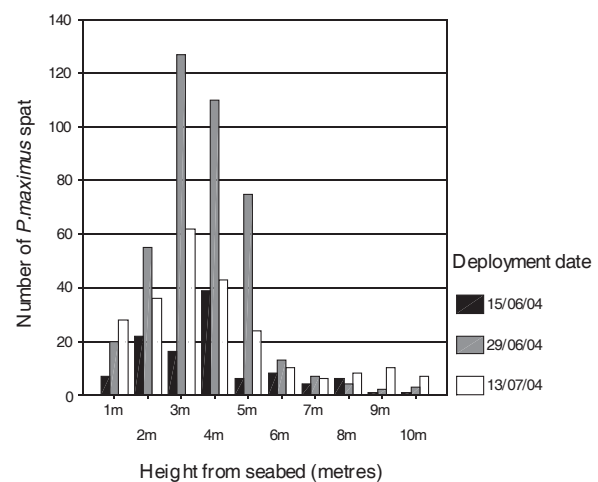


Figure 4. *P. maximus* spat at heights from the seabed during three deployments in Start Bay

Influence of predators

No significant relationship could be found between the number of small crabs or echinoids and the number of spat found per collector. However, spat number was reduced for both species of scallop when large crabs were found within collectors. This agrees with results from studies in Bantry Bay Ireland, where crabs were the main source of predation in similar spat collection trials. Many small crabs and echinoids were recorded in collectors in this study but showed no effects on recruitment. The large crabs described were too big to have recruited to the collectors from the plankton and likely entered collectors through unnoticed holes in the outer mesh. Carapace width of *Carcinus maenus* is directly proportional to the shell length of consumed common mussel. In this study it is suggested that settlement of newly recruited crabs, echinoids and scallop grow in parallel and their predatory effects on this recruitment class. Subsequent settlement of younger spat may be predated by these previously settled predators, resulting in a strong age class of spat within collectors.

Density Dependant Growth

The hypothesis was formed that density-dependant growth, if present, would be driven by seston depletion within higher density scallop nets. Under this assumption, scallops under higher density treatments should show lower growth rates and higher mortalities. The density dependant growth component of this study was completed in Brixham Marina, Devon. The site was chosen because of its ease of access and sheltered conditions. The queen scallops used were acclimatised to the marina conditions for 18 days prior to the experiment. One-year-old queen scallops previously obtained from a 2003 DWT experiment were numbered using waterproof paint pens. An adequate drying time of 20-30 minutes was required to ensure paint was permanent. During this time scallops were sheltered from direct sunlight to avoid access dehydration. Numbering was checked for permanence a week after application and appeared satisfactory (Figure 5). Triplicate treatments of numbered and measured scallops (height; measured perpendicular to hinge, width, and depth) were placed into scallop culture pearl nets with additional scallops to create densities of 50, 100, and 200 individuals. Density treatments were then attached to the mooring pontoons of the marina at a depth of 2 metres from the surface. Treatment densities commenced on the 16th June 2004 and were left *in-situ* and undisturbed until 9th September 2004. Nets were then hauled and measurements of numbered scallops retaken along with details of mortality rates.

Of the 270 scallops numbered for each treatment density, 185 width, 185 height, and 176 depth measurement were identifiable and measurable after 8 weeks in the water. No difference was found between



Figure 5. Scallops were numbered and measured individually

the numbers and rates of mortality of *A. opercularis* spat in the density treatments. Similarly, no differences in growth rate could be found for measurements of any of the shell dimensions. It is suggested that the lack of effect shown here may be due to a short deployment time. However, if these results are consistent then it may be that commercially viable growth rates for full scallop culture are possible at high enough densities for good economics with species belonging to the genus *Aequipecten*.

Other factors

Larval development of spat is temperature dependant, with an optimum for *P. maximus* of 16–18°C; variations from this potentially producing potent effects on recruitment. CEFAS records for mean monthly sea temperature in the southwest of England fall within this range for longer periods than anywhere else in the UK. This provides a long growing season and illustrates the potential of the area for spat collection techniques. Finally, if spat collection and on-growing was on a commercial scale, fouling would be a genuine concern that would need consideration (Figure 6).



Figure 6. Heavy fouling of pearl nets after deployment

Acknowledgement

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REFINEMENT AND RESEARCH LEAD TO BETTER REARING RESULTS AT THE UK'S NATIONAL LOBSTER HATCHERY

Dylan Taylor, General Manager, National Lobster Hatchery, South Quay, Padstow, Cornwall PL28 8BL



The National Lobster Hatchery, Padstow

Background

The National Lobster Hatchery (NLH) is a charitable organisation based at Padstow, which aims to enhance wild stocks of the European lobster (*Homarus gammarus*) stocks by releasing large numbers of post larval hatchery-reared juveniles at selected coastal sites.

This programme is based on positive results from lobster stocking trials carried out by the Ministry of Agriculture Fisheries and Food (now part of Defra), and others in the 1980s and 1990s.

The NLH opened in 2000 but the larval rearing programme was beset with technical problems, with 2003 being a very difficult year when output was affected by a suspected pollution incident near the hatchery seawater intake. The gravity of these problems led to a complete review of the site and the rearing techniques by the manager Dylan Taylor and his staff.

This article presents the measures taken to improve the situation at the NLH at Padstow and reports on the increased production levels obtained in 2004.

Water quality

The team decided at the beginning of 2004 that the seawater intake system could not ensure delivery of the local seawater at a quality level suitable for the sensitive larval stages. The problem was overcome by the use of synthetic seawater to eliminate the risk of pollution. Although this was an expensive option, it has enabled the larval rearing programme to operate successfully until new life support systems and an upgraded intake water treatment system are installed. However, running the entire hatchery, including broodstock and juvenile on-growing areas on synthetic seawater was ruled out due to expense and the larger lobster stages have survived well in the natural seawater used for them.

In 2004, initial larval production proved problematic with high levels of mortality. The larvae were inactive

and showed no feeding behaviour. Many displayed pale colouration. Microscope examination revealed a high degree of epibiotic fouling of a filamentous appearance. With the kind assistance from Gregg Arthur and Stuart Fitzsimmons of the North Atlantic Fisheries College (NAFC) hatchery in Shetland and others, the fouling was identified as a type of filamentous bacteria, probably a species of the genera *Leucothrix*.

The filamentous bacterial problem has affected other lobster hatcheries and is observed to proliferate where high levels of dissolved organics are present in the seawater. The NAFC team had experience of using chloramine-T as a bath to treat the bacteria and suggested initial dose rates of 5 to 10ppm.

The NLH team developed a Chloramine-T treatment regime of bathing at 20ppm for one hour as an initial prophylactic treatment for all larvae immediately after hatching, followed by a bath at 10ppm every 72 hours until metamorphosis into post larvae (stage 4). This regime kept the larvae clear of fouling throughout. Filamentous bacterial fouling was never detected on post larvae at the hatchery.



A Stage 4 juvenile lobster

Organic loading on the water was reduced in the larval system by increased protein skimming, carbon filtration, additional UV treatment and provision of an ozoniser.

This regime along with other improvements brought larval survival rates from zero up to around 27%, which at a stocking level of around 33 larvae per litre compares impressively with previously published figures of 14-20%, when stocked less densely at 25 larvae per litre.

The fact that these lobster larvae are able to tolerate being removed from natural seawater into synthetic seawater and treated with repeated exposure to chloramine-T involving handling every 72 hours shows how robust the lobster larvae are when compared with fish larvae.



Releasing hatchery reared juvenile lobsters

New larval feed supplement

Research into natural immune modulators and immune enhancing feed additives carried out at the NLH in the summer of 2004, showed that lobster larval survival and growth rates are significantly improved by the addition of mannan oligosaccharide (MOS) to the feed. MOS is already widely used to replace antibiotic growth promoters and improve gut health and immune function in agriculture; these latest results suggest that there are also likely to be many applications for the use of MOS in aquaculture.

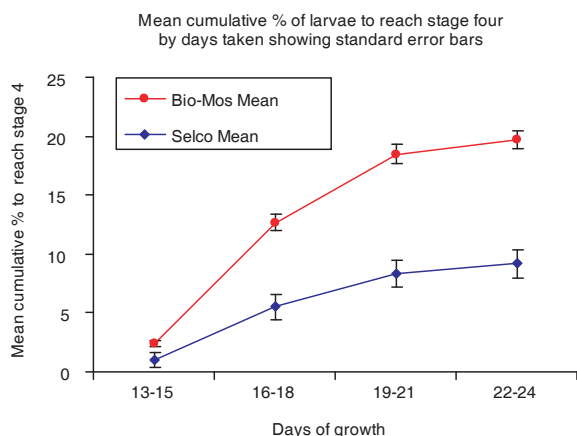
Student Carly Daniels (working towards her Marine Biology and Coastal Ecology honours degree at the University of Plymouth) carried out the study at the hatchery.



Researcher Carly Daniels returning from a lobster release trip

During the study several batches of larvae were observed; four batches were fed upon *Artemia nauplii* enriched purely with A1 DHA Selco (INVE Aquaculture), while six other batches were fed upon *Artemia nauplii* enriched with a mixture of A1 DHA Selco and Bio-Mos[®] (mannan oligosaccharide from Alltech Ltd). Results clearly indicated that the addition of Bio-Mos[®] to A1 DHA Selco improved the survivorship of lobster larvae to the juvenile stage (stage IV).

Where A1 DHA Selco was used as normal, survival varied between 5 and 13% per batch of larvae. With the addition of the Bio-Mos[®], this increased to between 12 and 28% per batch of larvae.



Growth and development is improved with MOS supplement

These results are of potential importance to both crustacean aquaculture and aquaculture in general. Antibiotics and disinfectants used to control infections

within closed recirculation systems present problems with effluent discharge and antibiotic resistance, damaging beneficial microbes both within the gut of the animals being cultured, reducing growth, and in recirculation systems where bio-filters are affected, reducing filtration efficiency. MOS is reported to specifically bind with pathogenic microbes preventing cell attachment whilst leaving beneficial gut bacteria unharmed and boosting the organism's immune system.

Carly's supervisor, Dr Simon Davies of the University of Plymouth, said the results demonstrated in the trial showed the potential for a natural product, mannan oligosaccharide, to be used prophylactically as a "functional nutritional supplement" in a hatchery situation. The product appeared to increase disease resistance, leading to the production of fitter individuals.

The NLH now continues to use Bio-Mos[®] as a supplement for larval feeding. At the end of the 2004 season, we have produced a very robust operations protocol, which allowed us to triple our output this year, to around 7,000 juvenile lobsters. With this regime in place, following the refit of the life support systems next year, it is anticipated that production figures will rapidly move towards 20,000 juveniles per year.

Further information

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EVALUATION OF SOME FACTORS AFFECTING NATIVE OYSTER STOCK REGENERATION

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A species in decline

The native oyster *Ostrea edulis* was once so abundant that an impoverished Dr. Johnson could afford to feed his cat 'Hodge' on oysters. However, the twentieth century saw a long, near-continuous decline in stocks of *O. edulis* in British waters that has lasted to the present day. This decline not only represents the decline of a valuable fishery but also a deleterious change in the community structure of our coastal biota. Over the years many reasons have been put forward to explain the loss of the species

from British waters and these have included disease, over-exploitation, non-native predators, pollution and adverse weather conditions.

More specifically:

- 1) The rapidity of rail and later, road, transport created new markets, leading to over-exploitation of natural fisheries. At the same time there were dramatic mortalities reported in the 1870s consistent with the appearance of a pathogen with a similar impact to that of *Bonamia* in the 1980s, as were the mass mortalities investigated by H.A. Cole in the 1920s.

- 2) The slipper limpet *Crepidula fornicata* was introduced with *Crassostrea virginica* from North America around 1900 and is a filter feeder that deposits pseudofaeces and creates 'mussel mud'. This mud degrades the grounds and hinders recruitment, although dead *Crepidula* shell provides cultch upon which oyster settle.
- 3) Severe winters, such as those experienced in 1947 and 1963, caused high mortalities in the UK, particularly on the east coast where stock levels have not recovered to the pre-1963 levels.
- 4) The parasitic protozoan *Bonamia ostreae* has caused massive mortalities since its appearance in British waters in the early 1980s.
- 5) TBT (tri-butyl tin) anti-fouling paints used on ships and leisure craft in the early 1980s caused stunted growth and probably affected reproductive capacity, though the restrictions on the use of this agent have reduced its impact and even more sensitive species such as dog whelks are now recovering.

NOSAP

The problem of this decline was specifically addressed by the UK Biodiversity Action Plan and this eventually led to the development of the Native Oyster Species Action Plan (NOSAP). Funding as part of the NOSAP programme was provided by Defra and English Nature to set up a study to evaluate methods of enhancing the survival and growth of newly-settled *O. edulis*, identifying procedures that would help to revive stocks of this species.

Defra funding was allocated from within the Committee for Aquaculture Research and Development (CARD) programme budget.

Study objectives

The scientific objectives of the study were to use established measures of physiological and immunological stress to evaluate the effects of post settlement culture of *Ostrea edulis* on and off a range

of cultch materials (broken and whole scallop, cockle and weathered *Crepidula* shells – see Figure 1), at different oyster densities and in absence and presence of *Crepidula* also at a range of densities. In addition, comparisons were made between hatchery-reared stock and juveniles collected and reared from brooding wild stock in the Solent. The objectives of the study were:

- 1) To test the efficacy of three different cultch materials in promoting the survival of oyster juveniles.
- 2) Examine the effect of stocking densities on survival and immunocompetence.
- 3) Quantification of competition with the slipper limpet *Crepidula fornicata*.

The oyster stocks that were tested were obtained from two sources. Firstly, from parental brood stock of known origin and genetic relationship provided by 'Seasalter Shellfish (Whitstable) Ltd' Kent and secondly, from spat obtained from a random assortment of reproductive adults collected from the Solent during the peak spawning phase in May/June (Figures 2 and 3). *Crepidula* were also obtained from the Solent. Throughout, animals were maintained at a fixed temperature and salinity of 15°C and 34 psu respectively and provided with food using the methods and species of micro-algae used in previous studies of bivalves at Southampton. These studies have defined the feeding requirements of *O. edulis* and the design of the upwelling tank systems produces turbulent flow at rates that ensure maximum filtration and uniform distribution of the micro-algal food. Animals were tested after a minimum of 14 days exposure to relevant test conditions.

Intra- and inter-specific density related effects were measured in individual *O. edulis* from the control and experimental groups set out in Table 1. Each set of control and experimental groups contained a minimum of 12 individuals and were duplicated.

The following indicators were used to quantify the responses of *O. edulis*:

- Measurement of differential haemocyte counts, cell motility and phagocytic ability following pathogen challenge.



Figure 1. Cultch types - broken and whole scallop shells (left), *Crepidula* shells (middle) and cockle shells (right)

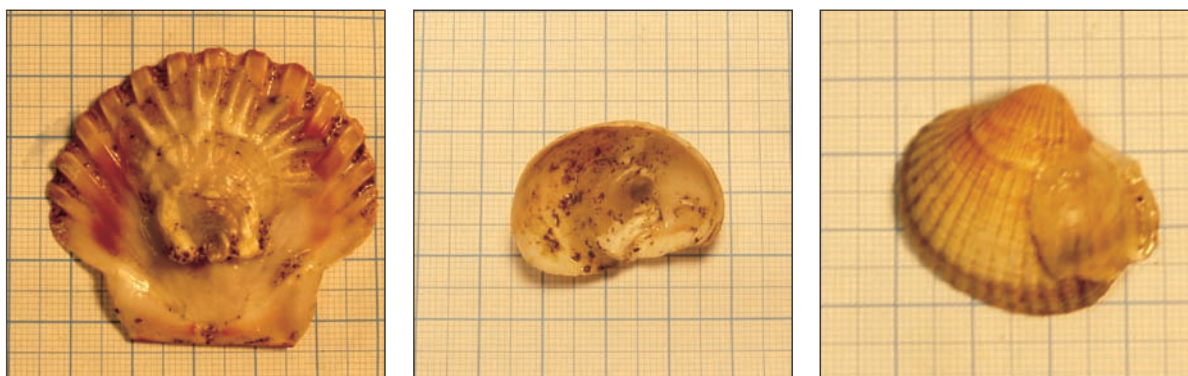


Figure 2. Whitstable spat settled on scallop, (left) *Crepidula*, (middle) and cockle (right) shells

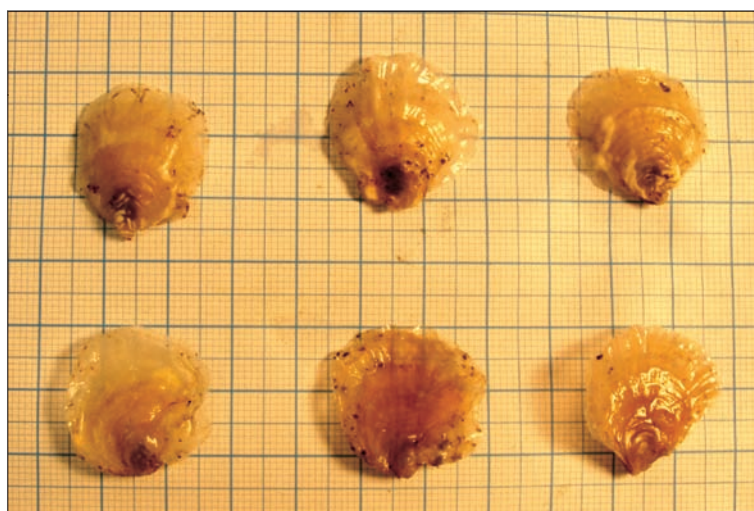


Figure 3. Cultchless Whitstable spat

Table 1. Density effects investigated

Wet Weight of Soft Tissue expressed as g m ⁻²	
<i>Ostrea edulis</i>	<i>Crepidula fornicata</i>
1	9
4	16
5	5
9	1
10	0 and 10
12	18
15	15
16	4
20	0, 20, 40 and 80
30	0 and 30
40	20
50	50
60	0 and 60
80	20
100	0 and 100
200	0 and 200

- Measurement of haemolymph microcidal activity in the form of hydrogen peroxide and lysozyme titres following pathogen challenge.

Examples of the large volume of data that was generated are shown in Figure 4.

Overall pattern of results

Overall, no differences were detected in immunological functions between hatchery-reared and wild stocks, indicating that the former would be suitable for stock restoration. Cultchless groups appeared to out-perform oysters settled onto shell cultch. For both of these groups there was generally an increased stress response with an increase in overall density of live animals, irrespective of whether this consisted of oysters, slipper limpets or both organisms. With one of the tests, Neutral Red retention time, which is an indicator of lysosomal membrane stability and reflects the viability of haemocytes (and other tissues) in response to stressors, there was a response related

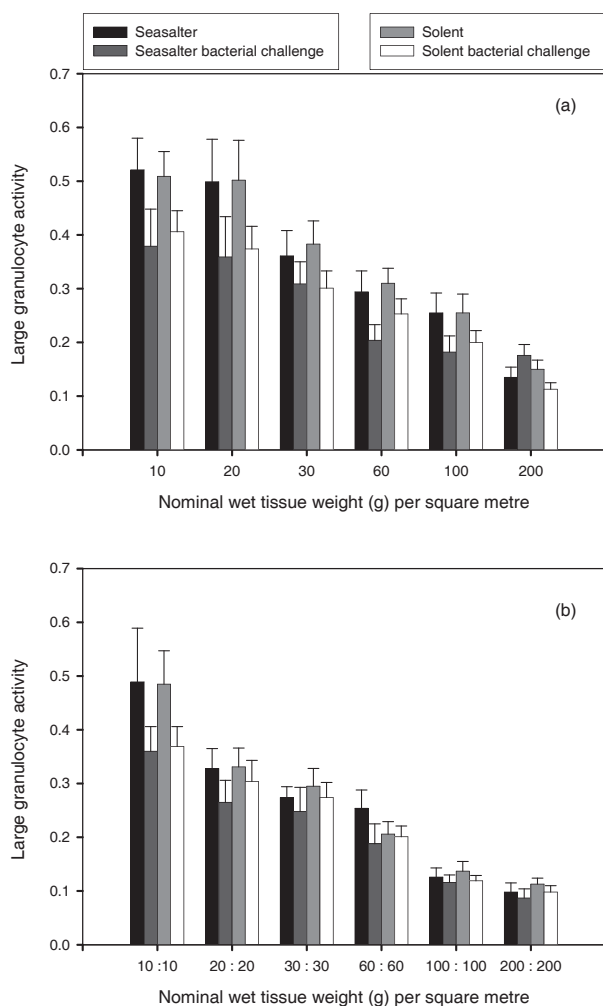


Figure 4. Large granulocyte activity versus animal density (expressed as g wet weight of soft tissue per square metre) for cultchless spat from Seasalter and the Solent. (a) *Ostrea edulis* only, (b) equal densities of *Ostrea edulis* and *Crepidula fornicata*

specifically to the density of slipper limpets. This effect of increasing density was more pronounced for oysters settled onto cockle or slipper limpet shell than for oysters settled onto scallop shells. This may be related to the interactions between curved shells and benthic boundary layer microflows.

In terms of husbandry the results from this study suggest that for the sets of conditions examined cultchless stock appears to have greater immunocompetence than animal attached to the cultch materials tested. Whilst it is safe to conclude from this study that cultchless oysters would be the stock of choice in hatcheries and controlled outdoor rearing ponds with low velocity bottom flows, further work would be necessary to determine if attachment to cultch confers any benefits in coastal waters, where bottom currents are sufficient to re-suspend spat, especially if not attached to a piece of heavier material.

Acknowledgements

The above work was jointly funded by Defra and English Nature as project FC 0926. Further details of this project, and other Defra funded research projects, can be accessed online at: http://www2.defra.gov.uk/research/project_data/Default.asp

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RESEARCH TO SUPPORT SUSTAINABLE AQUACULTURE

Report by Doug McLeod, ASSG

A workshop dealing with the topic “Research To Support Sustainable Aquaculture” was convened by the Joint Research Directorate General of the European Commission in Seville in January, 2005, to bring together a group of representatives from the international scientific and industrial aquaculture community, to consider the future of the sector over the next 20 – 30 years. The objective was to discuss what issues required contributions from research in order to support policy initiatives from the public sector, in the context of ‘sustainability’ (economic, environmental and social) – specifically, to achieve a better understanding of the potential of new

technologies and production systems. The immediate context was the Commission’s ‘Strategy for the sustainable development of European aquaculture’ and the focus in FP6 on research into health and environmental issues.

The European shellfish sector was represented by Angeles Longa (‘Mexillion de Galicia’) and myself (both there as EMPA representatives). We presented a background to the European shellfish cultivation, for the benefit of overseas participants, with a detailed description of the Galician industry, before focusing on areas of future research interest.

These ranged across the usual themes, namely the maintenance and improvement of water quality, assessment of biological carrying capacity and multi-species poly-culture, relationships between environmental changes and HABs, depuration of biotoxins, development of improved husbandry, processing and marketing technologies and techniques and investigation of novel uses for shellfish (biotechnology).

There was a significant degree of interest expressed in the concept of integrated aquaculture. It was generally agreed that information about the economic performance of different systems in varying environments was lacking (e.g. profitable in Asia, unproven in Europe), although in Europe it was fairly clear that higher values and new markets for the incremental output (especially seaweeds) would be required. But in terms of 'sustainability', integrated aquaculture was perceived as improving resource use, required a focus on nutrient extractive species and overall was in balance with natural systems (Max Troell, Royal Swedish Academy of Science).

Much of the discussions inevitably revolved around fin-fish aquaculture, and the associated sustainability issues relating to fish oils, meal and feed, which will continue to influence the outlook for farming operations, particularly in Europe. The long-term future was assessed through a complex world model (Dr Mahfuzuddin Ahmed, 'World Fish Center', Malaysia), which indicated a Base Case expansion of aquaculture from a 1997 level of 31% of global production to 41% of 130 million tons supply in 2020, with growth dominated by developing countries. This latter conclusion appeared to be supported by the FEAP view of current European developments, where the short-term outlook is already for reduced volumes for salmon and trout, 'consolidation' for turbot, slow recovery for carps and growth limited to seabass/seabream.

A worthwhile meeting, which additionally extended contacts within DG Research, where it has been indicated that proposals for research projects from industry would be welcomed.

AUTOMATED ALGAE MONITORING

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Introduction

Unlike other projects, which have centred on image acquisition, in Plymouth we have spent 15 years in developing image discrimination. Software has been developed to successfully discriminate Dinoflagellates. We are now in the first stages of real-time image acquisition, having previously worked with digital images from partner laboratories. The images shown in this article are the first obtained with our new camera system. The combined camera and DiCANN software will enable *in situ* non-invasive identification of marine plankton, (phytoplankton, micro and mesozooplankton) including harmful algae species.

Automated sample analysis

Marine ecologists and expert taxonomists carry out categorisation or labelling of biological specimens manually. Current monitoring for Harmful Algae Bloom (HAB) species comprises manual collection and shipping of water samples to laboratories for analysis. During certain periods of the year seawater samples are taken at least once per week from selected water monitoring stations for screening for harmful algae species. This is time consuming and requires considerable manual resources. Research to automate the task has been on going for many years relying on developments in pattern analysis, image processing, multi-spectral analysis and immunofluorescence.

Although many systems have been shown to work in small-scale laboratory conditions with cultured populations, few have succeeded when applied to field collected specimens. The reasons are diverse, but are principally due to severely degraded performance of the chosen processing algorithms in the presence of noise and natural morphological variability of the organisms. Even recently developed flow cytometer systems can only achieve genera/family discrimination using multi-spectral laser probes and their very limited sampling rates (2.5 ml per hour) make them impractical for the high volume sampling required in monitoring programmes.

Species recognition

Recently, artificial neural networks, which are essentially new methods of noise resilient and trainable pattern matching algorithms, have offered increased reliability and robustness for species recognition. Several programmes have shown the efficacy of systems based upon these methods. Statistical methods are also being developed by marine taxonomists to assist their understanding of species classification. These methods seek to describe specimen category according to morphological and genetic classification. Both these methods are too specific, requiring hand crafting to each new species set, and both cannot cope with the high morphological variance found in HAB species.

Many other instruments can image the selected species, but have no automatic species labelling capability. For example FlowCAM (Biglow Laboratory for Ocean Sciences), which is able to acquire images automatically, but still requires manual identification. HOLOMAR (EU project MAS3-97-0079) developed a 3D holographic imaging system, which can resolve phytoplankton at the limits of its range. The species recognition component of the project failed, leaving manual identification as the only option in the analysis of the 3D images. Resolution is not sufficient in either of these machines for HAB species identification. Several members of the consortium have collaborated since 1991 on automatic species analysis.

The HAB system

A new instrument has been developed and built, designed for use in the laboratory or *in situ*, for the identification of phytoplankton cells. Presently it has been configured for HAB species of the genus *Dinophysis*, responsible for the occurrence of DSP outbreaks in Europe.

The system comprises a near-infra-red light source, flow cell, lens and camera interfaced to a high-speed dual processor computer with 2 GB of local memory (Figures 1 and 2).

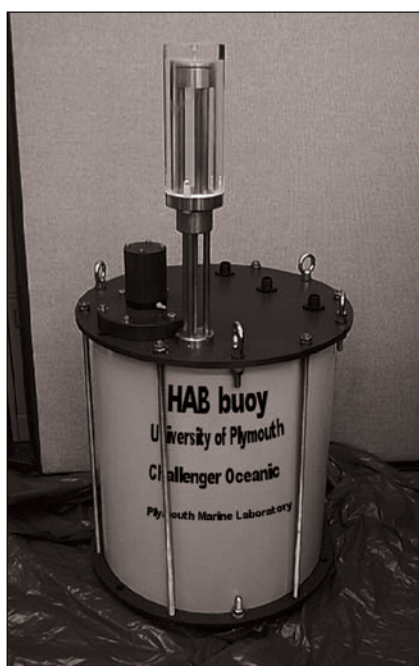


Figure 1. HAB BUOY in housing

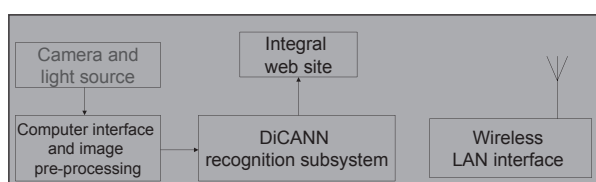


Figure 2. HAB BUOY software system

Throughput is approximately 250 ml in 40 min. Camera resolution is 1 μm . Automatic analysis and labelling of specimens is completed internal to the instrument using advanced pattern recognition and categorisation software known as DiCANN. Specimen labels and object characteristics are stored for later analysis. The HAB Buoy communicates to the controlling base station, over a distance of a few kilometres, through a Wireless LAN link, allowing the system to be placed *in situ* for continuous monitoring of phytoplankton. Data is written to the on-board website to simplify external access.

DiCANN applies the coarse coded channel method for image analysis (see Figure 3). Specimen images are processed at relatively low resolution through six complimentary channels. An image is band-pass filtered using a wavelet transform and points of local maxima are identified. Each of these is then processed in one of the six coarse data channels. The resulting numeric descriptor is fed into an automatic categoriser for training and testing. The DiCANN processing is invariant to specimen rotation and translation in the field of view. It is also partially invariant to scale, allowing up to 10% variation in specimen size. The categoriser uses a committee of Support Vector Machines (SVMs). Each individual SVM takes as input one of the six coarse channels, and outputs a vote for category. Currently the majority rule is applied, producing an overall identification for the specimen.

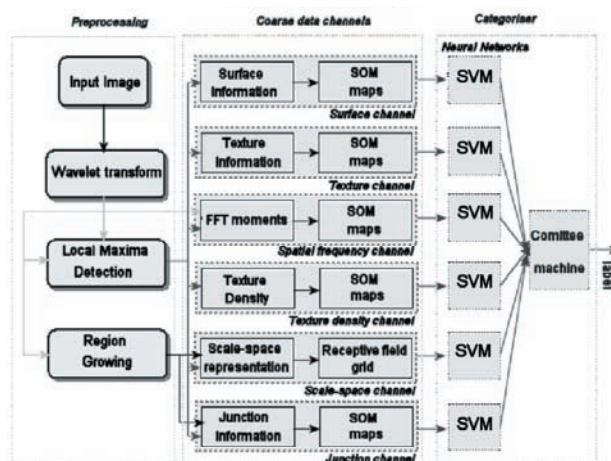


Figure 3. Diagrammatic representation of the DiCANN process

Monitoring issues

Figure 4 illustrates the density of HAB species in the water column throughout the year. As can be seen, the measured density of *Dinophysis* spp. is very low. Accurate measurements therefore require large volumes of water to be monitored. HAB Buoy samples 250 ml

in 40 minutes, analysis taking another 40 minutes. In the summer months, sampling at this rate, at least 15–20 *Dinophysis* spp. would be identified from each of these samples from a background of thousands of other phytoplankton cells and debris.

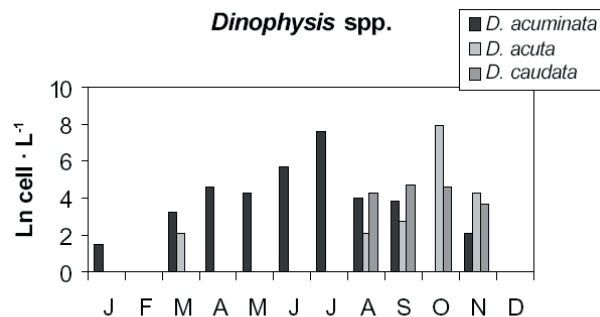


Figure 4. The annual variability of the average (over depth) concentration of three *Dinophysis* species at station E14 of Ría de Vigo, Spain

First images

One of the first sample aliquots processed with the new unit presented over 26,000 specimens for analysis. As can be seen on the example images on Figure 5, initial data has some motion blur and depth of field blur, which is being resolved.

Conclusions

- The whole system can handle a wide range of object dimensions, giving a very high dynamic range: from 20-micron diameter up to more than 600-micron diameter with over 1mm length. This range encompasses both the phytoplankton and the mesozooplankton in one instrument.
- The instrument can image and analyse in one operation, producing labels for each specimen imaged automatically.

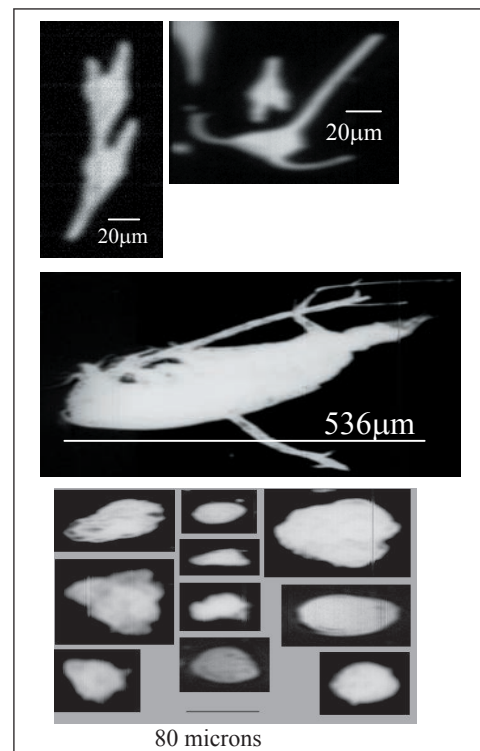


Figure 5. The first images from the HAB Buoy system - *Ceratium furca* (top left); *Ceratium* species (top right); *Calanus finmarchicus*, copepod (middle); mussel spat (bottom). Micron scale bars indicate specimen size as indicated

- There is much to do to improve the systems response and tests are continuing prior to commercial release.

Acknowledgement

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Further information

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SHELLFISH AND SEaweEDS - ADDRESSING THE IMPACTS OF AQUACULTURE

Maeve Kelly, Invertebrate Biology and Mariculture, Scottish Association for Marine Science

Integrated aquaculture

The principle is very simple; the culture of ‘fed’ species, such as the Atlantic salmon, results in nutrient enrichment, whereas shellfish and seaweeds remove particulate and dissolved nutrients. Combining these species, in integrated aquaculture, may then hold the

key to reducing environmental impacts. Integrated aquaculture has of course been implemented in extensive systems for centuries, but what recently funded research at SAMS now intends to establish, is whether integrated aquaculture has a place in mainstream, modern and traditionally monoculture aquaculture practice.

Integrated aquaculture research began at SAMS almost a decade ago, when sea urchins were first grown alongside the Atlantic salmon, and were shown to be benefiting from food pellets the fish hadn't consumed. The REDWEED project (*Reducing the environmental impact of sea-cage farming through cultivation of seaweeds*) subsequently explored the potential of edible red seaweeds grown adjacent to caged salmon to act as 'nutrient mops'. The principle is that the seaweeds, utilising dissolved salmon farm nutrients, in turn become a viable second crop for the salmon farmer.

The more recently formed Atlantic Arc Aquaculture Group (an EC Interreg Funded project) allows SAMS to continue the study of both red and brown macroalgae grown alongside salmon cages, their potential to reduce net nutrient output from the site and their suitability as foods for both humans and grazing invertebrates such as sea urchins and abalone.

Seaweeds

Recent data show that in some locations, the red seaweed *Palmaria palmata* is utilising salmon-farm origin Nitrogen over distances up to 150 m from the salmon cages. The culture of *P. palmata* and the brown macroalgae *Laminaria saccharina* from spores released from gravid plants has been successful. Long-lines at Loch Duart Ltd's salmon farm site have yielded *L. saccharina* up to 2 m long and *P. palmata* of 30 cm in a single growing season (from outplanting in February until the end of July).



Cultured *Laminaria saccharina* plants of harvestable size

Oysters and scallops

The MERMAIDS project, '*Multi-trophic level culture for Environmental Remediation - active management of aquaculture initiatives for diversification and sustainability*' which started in October 2004, is the first in UK waters to examine the commercial and environmental benefits to combining fish, bivalve shellfish (in this case scallops and oysters) and seaweeds in culture. The fate of nutrients through an open-water system containing species feeding at all trophic levels will be modelled; the constant removal of the seaweeds and shellfish at harvest representing both a net loss of nutrients to the system and an increase in aquaculture produce per unit area.

Sea urchins

The latest crop of EU funded aquaculture related research at SAMS sees the Invertebrate Biology and Mariculture group returning to its core theme of sea urchin cultivation. SPIINES 2 or '*Sea urchin Production In Integrated systems, their Nutrition and Roe Enhancement*' addresses the remaining challenges to the successful and economic production of sea urchins, cultivated for their roe, which is a luxury food product. Bringing together the leading SME's in sea urchin culture in Europe and experienced researchers from the UK, Israel and Norway, the project focuses on the two most commonly fished, farmed and consumed sea urchin species in Europe; *Paracentrotus lividus* which is at the northernmost limits of its range here in Scotland, and *Strongylocentrotus droebachiensis* common along the Norwegian coast and fished for its roe on the Atlantic and Pacific coasts of North America.

To improve economic viability there is a need to reduce the time it takes for urchins to reach market size. There is a need to develop the grow-out technology;



SPIINES partners discuss sea urchin hatchery techniques

the culture systems proposed in this research are all integrated, linking sea urchin culture to that of Atlantic salmon as well as with mussels. The aim is to demonstrate cost-effective and low environmental impact cultivation methods as a result of the integration of farmed species.



Juvenile sea urchins produced in the SAMS hatchery

It is hoped the economic viability of species previously considered marginally profitable may improve, if feeding rates are enhanced and infrastructural costs reduced in integrated systems. Together these projects will provide some of the data to support the changes in ethos, legislation and outlook that are necessary if integrated aquaculture is to be embraced as an inherent part of responsible coastal zone management for long-term sustainability and profitability.

Acknowledgements

We thank our funders: REDWEED, Highlands and Islands Enterprise, The Highland Council and Loch Duart Ltd; AAAG, EC Interreg IIIB; SPIINES, EC CRAFT project and MERMAIDS, Argyll and Islands Enterprise and West Minch Salmon.

Further information

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ANNOUNCEMENTS

CLOSURE OF ARD TOE MARINE LABORATORY

On 11th April 2005, the Board of Directors of SAMS Ardtoe Ltd announced the closure of the Ardtoe Marine Laboratory as a research facility. Ardtoe was the original location of aquaculture research in Scotland, and a pioneer in whitefish husbandry techniques.

The Scottish Association for Marine Science (SAMS) formed SAMS Ardtoe Ltd in November 2003 to take over management and operations of the Ardtoe research facility following the decision of the former owners, the Sea Fish Industry Authority, to close the site. In the intervening 17 months, SAMS Ardtoe Ltd has been engaged in a process of revitalisation, changing the focus of the site from one that concentrated on applied aquaculture, to harnessing the potential of the unique facilities for experimental marine ecosystem and aquaculture science, within the context of the research objectives of the UHI Millennium Institute. High quality basic and applied research leading to a successful outcome of core grant funding in the 2008 Research Assessment Exercise was the foundation for this approach. Unfortunately the financial resources available are insufficient to underpin the core activities until 2008 and the Board of Directors has had to take

the very difficult decision to cease operations at the site, despite considerable effort by all the public sector agencies in attempting to avoid this outcome.

SAMS fully understands that this decision is inevitable given the financial position and the lack of strategic support for the site. SAMS very much regrets that this decision has had to be taken, particularly at a time when the sustainability of human activities in the marine environment is becoming recognised as being of critical importance, both to the integrity of the natural environment and to the economic activities, and communities that depend on it.

SAMS also regrets the loss of the largest facility for experimental marine research in the UK academic sector, and the blow that this represents to marine science in Scotland. Nevertheless, SAMS remains committed to improvements in the marine science infrastructure and expertise in Scotland and the delivery of high quality science that will contribute to the sustainable use of the marine environment. SAMS operations at the Dunstaffnage Marine Laboratory near Oban are unaffected by the closure of the Ardtoe facility.

NEWS FROM LANTRA

New websites

To address the recruitment issues facing employers in the environmental and land-based sector, Lantra has recently developed two new careers websites - one for young people (www.ajobin.com) and one for mature entrants (www.afuturein.com). These sites will be a valuable resource for individuals looking for information on training, qualifications and the skills required for employment in the environmental and land-based sector. Sections of the sites are still under development, but we welcome comments on the current information available. Work has also begun on careers brochures to promote aquaculture and fisheries management.

Aquaculture benefits from Scottish Skills Fund

Another cohort to benefit from the Scottish Executive's Skills Fund management training pilot began their training last month. With a snowy Ben Nevis as their backdrop, five people from the aquaculture industry met to learn communication and team development techniques. Over the next two-months they will continue their management learning remotely, learning online with the support of a distance tutor. This group brings the total to start the Land-based Pilot of the Institute of Leadership and Management course to 36. For further information email: morag.holdsworth@lantra.co.uk

Aquaculture and fisheries research project

In a skills research project funded by the Welsh Development Agency, 40 businesses throughout Wales were given a SkillCheck to assess skills development needs and to collate labour market information. The research results published by Lantra will enable the Welsh Development Agency together with other organisations to shape and develop future work to meet the requirements of businesses within the Aquaculture and Fisheries sector. For more information contact Philippa Davies on 07867 908188 or philippa.davies@lantra.co.uk

Employers Drive Change As Government Unveils Skills Priorities

In March this year, representatives from Skills for Business - the new network of employer-led Sector Skills Councils of which Lantra is part - met with HM Government to drive forward the future of skills provision in the UK. A reception at 11 Downing Street, attended by the Chancellor Gordon Brown and Secretary of State for Education and Skills, Ruth Kelly, was held to mark the progress of the Sector Skills Agreements which will have lasting implications for tackling skills issues within the environmental and land-based sector.

The new Sector Skills Agreements, strongly endorsed by the Government's Skills White Paper, ensure that education, training and business support more closely meets the real needs of employers. All Sector Skills Councils, including Lantra in partnership with employers, unions, trade organisations, colleges and universities, funding bodies, and qualifications authorities, are developing them. Peter Martin, Chief Executive of Lantra, said: "Lantra is leading the environmental and land-based Sector Skills Agreement. The process has started and Lantra is now carrying out the biggest single review of skills needs and learning provision that the aquaculture industry has ever seen. This has been an opportunity for the industry to voice what it really wants and needs from the education, training and business support sector to achieve continued growth and success. There is very real evidence that government and public agency policy is shifting to become more responsive to the needs of business."

Further information

The latest issue of Lantra's e-bulletin is now available at: <http://www.lantra.co.uk/news>. It includes the latest news on how Lantra is working with employers from our sector's 17 industries, as well as with government, funding agencies and other key partners across the UK, to address skills issues and increase business performance within the sector.

SCOTTISH AQUACULTURE RESEARCH FUNDING

THE Scottish Aquaculture Research Forum (SARF) has announced £400,000 worth of research grants, which have been allocated as a result of the first targeted call for research proposals in September 2004.

A spokesman said: "A number of high calibre proposals were received and the successful applicants will be starting work early in the New Year. Five projects were selected with a total cost to SARF of almost £300,000, with an additional £120,000 being provided by Seafish, Defra and other sponsors."

SARF was set up as one of the key priorities of the Scottish Executive's Strategic Framework for Aquaculture. SARF is an independent body founded as a company and a registered charity in Spring 2004. Since that time the SARF Board, chaired by Professor William Ritchie of the University of Aberdeen, has developed the infrastructure and financial backing to begin the task of commissioning research and development projects that will help to underpin the sustainable future of the aquaculture industry in Scotland.

The priorities for the first round of funding have focused very much on environmental issues that have implications for all stakeholders. The projects

supported include research into optimising the selection of sites for aquaculture, the potential consequences of amalgamating fish farms, improving the integration of data on fish farming through the novel use of Geographic Information Systems and, two projects that will focus on improving fish health.

As confidence in the company grows, the Directors hope to increase the SARF R&D budget. Building on the success of this year's funding round SARF has issued further calls for proposals in 2005 in the following areas:

1. The development of modelling techniques to improve predictions of assimilative capacity of water bodies utilised for marine caged fish farming – Phase 1
2. Review of Environmental Quality Standards (EQS) for use in assimilative capacity model development.

The deadline for the submission of applications for these was 24th March 2005.

Further information

SARF website: <http://www.sarf.org.uk>

NEWS FROM SEAFISH



CD-ROM to benefit UK and Irish shellfish industries

A CD-ROM designed to provide invaluable information to the UK and Irish shellfish industries was launched in Oban in November by Seafish and BIM, the Irish Sea Fisheries Board.

A Guide to Commercial Bivalve Molluscs has been developed in response to the information needs of the industry. The easy-to-navigate CD-ROM has a wide-ranging content, which includes harvesting techniques, environmental issues, innovative marketing ideas, recipes for the consumer and unique underwater footage. It covers a range of areas common to both the UK and Irish industries, and its accessible, user-friendly format will ensure it appeals to a wide audience.

Speaking at the launch, Seafish development director Jon Harman said, "The Bivalve Mollusc CD-ROM is an invaluable tool for those working in the shellfish industry. This electronic encyclopaedia contains advice from a wide variety of experts in the bivalve mollusc sector. Not only that but it has been produced in an accessible format which all those involved in the industry, including new entrants, who have little or no understanding of the sector, will find easy to understand."

To request a copy of the CD-ROM, please contact Deborah Dalton at Seafish on 01482 327837 or email d_dalton@seafish.co.uk

Seafish sponsor Abalone Workshop

Seafish sponsored a workshop on abalone culture in the UK in conjunction with the South West Abalone Growers Association. The venue for the

workshop, which was held in November 2004, was Plymouth University and it was attended by industry members from the UK and France; regulatory/support organisations such as Seafish, Devon Sea Fisheries, Cornwall Sea Fisheries, CEFAS, Devon Wildlife Trust, SW Pesca as well as other invited consultants and researchers.



Andy FitzGerald addresses the workshop

Martin Syvret, Inshore Advisor at Seafish, opened the workshop with a presentation on the current status of abalone culture in Ireland, Europe and the UK. Information was given on current market prices as well as the prospects for export to Asian markets.

Ted Smith then gave a video presentation of abalone culture techniques in Japan, California and Korea. This video highlighted a range of systems that were being used to raise abalone seed for both the restocking of wild stocks and on-growing purposes. The techniques used are very similar to those used in UK hatcheries although the scale of the systems viewed was vastly different with an emphasis on the use of enormous raceway tanks. The life histories for the different species of abalone were all broadly similar to that of our own European abalone with the same essential stages in spawning, fertilisation, larval development, settlement and on-growing. All the countries shown in the video utilised a variety of both natural seaweed and artificial diets at different stages in the life history.

Andy FitzGerald, Chairman of SWAGA, then gave a review of the current limitations to expansion of the industry in the UK and also where the opportunities lie with this high value product.

This then led to discussion amongst the delegates of a wide range of subjects including the opportunities for using no take zones for static gear for abalone culture; sustainable seaweed culture; re-circulation technology; disease issues with respect to seed imports/exports and diversification for inshore fishermen.



Abalone in an on-growing system

Seafish have produced a CD for this workshop that will include proceedings, presentations, technical information, and proceedings of the 2003 BIM workshop together with an overview of Irish abalone farm visits.

For further information or to obtain a copy of this CD please contact Martin Syvret on 078760 35746; m_syvret@seafish.co.uk or Andy Fitzgerald on 01752 339005; andyfitzy@compuserve.com.

New team to focus on inshore fisheries

At the Association of Scottish Shellfish Growers' conference in November 2004 Seafish announced the investment of over £3/4 million in a new team to focus on the important inshore sector of the fishing industry. Seafish's new Inshore Group will work closely with industry, environmental groups and government, as well as local managers and regulators to help develop inshore fisheries and aquaculture.

The sector already supports at least 45 per cent of total UK fisheries employment, and has the potential to provide even more high value fishing jobs into the future. It also contributes to the value of culture and tourism of many small communities dispersed around the UK coast.

The Prime Minister's Strategy Unit *Net Benefits* report, published earlier this year identified development of the inshore sector as one of the opportunities. Government will respond to this report next year.

"Through the creation of this Inshore Group Seafish is helping to improve marketing to UK consumers, processors and retailers and to increase demand for the higher value species that are currently largely exported.

"This strategy is in keeping with recommendations of The Strategy Unit report on the fishing industry.

They also recommend that the industry should exploit mariculture opportunities and co-operate with other users of the local marine environment. Our new Inshore Group will help to achieve this,” explains Dr Sue Utting, who will manage the group.

Members of the group have particular expertise in:

- inshore shellfisheries;
- marine fish and shellfish aquaculture;
- molluscan depuration;
- crustacea handling and storage from catch to market;
- economic review and assessment.

The group will also draw on expertise from across Seafish on other aspects of inshore fisheries and to help the sector meet the Strategy Unit’s recommendations. This includes assisting with bids for government and EU funding, something which this sector has found difficult to secure in the past, providing the team with economic advice and identifying marketing opportunities. For more information contact Kirsty Innes tel: 0131 524 8656, email: k_innes@seafish.co.uk.

Top seafood businesses in the UK announced

The best seafood business in the industry gathered at an Oscar style awards ceremony in London on March 9 where the winners at the first ever Seafood Awards, organised by the Sea Fish Industry Authority (Seafish), were announced.

Compered by broadcaster and TV presenter Sandi Toksvig, the cross sector awards, which took place at the Royal Lancaster Hotel were aimed at rewarding the achievements of the best in the seafood sector, from catching through to processing, retail to food service.

Seafish Chairman Andrew Dewar-Durie said: “Congratulations to all the winners at this year’s Seafood Awards. Seafish have been extremely impressed by the high level and quality of entries that this inaugural event has attracted.



Seafish Chairman, Andrew Dewar-Durie speaks at the inaugural Seafood Awards in London

He continued, “We are delighted to be playing such a central role in encouraging enterprise, and celebrating innovation and excellence in all sectors of the UK seafood industry.”

The winners in each of the sixteen award categories are as follows:

- Catching for the Market (Sponsored by Seafood Scotland) – Loch Torridon Nephrops Management Group, Strathcarron, Scotland
- Technical Innovation – Nesco Weighing Ltd, Hull
- Seafood Retailer of the Year (Multiple) – Waitrose
- Seafood Retailer of the Year (Independent) – Ramus Seafoods, Harrogate
- Best Individual Store Seafood Retailer (Multiple) - Asda, Southport
- Best New Seafood Product, Shellfish – Scottish Live Oysters – Scottish Shellfish Marketing Group Ltd
- Best New Seafood Product, Whitefish – Sainsbury’s Smoked Haddock Fishcakes
- Best New Seafood Product, Pelagic - Tinned Smoked Pilchards, The Pilchard Works, Newlyn, Cornwall
- Best New Seafood Product, Salmon –Tesco 2 Salmon En Crouete – Young’s Bluecrest, Grimsby.
- UK Seafood Restaurant of the Year (Sponsored by the AA) - Eeusk, Oban, Argyllshire, Scotland
- UK Seafood Pub of the Year (Sponsored by the AA) – Penhelig Arms, Aberdyfi, Wales
- Trainee of the Year, Onshore – Andrew Crook, Crooks Fish and Chicks, Preston, Lancashire
- Trainee of the Year, Offshore – Michael Anderson, Shetland
- Best Seafood Week Campaign – Humber Seafood Group, Hull
- Aquaculture Producers Award – MYTI Mussels, Bangor, Wales
- Outstanding Achievement – Rick Stein, Cornwall.

For further information please contact Grant Collier or Andre Daffon on 01322 611339 or Anne Kennedy on 0131 524 8658.

Seafood Week 2005



The dates for Seafood Week 2005 have been confirmed as 7-14 October.

Seafood Week, co-ordinated by Seafish, is one of the biggest, exciting and most inclusive national events in the calendar with seafood businesses and organisations across the UK working together to celebrate seafood.

The Week has been running for five years and has been fronted by a range of seafood experts, including Rick Stein, Gordon Ramsay and Antony Worrall Thompson.

Seafood Week 2004 was a huge success. Thousands of businesses, including supermarkets, pubs, restaurants, fish and chip shops and hotels took part in Seafood Week 2004 and many of them saw an increase in sales.

Seafish is confident it can build on the success of last year's event. Seafish is also working together with supermarkets and key players in the foodservice sector to promote seafood to the consumer. Sales promotional packs will be produced to help businesses with promotional activities.

To pledge your support for Seafood Week 2005 please email seafoodweek@seafish.co.uk or call 0131 524 8641.

Further information, including ideas for events and Seafood Week logos, can be found at www.seafoodweek.co.uk.

New funding scheme to help address the Animal By-products Regulations

Seafish has launched a new funding scheme to help the seafood industry address important regulations on the disposal of animal by-products.

The Animal By-products Regulations 2003, which have been introduced throughout the UK to enforce European legislation, control the collection, transport, storage, handling, processing and use or disposal of animal by-products.

Under its new Waste Utilisation Development Programme, Seafish will allocate £30,000 to help the seafood industry address these regulations through initiatives aimed at developing new routes to handle waste from the seafood processing industries. Successful projects will be given up to £3,000 for a maximum of 12 months and must have a minimum of 50 percent match funding in cash or in kind. Initiatives might include the development of commercially viable methods for using waste, disposing of waste, cleaning shell waste or collecting waste from regions or smaller processors. The closing date for applications was 8th April. Although principally aimed at members of the industry, applications were also welcome from the academic community provided they could demonstrate direct industry participation in the project.

NEWS FROM THE TRADE ASSOCIATIONS

SHELLFISH ASSOCIATION OF GREAT BRITAIN (SAGB)

The Shellfish Association of Great Britain usually produces a brief report of recent activities for Shellfish News. For this copy, however, the Association has been too pre-occupied resolving the problems surrounding the appearance of atypical signs during the DSP mouse bioassay, both at a UK and international level, to have been able to prepare a full article.

The Association believes the issue to be close to resolution and hopes that changes to the testing regime will be in place to be presented in the November issue. An article covering the involvement of the SAGB in

research at Southampton Oceanography Centre on native oyster restoration, funded under the Native Oyster Species Action Plan (NOSAP) is included in this issue.

Further information

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

ASSOCIATION OF SCOTTISH SHELLFISH GROWERS (ASSG)

VIEWS FROM THE ASSG

A successful conference

The 2004 ASSG International Conference enjoyed two additional activities in the form of the SFIA/BIM launch of the interactive CD "A Guide to Commercial Bivalve Molluscs" and the regular meeting of the full Bureau of the European Mollusc Producers Association (EMPA).

All three events were successfully completed, I believe, although my memory of them is somewhat chaotic as organisation and management of the various activities kept me fully occupied for the week!! In particular, I have received positive reports on the Conference (themed on 'Innovation' this year) from ASSG members, the most important audience as far as I'm concerned! But there has also been positive feedback from non-member participants and speakers, so we must be doing something right!

I would like to thank all those individuals who helped to organise and run the Conference and make the event a success; and I'd also like to thank those organisations who contributed resources - equipment, people and funds - to the 'bash' (namely SFIA, BIM and FIFG through SEERAD).

There is a CD-ROM of the Conference 'proceedings' available, which will allow those who failed to make it see what they missed, and perhaps to make a note to make the extra effort in 2005!

Consultations

The final Quarter of 2004 was exceptionally busy, with several important consultations underway. These have ranged from Q&S III (the review and assessment of the capital budget for 'Scottish Water' for the period 2006 – 2014), through implementation of the various aspects of the Water Framework Directive, to the next round of Designations of Shellfish Growing Waters and the prospective reincarnation of European funding for the sector (the 'European Fisheries Fund' which will replace FIFG).

This in addition to the normal round of meetings and discussions covering developments relating to our shellfish interests, including a meeting with the independent reviewer (Baroness Dean) of the FSA's performance in the 5 years since it was created. As you might expect, I explained in detail the concerns of shellfish farmers over the Agencies' efforts in both microbiological and biotoxin areas (classifications and monitoring respectively).

Campaigns

Looking back on 2004, I would suggest that the most significant achievement of the Association, acting in concert with colleagues in the UK and across the European industry, was the successful lobbying over the proposal by the Community Reference Laboratory for Microbiology (CEFAS, Weymouth) that a new indicator of bacteriophage should be introduced for depuration facilities, with minimum criteria of 5 days at a temperature in excess of 20 °C. The impracticality of the proposal (particularly for northern Member States), the diversion of productive investment funds, the lack of evidence of effectiveness in reducing virus-related outbreaks and the co-ordinated trans-national lobbying combined to persuade DG Sanco that 'there must be a better way'!

And while the Tiered Marketing regime for scallops with ASP failed to be approved by Scottish Executive Ministers, the current pragmatic approach by the FSA has enabled the sector to survive, while further efforts are applied behind the scenes. One example is the recently completed research study into scallop 'portion size' across 5 Member States for both home and catering sector consumption. The results clearly indicated that adductor and gonad portions are significantly below the 250 gram portion (based on mussel meats) used in assessing the risk of domoic acid to consumers. As a result, we hope that further discussions during 2005 may lead to a revision in the Action Level for domoic acid presence in scallops.

Other developments in 2004

Other ASSG developments during the past year include the election of John Brewer (Isle of Shuna Shellfish) to membership of the ASSG Management Committee at the AGM in May, as well as the resignation by Judith Vajk from the burdens of Editorship of 'The Grower' after seven years of commitment and effort, and her able replacement by Janet Brown. The refreshing of the presentation of 'The Grower' is already apparent, and I guess we can look forward to more changes in 2005!

Classification

The First Quarter of 2005 is now behind us, with the trade association almost inevitably drawn into a series of consultation/advisory/ preparatory Workshops, meetings and discussions.

This year the publication of the 'New Year's' Harvesting Area Classifications has increased this

workload, as there has been a perceived increase in downgrades compared with 2004 across the majority of areas – overall the number of sites with a less favourable classification has more than doubled, from 24 to 65, that is from 19% to 47%. To put it another way, almost half of all sites have been downgraded as a result of this year's assessment. This is so unusual that it is essential to investigate whether these changes are real or perceived.

All members with a substantive case to argue, with data to indicate that *E. coli* readings have not changed significantly over the past twelve months, have been encouraged to utilise the well-documented Appeals procedure established by the FSAS.

However, assuming that the majority of downgrades are accurate reflections of the verified and credible sampling results, then the implication is that there has been a significant deterioration in water quality. Ironically this has occurred at the time of the 'Quality & Standards III' process (Q&S III), which establishes the future budget (2006 – 2014) for 'Scottish Water', the organisation responsible for sewerage treatment and disposal.

Although Scottish Executive Ministers have agreed to the Q&S III proposals for safeguarding designated shellfish waters, this will clearly be inadequate in light of these data. As a result, I am seeking urgent formal discussions with SEPA, the competent authority for designations under Directive 79/923, SEERAD and 'Scottish Water', the operating agent. A meeting with FSAS is also planned, following the outcome of the appeals process.

Biotoxins

I have gained a clear impression that there is a major acceleration in research outcomes relating to biotoxins, especially in terms of analytical methods – the wish to move away from the 'mouse test' expressed by DG Sanco representatives of the European Commission has generated significant amounts of creative energy amongst the scientific community, from Jellett Rapid Test in Canada to BioSense in Norway, as well as the usual candidates in New Zealand and elsewhere.

The Canadian NRC is the leading source for Certified Reference Material (CRM) for much of the world's regulatory infrastructure (eg National Reference Laboratories in the EU), as well as having an active and industry oriented shellfish physiology section. Following Commission Decisions 225 and 226 in 2002 (tiered testing for ASP in scallop parts and 'unbundling' of DSP into its component toxins with the potential for non-bioassay analysis), the momentum in favour of chemical testing methods for the exhaustively extensive list of biotoxins has focused a lot of attention on CRMs.

These chemical analytical methods require calibration solution CRMs and shellfish tissue CRMs (to test the entire method for accuracy), prepared with careful attention to toxin purity and stability, including cross-comparisons using different procedures such as gravimetry, nuclear magnetic resonance spectroscopy, liquid chromatography, capillary electrophoresis, etc, etc! Without these standards it is impossible for labs to perform accurate analyses for regulatory purposes. Which is where the NRC comes in, as suppliers to much of the world's regulatory labs, including the EU's.

At the moment NRC offers CRMs for ASP (2), DSP (2), PSP (10) and 4 for other toxin, including pectenotoxin-2 and Yessotoxin. However, I have been told that the yessotoxin calibration solution suffers from a stability problem, which means that the CRM is not practically available yet – however that "hiccup" is expected to be solved within the year.

Which would be helpful to industry, as there is a widespread belief that yessotoxin, which is relatively non-harmful to human health, is a major contributor to DSP positive results and therefore the separate analysis of this toxin would reduce the incidence of 'perceived' DSP.

The NRC Programme is currently developing RMs for PSP and AZA, as well as working on a CRM for PTX11 and DTX1, and is seeking collaboration, partnership and support from European sources. It should be of concern to the European industry that although FRS MarLab Aberdeen has been a partner in some developmental work, overall more financial support has come from Asia than Europe. The call from NRC is one of appealing for collaboration between labs, to avoid re-invention of the wheel, in the form of complementary work programmes or pooled resources – that would avoid the current difficulty of securing EU funding for a Canadian laboratory while facilitating the accelerated development of these essential tools for the much sought after move from the mouse test to chemical methods. I believe that we should support such inter-lab collaboration wherever appropriate.

Meetings

I attended a workshop on "Research to support Sustainable Aquaculture" in Seville January 2005. A report on this appears elsewhere in this issue of Shellfish News.

The date/venue/Speaker for this year's ASSG AGM have been determined, namely the afternoon of Friday 6th May at Dunstaffnage Marine Laboratory near Oban. The Keynote Speaker will be Alessandro Piccioli, from the Aquaculture Unit of DG Fisheries of the European Commission, who will address the numerous Commission initiatives which have relevance to our sector, ranging from the "Strategy for the

development of a sustainable European aquaculture' through support for the 'Women Achievers in Aquaculture' project (in which the ASSG participated) to the planned replacement of FIFG with a 'European Fisheries Fund'.

Further information

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MONITORING REPORTS

THE MARINE BIOTOXIN MONITORING PROGRAMME FOR ENGLAND AND WALES: 2004 –2005

Ben Stubbs, Steve Milligan and David Lees, CEFAS

Summary

This report on the results of the Marine Biotoxin Monitoring Programme for England and Wales covers the period from 1st April 2004 to 31st March 2005. During this period, 314 water samples were analysed from 40 sites within 21 harvesting areas, and 949 shellfish samples were analysed from 119 sites within 64 harvesting areas.

Paralytic Shellfish Poisoning (PSP) toxins were detected in two samples this year. These two positive samples came from Holy Island, Northumberland and the Fal Estuary, Cornwall, and were positive for one week only in May and June respectively. Neither of these samples was above the Maximum Permitted Level (80µg/100g flesh). PSP toxins have been detected in samples from these sites in previous years.

Diarrhetic Shellfish Poisoning (DSP) tests were positive in fourteen samples from 8 separate sites, 10 of these results were atypical positive, and 4 were classic DSP positive. The areas that recorded positive atypical DSP results were: The Wash, The Thames (including the River Swale) and Milford Haven. Atypical positive results have been reported from all of these areas in previous years.

Classic DSP was detected in a number of samples from the Morecambe Bay/Lune area during July 2004. Amnesic Shellfish Poisoning (ASP) toxins (domoic and epi-domoic acid) were detected in eight samples from five areas: The Wash, The Thames, Fowey Estuary and offshore Scallop grounds EC20 and EC35. ASP was not detected above the Maximum Permitted Level (20 µg g⁻¹) in any sample. The highest level (4.48 µg g⁻¹) being found in a sample of Scallops from EC35 in November 2004.

Introduction

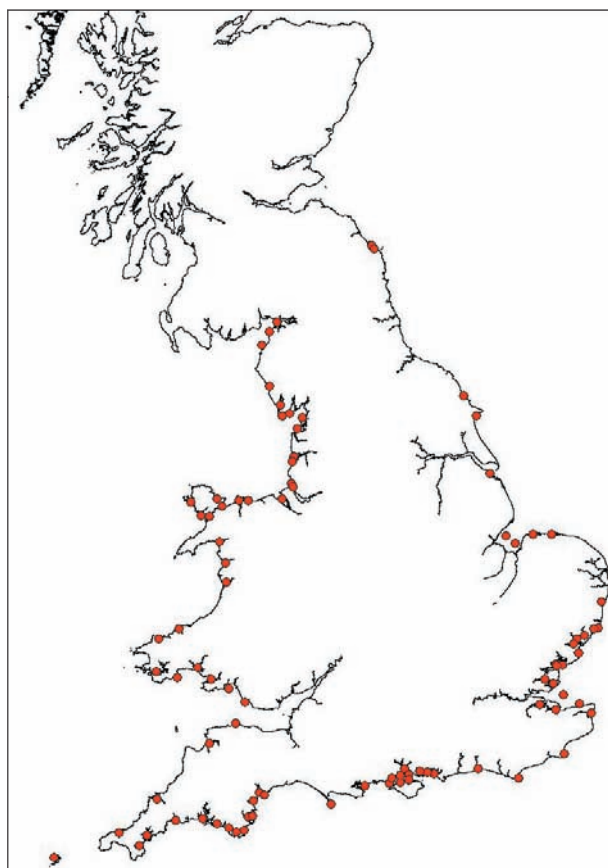
The operation of a monitoring programme for algal biotoxins is a requirement of the Shellfish Hygiene Directive 91/492/EEC, which is implemented in England and Wales by the Food Safety (Fishery Products and Live Shellfish Hygiene) Regulations 1998 (as amended). This legislation requires EU member states to monitor for the possible presence of toxin producing phytoplankton in production and relaying areas, and biotoxins in live bivalve molluscs.

Within England and Wales, monitoring for algal biotoxins is divided into two programmes, the flesh monitoring programme, where samples of shellfish from designated shellfish harvesting areas are tested, and the water monitoring programme, where water samples are collected from fixed sites within selected harvesting areas. The monitoring year runs from April to March, and wherever possible, the flesh and water sampling points correspond with the microbiological sampling points, as these are well defined, and lend homogeneity to the different programmes.

The flesh monitoring programme for 2004 - 2005 was based on each classified shellfish harvesting area, and included all areas in England and Wales where commercial harvesting occurs. Samples were collected and submitted to the testing laboratories on a monthly basis, except in areas with a history of shellfish biotoxins or toxic phytoplankton, where samples were collected fortnightly during weeks 14 - 39 (April to September inclusive). Where positive results occur, the affected sites continue to be tested on a weekly basis, at least seven days apart between samples, until two consecutive negative results are obtained.

The water monitoring programme for 2004 - 2005 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 the monitoring programmes are effectively carried out, and the CEFAS Weymouth Laboratory is responsible for identifying the sample areas and co-ordination of the programme. The relevant Local Authorities (LA's) are responsible for collecting the water and flesh samples from designated sites, which are then sent to the appropriate testing laboratory. For the period covered in this report they were the CEFAS Weymouth Laboratory (for flesh analysis for ASP, DSP and PSP) and the CEFAS Lowestoft Laboratory (for water sample analysis).

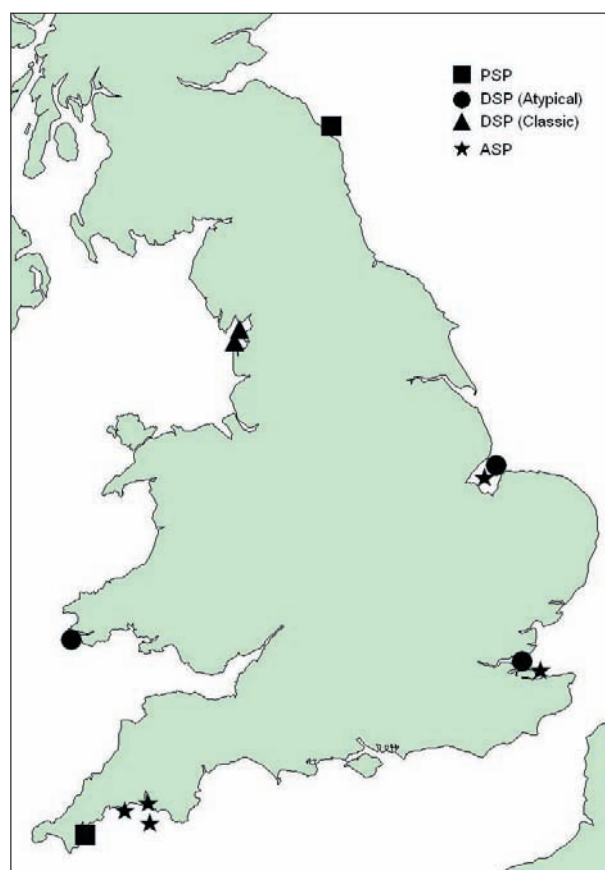


Designated bivalve mollusc production areas in England and Wales

Results of the 2004 - 2005 sampling programme

Sample collection and analysis

For the monitoring year commencing 1st April 2004, sixty-four harvesting areas were included in the primary shellfish testing programme, and 21 harvesting



Algal biotoxins detected in shellfish from England and Wales during 2004 - 2005

areas in the water testing programme. Additionally, there were two ports from where samples of Scallops were obtained. In total, shellfish from 119 sampling locations were tested from the 64 harvesting areas. During the period covered in this report, a total of 314 samples were tested for the presence of potentially toxic algae, as part of the water testing programme.

The flesh testing programme analysed 949 shellfish samples, performing 841 tests for ASP, 847 tests for DSP and 876 tests for PSP. This gave a total of 2,564 test results for shellfish samples in the fourth twelve-month period of the programme.

PSP results

A total of 876 tests for PSP were carried out during the monitoring year. PSP toxicity was detected in two single samples of Mussels from Holy Island, Northumberland and Fal Estuary, Cornwall. Both of these positive results were below the MPL. The levels of toxicity detected were 68 µgSTX/100 g in the sample from Holy Island, and 48 µgSTX/100 g in the sample from the Fal Estuary. These results are not unexpected, as they occurred in what is predicted as the peak time for PSP incidence, in areas with a history of PSP toxicity in shellfish.

Alexandrium spp., the organism responsible for PSP, was detected in six water samples during the year, but there was no correlation between these samples and toxicity in shellfish. The highest level of *Alexandrium* spp. detected was 950,000 cells per litre, in a sample from Weymouth Harbour, collected in June 2004.

DSP results

A total of 847 tests for DSP were performed this monitoring year. Toxicity was detected in 14 samples from 8 sites, a marked decrease in prevalence compared with previous years. Of these 14 results, 10 were atypical DSP positive, with the remaining 4 being classic DSP positive. The main areas affected by atypical DSP were the Wash and the Thames. Samples from the Wash only recorded positive results between April and June 2004. Samples from the Thames area recorded atypical positive results in May 2004, and again between January and February 2005. The other area that recorded an atypical positive result was Milford Haven, however, this area recorded a positive result for just one week in May 2004.

The number of samples that tested positive for classic DSP was low again this year, with samples from two adjacent areas recording four positive results in July 2004.

Of the 314 samples analysed in the water monitoring programme, *Dinophysis/Prorocentrum* spp., the causative organisms for DSP, were detected in just six samples. There was no correlation between any of these water results and toxicity in shellfish. Only one of these samples was above the action limit - a sample collected from Blyth in July 2004, recording a count of 280 cells per litre.

ASP results

A total of 841 tests for ASP were carried out during this monitoring year. Toxicity was detected in 8 samples from 5 different areas; the Wash, the Thames, Fowey Estuary and offshore Scallop grounds EC20 and EC35. However, none of the positive samples exceeded the action level for ASP. The highest level of toxicity recorded was 4.48 µg g⁻¹, in a sample of whole Scallops collected in November 2004 from offshore Scallop ground EC35 (off the South West Coast of England), landed at Plymouth. The majority of samples in which ASP was detected were whole Scallop and Cockle samples (3 ASP positive results each).

Cells of *Pseudonitzschia* spp., the group of organisms responsible for ASP, were detected in 28 water samples. The action limit was not exceeded in any of these samples. Again, no correlation was found between these results and toxicity in shellfish.

Discussion and Conclusions

PSP incidence was low again this monitoring year, with just two of the 876 samples tested recording positive results. These results continue to demonstrate the low incidence of PSP in English and Welsh waters in recent years.

Atypical DSP positives continued to be detected in samples (predominantly Cockles) submitted for testing throughout the monitoring year. As with the previous reporting year, the occurrence of atypical positive results was low compared with preceding years. Whilst the incidence of atypical positive samples has diminished, sub-lethal atypical signs continue to be present in a significant number of Cockle, and occasionally Mussel samples.

CEFAS are continuing research into this phenomenon both independently, and in collaboration with other statutory and research organisations.

Classic DSP was detected in just four samples this year, all from the same geographical area in July 2004. These positive results continue to demonstrate the low incidence of DSP in English and Welsh waters in recent years.

As with PSP and DSP, ASP incidence was low again this year, although as with previous years, the majority of positive results came from whole Scallop samples.

Acknowledgements

We would once more like to thank all the sampling authorities that have collected the water and shellfish samples for analysis during the past year, particularly the authorities that have collected additional material for research on our behalf.

The success of the biotoxin monitoring programme relies upon the co-operation between the sampling authorities and the testing laboratories. The Local Authorities and their agents have been unfailingly helpful.

Further information

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THE MARINE BIOTOXIN MONITORING PROGRAMMES FOR SCOTLAND: 2004 - 2005

Colin Megginson and Eileen Bresnan, Fisheries Research Services, Marine Laboratory, Aberdeen.

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.

Monitoring is carried out on samples of bivalve molluscs collected from classified harvesting areas, and from offshore scallop fishing grounds. Sampling is undertaken throughout the year. The programme is based upon a sampling frequency of monthly during the period October to March, and fortnightly or monthly during the period April to September. 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. Sampling frequency may be increased to weekly if toxins are detected, and species other than bivalve molluscs can be tested.

During the period 1 April 2004 to 31 March 2005 a total of 587 water samples were received from 20 coastal and 3 offshore sites around the Scottish coast and analysed for the presence of *Alexandrium* spp., *Dinophysis* spp., *Pseudo-nitzschia* spp., *Protoperidinium* spp., *Lingulodinium polyedrum*, *Protoceratium reticulatum*, *Prorocentrum lima* and *Prorocentrum minimum*. A total of 5,288 shellfish samples were analysed, of which, 1,551 were analysed for Paralytic Shellfish Poisoning (PSP) toxins, 1,310 for Diarrhetic Shellfish Poisoning (DSP) toxins, and 2,427 for Amnesic Shellfish Poisoning (ASP) toxins.

Results of the 2004 – 2005 Monitoring Programmes

Phytoplankton Monitoring

Alexandrium spp. cells were observed in low numbers in May and June along the east coast, extending into Orkney and Shetland, and at selected sites along the west coast. The maximum number of *Alexandrium* cells observed was in Vaila Sound, Shetland in August 2004 (1,900 cells l⁻¹).

Dinophysis spp. cell densities during 2004 were considerably lower than those observed during previous years. The maximum number of cells observed was in Scapa Bay in July 2004 (1,900 cells l⁻¹). The *Dinophysis* population was dominated by *D. acuminata*. *D. acuta* cell concentrations were observed to be lower with a maximum number of only 400 cells l⁻¹ observed (Southannan, September 2004).

Two distinct blooms of *Pseudo-nitzschia* cells were recorded during 2004/2005. A bloom of *P. delicatissima* 'type' cells (diameter <5 µm) was observed during April 2004/March 2005. Analysis of these samples using transmission electron microscopy (TEM) showed these populations to be composed of *P. cf. delicatissima* and *P. cf. pseudodelicatissima*. The maximum number of *P. delicatissima* 'type' cells recorded was at Loch Ewe in northwest Scotland (1,500,000 cells l⁻¹ in March 2005). An extensive bloom of *P. seriata* 'type' cells (diameter >5 µm) was observed around the Scottish coast during August/September 2004. Analysis using TEM showed these populations to comprise *P. cf. australis*, *P. cf. seriata* and *P. pungens*. The maximum number of *P. seriata* 'type' cells (350,000 cells l⁻¹) was recorded at Loch Spelve during September 2004.

Other potential toxin producing species were infrequently observed in samples from Scottish waters.

Shellfish

Inshore Harvesting Areas

There were no incidences of PSP toxin concentrations above the closure limit of 80 µg Saxitoxin equivalents per 100 g tissue (STX 100 g⁻¹) during the sampling period, although low concentrations were recorded at various sites around Scotland from May to August.

The occurrence of PSP toxins was first noted in early May when they were detected in mussels from Busta Voe at 28 µg STX 100 g⁻¹. By early June, toxins were detected at other mussel sites in Shetland with the highest concentration found at Busta Voe and Linga (65 µg STX 100 g⁻¹). PSP toxins were detected at two locations outwith the Shetland Isles, St. Abbs on the East Coast during late May (29 µg STX 100 g⁻¹ for mussels) and Scalpay, Skye during mid-June (40 µg STX 100 g⁻¹ for queens).

Whilst there were no positive PSP incidences, DSP toxins were detected in many areas from April through to September. DSP toxins were first detected in April in mussels from Loch Torridon, Ross and Cromarty. By mid-May DSP toxins were detected in other mussel sites at Quilse, Vailasound (Riskaness), East Burra Firth and Sandsound Voe in Shetland, Loch Ailort and Loch Linnhe, and in queen scallops (*Chlamys opercularis*) from Ura Firth, Shetland. In June DSP toxins were detected at Papa Little Voe, Galtaskerry, Gruiting (Seli Voe), Busta Voe and Linga, Seggi Bight and Baltasound harbour in Shetland, Scalpay (queens), Loch Greshornish and Islay in Skye, Loch Beag and Loch nan Ceol in Lochaber and Lamlash Bay (Arran). Additional mussel sites affected between July and September included Loch Stockinish and Loch Drovinish in the Western Isles, Loch Fyne, Loch Creran and Loch Striven in Argyll and Bute and Glenuig Bay (Lochaber). DSP toxins were also detected in Pacific oysters from Loch Harport, Sutherland and Colonsay, Argyll and Bute during August and September respectively. The FSAS implemented harvesting restrictions and VCAs where appropriate.

At inshore aquaculture sites, ASP toxin concentrations above the closure limit of 20 µg domoic acid (DA) g⁻¹ shellfish flesh were detected in whole king scallops from Scalpay, Skye in June (50 µg DA g⁻¹) and July (39 µg DA g⁻¹) and from king scallop gonads from Weisdale Voe, Shetland in November (51 µg DA g⁻¹). Harvesting restrictions were imposed as necessary, but in cases where whole scallops were affected, if gonad tissue toxin levels were below the regulatory limit, FSAS allowed shucked and processed material to be placed on the market.

Offshore Scallop Grounds

PSP toxins were first detected in whole scallops from East Coast grounds during April (37 µg STX 100g⁻¹ tissue). Seventeen other incidences of PSP toxin concentrations were detected during the reporting year from scallop grounds in the Shetland and Orkney Isles, South Minches and East Coast, but all were below the regulatory limit. The highest PSP toxin concentration was found during April in Shetland (73 µg STX 100g⁻¹

tissue). No PSP toxins were detected in scallops from the North Minch grounds.

Positive DSP results from whole scallops were found in East Coast and Moray scallops during the summer months when tested by bioassay. However, subsequent chemical assays found little or no trace of DSP toxins. DSP toxins were detected, using routine chemical analysis, from June to October in most areas but only at trace levels.

ASP toxins continued to cause problems in scallop fisheries, and were detected throughout 2004 - 2005. 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 all grounds by fishing vessels specifically chartered for this task by the FSAS. Of the scallop samples analysed, the highest concentration detected from scallop gonad tissue was >250 µg DA g⁻¹ from the South Minches and Orkney grounds and, in whole scallops levels were routinely greater than 250 µg DA g⁻¹ for both the North and South Minches for the whole year. For other areas whole scallops were routinely greater than 250 µg DA g⁻¹ from July onwards.

FSAS imposed fishery closures under the Food and Environment Protection Act (FEPA) 1985, in areas where ASP toxins in scallop gonad tissue exceeded the permitted level of 20 µg DA g⁻¹ 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 end of the monitoring year, April 04 – March 05, fifteen FEPA Orders were in force with processing restrictions on most other boxes.

Acknowledgements

The authors wish to thank Joyce Petrie, Nigel Brown, Sylvie Charles, Margaret McCann, John Turriff, Shona Kinnear, Dave Watson, Bob Anderson, Sheila Fraser, Nikola Smith and Lindsay Brown for their hard work in sample analysis and the production of results.

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 website later in 2005 and full reports will also be available on request from FSAS for a small administration fee.

THE UK *BONAMIA* AND *MARTEILIA* SAMPLING PROGRAMME 2004

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Introduction

The two most serious diseases of native oysters in Europe are Marteiliosis and Bonamiasis. In 2002 the UK achieved Approved Zone status in respect of these two diseases (Commission Decision 2002/300/EC). Approved Zone status recognises that it has been demonstrated, by regular and targeted sampling and testing, that the oysters in the specified areas are free from the causative organisms of these diseases. For *Marteilia refringens*, the whole coastline is approved and for *Bonamia ostreae* the whole coastline, except for three restricted areas, where the disease is found, is approved. These three 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 any 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 Laboratory, Aberdeen (in Scotland). Addresses are at the back of this issue of Shellfish News.

Sampling results for England and Wales in 2004

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 2004. 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 2004. No cases of *Bonamia* were detected in these samples.

All samples were also examined for *Marteilia*. This was not detected in any samples. The species of *Marteilia* that infects and kills native oysters is *M. refringens*. A closely related species, *M. maurini*, was detected for the first time in the UK in 2004, in a sample of mussels collected for contaminant analysis from a pier in Southampton Water. The level of infection was relatively low, eight out of 150 mussels collected were infected, and there was no apparent mortality of the mussels.

In Table 1 the results for 2004 are compared with those for the previous 4 years. The level of Bonamia infection in 2004 appeared to be slightly lower in farms but slightly higher in fisheries than in previous years. The average for all the sampled farm sites was 13.15% of oysters infected, compared with 21.86% the previous year and a ten-year average of 17.97%. The average for all the fishery sites sampled was 5.19%, compared with 4.98% the previous year and a ten-year average of 4.27%. The disease has not spread outside of the restricted areas in which it has been recorded in previous years.

Sampling results for Scotland in 2004

Approved Zone status for the notifiable diseases Bonamiasis and Marteiliosis was maintained in 2004. Testing confirmed the absence of these diseases in samples taken from all eight farm sites holding native oysters in Scotland. Two tests (spring and autumn) were carried out, with a sample of 30 oysters examined in each case.

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.

Table 1. Summary of results of native oyster sampling in England and Wales for Bonamia 2000-2004

Year	Restricted Area 1 The Lizard to Start Point		Restricted Area 2 Portland Bill to Selsey Bill		Restricted Area 3 Shoeburyness to Landguard Point		Unrestricted Areas	
	Sites	% infected (range)	Sites	% infected (range)	Sites	% infected (range)	Sites	% infected (range)
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
2003	11	0-25	23	0-33	15	0-62	6	0
2004	6	0-7	24	0-30	20	0-50	7	0

RESEARCH NEWS

Research News includes abstracts of recent work that may be of interest to the shellfish industries. These abstracts can be 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 sperm (1)

This paper describes a simple method for cryopreserving sperm of the Pacific oyster in quantities suitable for commercial spat production. The experiments demonstrated the key role of trehalose. Trehalose alone (at 0.45 M final concentration) was an effective cryoprotectant.

The addition of 2.5-15% dimethyl sulphoxide (DMSO) in combination with 0.45 M trehalose gave only modest improvement in fertility over trehalose alone. Seawater without cryoprotectant gave very poor results, but yielded some fertilization at very high sperm concentrations (7% at 100 million sperm per ml and 21% at three times this concentration).

Fertility of unfrozen sperm was 30- to 100-fold higher than that of sperm cryopreserved with DMSO and/or trehalose. For sperm cryopreserved in 4.5-ml cryovials, two simplified freezing methods gave fertilization rates equivalent to sperm cryopreserved by controlled rate freezing. These methods involved securing the cryovials to aluminium canes and then either placing them into a bath of methanol chilled with dry ice or holding them on a floating rack 3 cm above liquid nitrogen. A third technique of plunging the cryovials directly into liquid nitrogen gave reduced and variable fertility relative to the methanol/dry ice bath method.

The commercial applicability of the protocols was demonstrated on a batch of 30 million eggs. Fertilization with cryopreserved sperm yielded 81% fertilization, and larval rearing by normal commercial methods yielded 3.7 million settled spat, which was comparable to the 2.5 million spat from a parallel batch fertilized with unfrozen sperm.

Reference

ADAMS, S.L., SMITH, J.F., ROBERTS, R.D. (rodney.roberts@cawthron.org.nz), JANKE, A.R., KASPAR, H.F., TERVIT, H.R., PUGH, P.A., WEBB, S.C., KING, N.G., 2004. Cryopreservation of sperm of the Pacific oyster (*Crassostrea gigas*): development of a practical method for commercial spat production. *Aquaculture*, Vol 242, pp 271-282.

2. Cryopreservation of oyster sperm (2)

This paper describes the first studies on cryopreservation of sperm from tetraploid Pacific oysters and demonstrates that sperm from tetraploid oysters can be collected, frozen, and stored for production of triploid offspring. Such a product would be commercially useful.

The cryoprotectants propylene glycol and dimethyl sulfoxide were used. Tetraploids responded differently to diploids. The majority of tetraploid experiments resulted in less than 10% motility after thawing and less than 5% fertilization. This compares with the highest fertilization rate obtained for thawed sperm from diploid oysters of 96%. The highest fertilization rate obtained for thawed sperm from tetraploid oysters was 28%. However, the use of cryopreserved sperm from tetraploid Pacific oysters produced 100% triploid offspring by fertilization of eggs from diploid females, as determined by flow cytometry of larvae.

Reference

DONG, Q.X. (qdong@agctr.lsu.edu), EUDELIN, B., HUANG, C.J., ALLEN, S.K., TIERSCH, T.R., 2005. Commercial-scale sperm cryopreservation of diploid and tetraploid Pacific oysters, *Crassostrea gigas*. *Cryobiology*, Vol 50, pp 1-16.

3. Polyploidy in Pacific oysters

This study suggests that triploid Pacific oysters are not completely sterile and cannot offer complete containment of cultured populations.

Reproduction and chromosome inheritance in triploid Pacific oysters (*Crassostrea gigas* Thunberg) were studied in diploid female x triploid male (DT) and reciprocal (TD) crosses. Relative fecundity of triploid females was 13.4% of normal diploids. Cumulative survival from fertilized eggs to spat stage was 0.007% for DT crosses and 0.314% for TD crosses. Chromosome number analysis was conducted on surviving progeny from DT and TD crosses at 1 and 4 years of age. At Year 1, oysters from DT crosses consisted of 15% diploids ($2n = 20$)

and 85% aneuploids. In contrast, oysters from TD crosses consisted of 57.2% diploids, 30.9% triploids ($3n = 30$) and only 11.9% aneuploids, suggesting that triploid females produced more euploid gametes and viable progeny than triploid males. Viable aneuploid chromosome numbers included $2n + 1$, $2n + 2$, $2n + 3$, $3n - 2$ and $3n - 1$. There was little change over time in the overall frequency of diploids, triploids and aneuploids. Among aneuploids, oysters with $2n + 3$ and $3n - 2$ chromosomes were observed at Year 1, but absent at Year 4. Triploid progeny were significantly larger than diploids by 79% in whole body weight and 98% in meat weight at 4 years of age. Aneuploids were significantly smaller than normal diploids.

Reference

GONG, N., YANG, H., ZHANG, G., LANDAU, B.J., GUO, X. (xguo@hsrl.rutgers.edu), 2004. Chromosome inheritance in triploid Pacific oyster *Crassostrea gigas* Thunberg. *Heredity*, Vol 93, pp 408-415.

4. Long term effects of larval food supply

The effects of constant versus variable larval food availability on the marine mussel *Mytilus galloprovincialis* were assessed. In the laboratory, larvae were raised in four food concentrations: constant high, constant low, initial low switched to high, and initial high switched to low. After settlement, juveniles were planted out to the field for two weeks.

Changes in food availability affected larval size and lipid stores, and covariance between the two. Losses of juveniles were greater, and juvenile growth was lower, for those that had been reared as larvae in constant low food compared to those reared in constant high larval food. For the switched treatments, losses were greater, and growth was lower, for juveniles that had experienced initial low larval food relative to those that had experienced initial high larval food, regardless of average larval size or lipid stores from the different treatments. Thus, the timing of pulses of larval food may impact dynamics of later stages.

Reference

PHILLIPS, N.E. (Nicole.Phillips@vuw.ac.nz), 2004. Variable timing of larval food has consequences for early juvenile performance in a marine mussel. *Ecology*, Vol 85, pp 2341-2346.

5. Rearing scallops in the hatchery

Scallop farms in Norway rely exclusively on hatchery production of spat. Larval rearing is one of the most difficult parts of the production, and several experiments have been performed during recent years to improve the larval systems.

This paper describes results from commercial and experimental trials carried out between 1996 and 2001. Four different rearing systems were used: untreated batch cultures, chloramphenicol-treated batch cultures, flow-through cultures with filtered water and flow-through cultures with water from a biofilter. Overall, the chloramphenicol-treated batch cultures had significantly higher survival rates than the untreated and flow-through cultures. There were no significant differences in survival between untreated and flow-through cultures. The average survival rates for the untreated, treated and flow-through cultures were 6.8, 23.0 and 8.6%, respectively. No significant seasonal differences were found for the untreated and treated larval groups, whereas for larvae reared in flow-through systems survival was significantly higher in the winter than the spring. Overall best results were obtained during winter in years with high salinity water in the fjord.

Reference

TORKILDSEN, L., MAGNESEN, T., 2004. Hatchery production of scallop larvae (*Pecten maximus*) - survival in different rearing systems. *Aquaculture International*, Vol 12, pp 489-507.

6. Rearing whelks

Newly hatched juvenile whelks (*Buccinum undatum*) can be reared under laboratory conditions. Good growth was achieved when juveniles were fed on combined diets (blue mussel, cod, and fish pellets). Juveniles reached shell heights of 33 mm (fed the combined diet), 26 mm (blue mussel), 23 mm (cod), and 20 mm (fish pellets) after 14 months of feeding under ambient sea temperature and salinity. After 14 months juveniles fed blue mussel had the highest survival rates (67%) followed by those fed a combination of all other experimental diets (61%), cod waste (53%) and fish-feed pellets (46%). High mortalities were recorded in most treatments during the summer months, between June and September. This species appears to have an aquaculture potential, as juveniles readily feed on artificial diets at an early age, show high survival rates and could potentially reach market size in 2 years or less. The major constraint in realising this potential at present is the relatively low value of the species; if market values increased as a result of serious depletion of natural populations, hatchery production of juveniles for intensive aquaculture or restocking could become economically viable.

Reference

NASUTION, S., ROBERTS, D. (d.roberts@queens-belfast.ac.uk), 2004. Laboratory trials on the effects of different diets on growth and survival of the common whelk, *Buccinum undatum* L. 1758, as a candidate species for aquaculture. *Aquaculture International*, Vol 12, pp 509-521.

7. Transmission of Oyster Herpes Virus

Ostreid Herpesvirus 1 (OsHV-1) is detected in Pacific oysters at different stages of development. Viral infections are associated with high mortality rates in the spat and larvae. Furthermore, the persistence of OsHV-1 in asymptomatic adults has been demonstrated.

In the present study three successive generations of *C. gigas* (G(0) and G(1) parental oysters, G(1) and G(2) larvae) were screened for OsHV-1 by PCR. Viral DNA was detected in 2-day-old larvae, indicating that infection may take place at very early stages. Although this suggests a process of vertical transmission results are not fully consistent with this theory. The detection of viral DNA in parental oysters did not systematically correspond to a productive infection or result in a successful transmission to the progeny. Crosses involving an OsHV-1 infected male and a non-infected female resulted in hatching and larval survival rates statistically lower than those observed in the other types of cross. These results suggest that OsHV-1-infected females may transmit to their offspring some kind of protection or resistance against viral infection.

Reference

BARBOSA-SOLOMIEU, V., DEGREMONT, L., VAZQUEZ-JUAREZ, R., ASCENCIO-VALLE, F., BOUDRY, P., RENAULT, T. (trenault@ifremer.fr), 2005. Ostreid Herpesvirus 1 (OsHV-1) detection among three successive generations of Pacific oysters (*Crassostrea gigas*). Virus Research, Vol 107, pp 47-56.

8. Vibrios in clam aquaculture

Two episodes of mortality of cultured carpet shell clams (*Ruditapes decussatus*) associated with bacterial infections were recorded during 2001 and 2002 in a commercial hatchery located in Spain.

Vibrio alginolyticus was isolated as the primary organism from moribund clam larvae that were obtained during the two separate events. *Vibrio splendidus* biovar II, in addition to *V. alginolyticus*, was isolated as a result of a mixed *Vibrio* infection from moribund clam larvae obtained from the second mortality event. The larval mortality rates for these events were 62% and 73%, respectively. Mortality was also detected in spat. To our knowledge, this is the first time that these bacterial species have been associated with larval and juvenile carpet shell clam mortality.

Reference

GOMEZ-LEON, J., VILLAMIL, L., LEMOS, M.L., NOVOA, B., FIGUERAS, A. (patoll@iim.csic.es), 2005. Isolation of *Vibrio alginolyticus* and *Vibrio splendidus* from aquacultured carpet shell clam (*Ruditapes decussatus*) larvae associated with mass mortalities. Applied and Environmental Microbiology, Vol 71, pp 98-104.

9. Perkinsus in clams

Samples of clams *Ruditapes decussatus* were collected from five different sites along the Portuguese coast and in Galicia between winter 2000/2001 and 2002/2003. The infection level with *Perkinsus atlanticus* was evaluated by the Ray Fluid Thioglycollate medium (RFTM) method using the body burden assay. In addition, condition index (CI; edible part as a percentage of the total weight of the clams) was measured to investigate a possible correlation between this parameter and the intensity of infection.

No clear relationship between infection intensity and condition index could be determined although a significant decline in CI was found for heavily infected clams. Results of a 2-year survey demonstrate the presence of *Perkinsus* sp. in all sampling sites albeit with different intensities. Sites where human interference was minimal showed the lowest levels of infection. There were no significant differences in *Perkinsus* sp. infection intensity between samples collected in winter and summer, in contrast with several studies describing higher intensities at the end of the summer. Nevertheless, major differences were observed from year to year and site-to-site.

Reference

LEITE, R.B., AFONSO, R., CANCELA, M.L. (lancela@ualg.pt), 2004. *Perkinsus* sp infestation in carpet-shell clams, *Ruditapes decussatus* (L), along the Portuguese coast. Results from a 2-year survey. Aquaculture, Vol 240, pp 39-53.

10. Brown Ring Disease

Brown Ring Disease (BRD), a vibriosis affecting the clam *Ruditapes philippinarum*, is present on the Atlantic coasts of Western Europe and is considered to be a cold-water disease. The present work investigated the effect of temperature on immune response and its relationships with BRD development. Clams maintained at different temperatures (8, 14 and 21°C) were experimentally challenged with the pathogen *Vibrio tapetis*, the etiologic agent of BRD.

Results demonstrated significant effects of temperature on disease development and on hemolymph immune parameters. Thirty days after challenge, clams maintained at 21°C displayed significantly higher values for all the measured immune parameters in comparison to specimens incubated at 14°C. Improved performance of the immune system was associated with a low BRD prevalence. The recovery process, which occurred mainly at 21°C, was associated with high percentages of viable hemocytes and high activities of leucine amino-peptidase and lysozyme. This laboratory study clearly demonstrates that temperature strongly affects BRD development and clam immune response

during infection. Favourable immune status at higher temperature may confer upon the clam a better capacity to fight the disease agent, and therefore to recover more easily.

Reference

PAILLARD, C., ALLAM, B., OUBELLA, R., 2004. Effect of temperature on defence parameters in Manila clam *Ruditapes philippinarum* challenged with *Vibrio tapetis*. Diseases of Aquatic Organisms, Vol. 59, pp 249–262.

11. *Marteilia* in oysters and mussels

Marteilia refringens is a paramyxean parasite which infects flat oysters and mussels. In the latter it has been attributed to a separate species, *Marteilia maurini*, by several authors. Doubts persist as to the existence or not of two species of *Marteilia* in Europe.

We have devised a molecular method for the diagnosis of *M. refringens*. Analyses indicate that the *Marteilia* parasites that infect oysters and mussels are two different strains of the same species.

Reference

LOPEZ-FLORES, I. (ilopez@ugr.es), DE LA HERRAN, R., GARRIDO-RAMOS, M.A., NAVAS, J.I., RUIZ-REJON, C., RUIZ-REJON, M., 2004. The molecular diagnosis of *Marteilia refringens* and differentiation between *Marteilia* strains infecting oysters and mussels based on the rDNA IGS sequence. Parasitology, Vol 129, pp 411-419.

12. Cultch as a disease vector

Oyster shell is the preferred substrate for replanting oyster beds and restoring oyster reefs. If pathogens remain viable in tissues attached to shell, then planting shell may inadvertently serve as a vector for pathogen transmission. Limited local shell sources may exacerbate the problem by increasing the risk of spreading novel strains into new areas if shell is derived from other regions.

In South Carolina, the primary source of oyster shell is currently the Gulf of Mexico, where the protozoan oyster pathogen *Perkinsus marinus* has been problematic. Although *P. marinus* is present in South Carolina waters, different strains exist in the two regions. Given the detrimental effects of *P. marinus* on oysters, protocols to minimize its spread via planting of shell are needed. We conducted a short-term, replicated experiment to follow changes in *P. marinus* abundance in oyster tissues by placing whole, intact oysters or shucked oysters in shell piles.

The results support the recommendation that the quarantine of shell for one month or more can dramatically reduce the potential risk of spreading *P. marinus* when planting oyster shell from other

geographic areas. This recommendation is applicable to virtually any region, but several parameters such as effects of climatic conditions and shell pile configuration warrant further investigation as does the persistence of other pathogens on shell piles.

Reference

BUSHEK, D. (bushek@hsrl.rutgers.edu), RICHARDSON, D., BOBO, M.Y., COEN, L.D., 2004. Quarantine of oyster shell cultch reduces the abundance of *Perkinsus marinus*. Journal of Shellfish Research, Vol 23, pp 369-373.

13. Bonamiasis in New Zealand oysters

Disease caused by the haplosporidian parasite *Bonamia exitiosa* swept through the dredge oyster (*Ostrea chilensis*) population of Foveaux Strait between 1986 and 1992, with consequent mortality reducing the population to 9% of the pre-disease level. Fishermen in the far western Foveaux Strait first saw dead and dying oysters in 1985 and more were found further east in 1986. Infection spread slowly through Foveaux Strait so the progress of the epizootic can be described from population surveys. A wave of infection radiated through the oyster population from the epicentre of infection in central western Foveaux Strait, and was followed by a wave of mortality. The epizootic ceased in oyster beds around the margins of oyster distribution in 1992. Infective particles released by diseased oysters spread through the water to infect other oysters directly. The epizootic broadly fitted a simple deterministic epizootic model and suggested that both diffusion and turbulent processes were important in transmission of infection. *Bonamia exitiosa* was also present in oysters at the end of an epizootic in 1964 and was probably the cause of that epizootic. Bonamiasis thus appears to be an endemic disease in Foveaux Strait yet the high mortality in the 1986-1992 epizootic was of the kind usually found when a newly introduced disease infects an immunologically naive population. We propose that other stressors have increased the susceptibility of oysters to this disease. Mechanical disturbance of oysters by increasingly intense dredging appears to be a major source of stress, as does the increasing scale of modification of benthic habitat by fishing. Recovery of the oyster population after the epizootic is closely linked to regeneration of habitat. The prognosis for the fishery could be improved by mitigating mechanical disturbance during dredging by use of lighter dredges and less damaging towing strategies, as well as pursuing rotational fishing strategies that allow benthic habitat to regenerate in undisturbed areas.

Reference

CRANFIELD, H.J. (j.cranfield@paradise.net.nz), DUNN, A., DOONAN, I.J., MICHAEL, K.P., 2005. *Bonamia exitiosa* epizootic in *Ostrea chilensis* from Foveaux Strait, southern New Zealand between 1986 and 1992. ICES Journal of Marine Science, Vol 62, pp 3-13.

14. Analysis of shellfish contaminants

Separation methods to detect *Cryptosporidium parvum* and *Escherichia coli* O157 in UK shellfish are described in this paper.

Whole tissue homogenates gave the best recoveries for *C. parvum* oocysts compared with gill or haemolymph extracts. The sensitivity of recovery from spiked samples was comparable to that achieved when processing water and varied from 12-34% in mussels, 48-69.5% in oysters and 30-65% in scallops.

Maximum recovery of *E. coli* O157 was achieved by enriching in buffered peptone water supplemented with vancomycin at 42°C. Increasing enrichment temperatures from 37 to 42°C gave a significant increase in target number recovery. Implementation of these methods into monitoring programmes and end-product testing will enable shellfish producers to better assess product safety.

Reference

MACRAE, M., HAMILTON, C., STRACHAN, N.J.C., WRIGHT, S., OGDEN, I.D. (i.ogden@abdn.ac.uk), 2005. The detection of *Cryptosporidium parvum* and *Escherichia coli* O157 in UK bivalve shellfish. Journal of Microbiological Methods, Vol 60, pp 395-401.

15. Detection of Noroviruses

Real-time RT-PCR, combining amplification and detection of virus-specific amplicons, is a promising tool for norovirus detection in environmental or food samples such as shellfish. We developed a real-time RT-PCR assay based on one-step detection using single primer sets and probes for norovirus genogroups I and II. Seventy and seven RT-PCR units of genogroup I and II reference norovirus strains, respectively, were detected in artificially contaminated oysters. Validation of the new method on 150 archived naturally contaminated shellfish confirmed the utility of the genogroup II primer set to detect a large range of different strains circulating in France since 1995, but genogroup I strains were detected infrequently.

Reference

LOISY, F., ATMAR, R.L., GUILLON, P., LE CANN, P., POMMEPUY, M., LE GUYADER, F.S. (sleguyad@ifremer.fr), 2005. Real-time RT-PCR for norovirus screening in shellfish. Journal of Virological Methods, Vol 123, pp 1-7.

16. High Pressure Treatment inactivates Hepatitis A

Previous results have demonstrated that hepatitis A virus (HAV) could be inactivated by high hydrostatic pressure (HHP). However, direct evaluation of HAV inactivation within contaminated oysters had not

been performed. This study confirms that HAV within contaminated shellfish is inactivated by HHP. Shellfish were initially contaminated with HAV by using a flow-through system. One, Two and Three fold log reductions were observed for 1-min treatments at 350, 375, and 400 megapascals, respectively, within a temperature range of 8.7 to 10.3°C. Bioconcentration of HAV of nearly 6 log fold was achieved under simulated natural conditions in untreated oysters.

Reference

CALCI, K.R., MEADE, G.K., TEZLOFF, R.C., KINGSLEY, D.H. (dkingsle@desu.edu), 2005. High-pressure inactivation of hepatitis A virus within oysters. Applied and Environmental Microbiology, Vol 71, pp 339-343.

17. Ozone and shelf life of mussels

The effect of ozonation in aqueous solution (O_3 concentration = 1 mg/l, time of ozonation: 60 and 90 min) on the shelf-life of shucked, vacuum-packaged mussels, stored under refrigeration was studied by monitoring the microbiological, chemical and sensory changes occurring in mussel samples, for a period of 12 days. Non-ozonated vacuum-packaged mussels served as the control sample.

Ozonation reduced bacterial populations. The effect of ozonation was generally more pronounced in the 90 minute treatment. Sensory evaluation (odour, taste and texture) of cooked mussels showed a good correlation with bacterial populations. On the basis of sensory analyses, a shelf life of 12 days was obtained for vacuum-packaged mussels ozonated for 90 min as compared to a shelf life of 9 days for the control sample.

Reference

MANOUSARIDIS, G., NERANTZAKI, A., PALEOLOGOS, E.K., TSIOTSIS, A., SAVVAIDIS, I.N., KONTOMINAS, M.G. (mkontomi@cc.uoi.gr), 2005. Effect of ozone on microbial, chemical and sensory attributes of shucked mussels. Food Microbiology, Vol 22, pp 1-9.

18. Origins of algal toxin limits

The origins of the safety levels for paralytic shellfish poisoning (PSP) and amnesic shellfish poisoning (ASP) toxins are summarised in this paper. The regulatory limit for PSP toxins (80 mug STX equiv. / 100 g shellfish) was established in the 1930s and is based on bioassays measuring toxic activity in mice. Amnesic shellfish poisoning (ASP) is a more recently discovered syndrome caused by one toxin, domoic acid (DA). It was identified in 1987 and the regulatory limit of 20 mug/ DA g tissue was established in the following year, based on the estimated DA dosage levels consumed by the first human victims of ASP. This study attempts to preserve the history of the origin of these regulatory limits, both of which have

not changed and have effectively protected consumers of commercial seafood since their implementation.

Reference

WEKELL, J.C., HURST, J., LEFEBVRE, K.A., 2004. The origin of the regulatory limits for PSP and ASP toxins in shellfish. *Journal of Shellfish Research*, Vol 23, pp 927-930.

19. New biotoxin monitoring method

A simple and sensitive *in situ* method for monitoring the occurrence of toxic algal blooms and shellfish contamination events has been developed. The technique involves the passive adsorption of biotoxins onto porous synthetic resin filled sachets (SPATT bags) and their subsequent extraction and analysis. The success of the method is founded on the observation that during algal blooms significant amounts of toxin, including the low polarity lipophilic compounds such as the pectenotoxins and the okadaic acid complex toxins, are dissolved in the seawater. The results of field trials during *Dinophysis acuminata* and *Protoceratium reticulatum* blooms are presented. These data prove the concept and demonstrate that the technique provides a means of forecasting shellfish contamination events and predicting the net accumulation of polyether toxins by mussels. As an early warning method it has many advantages over current monitoring techniques such as shellfish-flesh testing and phytoplankton monitoring. In contrast to the circumstantial evidence provided by genetic probe technologies and conventional phytoplankton monitoring methods, it directly targets the toxic compounds of interest. The extracts that are obtained for analysis lack many of the extraneous lipophilic materials in crude shellfish extracts so that many of the matrix problems associated with chemical and biological analysis of these extracts are eliminated. Analyses can confidently target parent compounds only, because analytical and toxicological uncertainties associated with the multiplicity of toxin analogues produced by *in vivo* biotransformation in shellfish tissues are reduced. Time integrated sampling provides a good simulation of biotoxin accumulation in filter feeders and the high sensitivity provides lengthy early warning and conservative estimates of contamination potential. The technique may reduce monitoring costs and provide improved spatial and temporal sampling opportunities. When coupled with appropriate analytical techniques (e.g. LC-MS/MS multi-toxin screens, ELISA assays, receptor binding assays), the technique has the potential to offer a universal early warning method for marine and freshwater micro-algae toxins.

Reference

MACKENZIE, L. (lincoln.mackenzie@cawthron.org.nz), BEUZENBERG, V., HOLLAND, P., McNABB, P., SELWOOD, A., 2004. Solid phase adsorption toxin tracking (SPATT): a new monitoring tool that simulates the biotoxin contamination of filter feeding bivalves. *Toxicon*, Vol 44, pp 901-918.

20. Alternative PSP tests

In the United States, the detection of paralytic shellfish poisoning (PSP) for regulatory purposes relies on the mouse bioassay (MBA). Using a saxitoxin presence/absence test could reduce animal usage significantly. Three *in vitro* methods were evaluated in parallel with the MBA using 106 twice-frozen, acidified extracts from California-grown mussel and oyster tissues. The RIDASCREEN, MIST Alert, and neuroblastoma bioassays correlated to the MBA at 0.849, 0.853, and 0.832 respectively when used for presence/absence detection. These data suggest that a reduction in MBA usage could be achieved in the surveillance of California-grown mussels and oysters for PSP-associated toxins.

Reference

INAMI, G.B. (ginami@dhs.ca.gov), CRANDALL, C., CSUTI, D., OSHIRO, M., BRENDEN, R.A., 2004. Feasibility of reduction in use of the mouse bioassay: Presence/absence screening for saxitoxin in frozen acidified mussel and oyster extracts from the coast of California with *in vitro* methods. *Journal of AOAC International*, Vol 87, pp 1133-1142.

21. Azaspiracids

Azaspiracid poisoning (AZP) is a recently discovered toxic syndrome that was identified following severe gastrointestinal illness from the consumption of contaminated mussels. The implicated toxins, azaspiracids, accumulate in bivalve molluscs that feed on toxic microalgae of the genus *Protopeperidium*, previously considered to be toxicologically benign. Although first identified in shellfish from Ireland, azaspiracid contamination of several types of bivalve shellfish species has now been confirmed throughout the western coastline of Europe. Toxicological studies have indicated that azaspiracids can induce widespread organ damage in mice and that they are probably more dangerous than previously known classes of shellfish toxins. The exclusive reliance on live animal bioassays to monitor azaspiracids in shellfish failed to prevent human intoxications. This was a consequence of poor sensitivity of the assay and the fact that azaspiracids are not exclusively found in the shellfish digestive glands used for toxin testing. The strict regulatory control of azaspiracids in shellfish now requires frequent testing of shellfish using highly specific and sensitive methods involving liquid chromatography-mass spectrometry.

Reference

JAMES, K.J. (kjames@cit.ie), SAEZ, M.J.F., FUREY, A., LEHANE, M., 2004. Azaspiracid poisoning, the food-borne illness associated with shellfish consumption. *Food Additives and Contaminants*, Vol 21, pp 879-892.

22. DSP in crabs

During the summer of 2002 there were several episodes of human intoxication after consumption of brown crabs caught along the Norwegian south coast. The cause was diarrhoetic shellfish poisons (DSP). Although these toxins are routinely found in blue mussels they have not previously been documented in brown crabs. The route and rate of toxin accumulation as well as the rate of toxin depuration in crabs were determined in laboratory experiments. The DSP toxins only accumulate in digestive organs in the crabs. When fed with blue mussels containing more than 1,000 mug of okadaic acid equivalents per kg, the crabs accumulated 3-30% of the toxin. After 2 weeks, the average toxin level in the crabs exceeded the preliminary limit of DSP toxins at 400 mug okadaic acid equivalents per kg hepatopancreas established by the Norwegian Food Safety Authority. A 50% reduction in toxin level was observed after 14-18 days when the crabs were fed fish instead of toxic mussels.

Reference

CASTBERG, T. (Tonje.Castberg@imr.no), TORGERSEN, T., AASEN, J., AUNE, T., NAUSTVOLL, L.J., 2004. Diarrhoetic shellfish poisoning toxins in *Cancer pagurus* Linnaeus, 1758 in Norwegian waters. Sarsia, Vol 89, pp 311-317.

23. Lobster genetics

The genetic differentiation of the European lobster (*Homarus gammarus*) was investigated in 3,283 individuals from 44 population samples throughout its geographical distribution (Norway to Greece) by means of polymerase chain reaction restriction fragment length polymorphism analysis of a 3-kb mitochondrial DNA segment.

Four major distinct groups were evident: Mediterranean, northern Norway, Netherlands, and the remaining Atlantic samples. Based on the low degree of differentiation revealed in the European lobster and its limited capacity for dispersal, the most probable hypothesis is that all populations have been established from a common refuge after the end of the last Ice Age, that is, within the past 15,000 years.

Reference

TRIANAFYLIDIS, A., APOSTOLIDIS, A.P., KATSARES, V., KELLY, E., MERCER, J., HUGHES, M., JØRSTAD, K.E., TSOLOU, A., HYNES, R., 2004. Mitochondrial DNA variation in the European lobster (*Homarus gammarus*) throughout the range. Marine Biology, Vol 146, pp 223-235.

24. Environmental effects of mussel cultivation (1)

A commercial mussel *Mytilus edulis* lay was established in 1998 in western inner Swansea Bay in a shallow, sub-littoral, high tidal energy environment,

on a substrate which previously supported a diverse inshore, sand/muddy sand benthic community. Within a year of commencement of this fishery, a significant change in the species composition of the benthic community occurred, with a decrease in the number of species and in the total number of individuals. The abundance of carnivorous and deposit feeding benthic species increased, whilst the mussels out competed other benthic filter feeding organisms, preventing the settlement of these organisms by ingestion of the larvae, and removed other benthic organisms by physical smothering.

Reference

SMITH, J. (j.smith@swansea.ac.uk), SHACKLEY, S.E., 2004. Effects of a commercial mussel *Mytilus edulis* lay on a sublittoral, soft sediment benthic community. Marine Ecology Progress Series, Vol 282, pp 185-191.

25. Environmental effects of mussel cultivation (2)

Concerns about the environmental impacts of mariculture have grown in recent years in response to the rapid expansion of the industry. The blue mussel (*Mytilus edulis*) is the main product of shellfish mariculture in the Northeast Atlantic and Baltic Sea; with approximately one third of the harvest cultured using suspended longlines within sheltered marine areas. The main aim of this study was to examine the interactions, and assess the impacts (if any) of mussel suspension culture on the seabird and seal community, employing a simultaneous study of culture and control sites. The study spanned a 20-month period (from November 2001 to August 2003) and encompassed six sites in Bantry Bay (Southwest Ireland).

There was no significant difference in species richness between mussel and control sites. Similarly, species diversity did not significantly differ between the mussel and control sites although control sites were generally more diverse than mussel sites. No significant difference was found between common seal numbers in mussel and control sites. Seasonal patterns of abundance were similar in mussel and control sites, with peak numbers of most species groups occurring in spring. Thus mussel suspension culture does not appear to have an adverse effect on the abundance of seabirds or common seals in this area. The safe perching platforms provided by suspension culture floats, combined with a number of other factors, contribute to an increased abundance of a number of seabird species, particularly gulls.

Reference

ROYCROFT, D. (d.roycroft@ucc.ie), KELLY, T.C., LEWIS, L.J., 2004. Birds, seals and the suspension culture of mussels in Bantry Bay, a non-seaduck area in Southwest Ireland. Estuarine Coastal and Shelf Science, Vol 61, pp 703-712.

26. Sustainable mussel cultivation

The impact of a large mussel farm in the Adriatic Sea on the benthic environment was investigated using a battery of benthic indicators of environmental quality. The differences across the seasons are typically higher than those between the impacted and the control stations. No effects are seen in terms of the sediment oxygen penetration and the downward fluxes (as the total mass, organic and phytopigment fluxes). The indicators based on the biochemical compositions of the sediment organic matter and the microbial parameters also show no evidence of eutrophication, except as a slight increase in the bacterial density in the sediments beneath the long-lines of the farm during the period of highest mussel stocks. Finally, no effects are observed in terms of the benthic faunal indicators. These are all indistinguishable between the farm sediments and the controls. These results show that mussel farming in the investigated system is eco-sustainable and does not significantly alter the coastal marine ecosystem.

Reference

DANOVARO, R. (danovaro@univpm.it), GAMBÌ, C., LUNA, G.M., MIRTO, S., 2004. Sustainable impact of mussel farming in the Adriatic Sea (Mediterranean Sea): evidence from biochemical, microbial and meiofaunal indicators. *Marine Pollution Bulletin*, Vol 49, Iss 4, pp 325-333.

27. Birds and mussels

Bottom cultivation of mussels on inter-tidal flats is practiced throughout the world. This often generates conflicts between commercial interests and competing birds such as oystercatchers. In the Menai Strait, the over-winter consumption of 242 tonnes of commercially harvestable mussels (>40 mm) by oystercatchers in 1999-2000 was worth £133, 000. This represented 19% of the value of the landings. We used a behaviour-based simulation model to predict the extent to which such losses can be reduced by novel commercial management practices, and to explore the consequences for the oystercatcher population. Simulations of novel lay management practices indicated that the losses of commercially harvestable mussels to oystercatchers could be considerably reduced by altering the shore level and/or extent of the commercial lays.

We propose a novel management strategy for the bottom cultivation of mussels in inter-tidal areas. Seed mussels (15-20 mm) should be laid relatively far up-shore, where losses to oystercatchers will be minimal. As the mussels grow over the next 2-3 years, they should be moved progressively further down-shore such that the largest mussels spend their last season prior to harvest in a relatively small area, lower on the shore than all mussels earlier in the cultivation cycle. Support

for the effectiveness of this proposed management strategy can be found in the reports of commercial operators who have incorporated this management strategy in new management practices in the last few years. They report an increase in the ratio of the live mass of harvested to seeded mussels from the previous norm of 1:1 to 4:1. By accepting greater losses of mussels earlier in the cultivation cycle, rather than later, the feeding conditions for oystercatchers might even be improved under this system. With appropriate management, the interest of shellfish growers and competing shorebirds need not conflict.

Reference

CALDOW, R.W.G. (rwgc@ceh.ac.uk), BEADMAN, H.A., MCGRORTY, S., STILLMAN, R.A., GOSS-CUSTARD, J.D., DURELL, S.E.A.L., WEST, A.D., KAISER, M.J., MOULD, K., WILSON, A., 2004. A behavior-based modeling approach to reducing shorebird-shellfish conflicts. *Ecological Applications*, Vol 14, pp 1411-1427.

28. Effects of oil on mussels (1)

A 3-year survey was made of several biological markers in mussels (*Mytilus edulis*) exposed in situ to the oil that came ashore after the wreck of the "Erika" tanker on the Brittany (France) coast in December 1999. The mussel response was assessed using a set of 7 biomarkers, most of them related to the metabolism of organic contaminants. After a series of validation tests, data was evaluated for only 5 biomarkers: The results show that mussel populations were affected by the oil spill only during the first year after the event.

Reference

BOCQUENE, G. (gilles.bocquene@ifremer.fr), CHANTEREAU, S., CLERENDEAU, C., BEAUSIR, E., MENARD, D., RAFFIN, B., MINIER, C., BURGEOT, T., LESZKOWICZ, A.P., NARBONNE, J.F., 2004. Biological effects of the "Erika" oil spill on the common mussel (*Mytilus edulis*). *Aquatic Living Resources*, Vol 17, Iss 3, pp 309-316.

29. Effects of oil on mussels (2)

This study reports on a survey of Pacific oysters from the Atlantic coast of Brittany after the "Erika" oil spill. Reared stocks were sampled twice a year from November 2001 to March 2003 at three impacted sites and at an additional site outside the spill area. One year after the spill, severe immunological alterations were observed in a site heavily impacted by oil. Since the oysters there had higher contents of PAH compared to the other sites, it was suggested that chronic contamination, possibly generated by oil trapped in the sediments, had induced immunotoxicity.

Reference

AUFFRET, M. (Michel.Auffret@univ-brest.fr), DUCHEMIN, M., ROUSSEAU, S., BOUTET, I., TANGUY, A., MORAGA, D., MARHIC, A., 2004. Monitoring of immunotoxic responses in oysters reared in areas contaminated by the "Erika" oil spill. *Aquatic Living Resources*, Vol 17, pp 297-302.

30. Effects of oil on mussels (3)

Mussels (*Mytilus galloprovincialis*) were exposed to two oil volumetric ratios (1:500 and 2:500) for 12 days. The mussels concentrated total polycyclic aromatic hydrocarbons (TPAH), probably due to the great tendency of these compounds to link to particles in water. Comet assay results reflected an increase in the DNA damage associated to oil exposure, higher in the mussels exposed to the higher aqueous TPAH content.

Reference

PEREZ-CADAHIA, B., LAFFON, B., PASARO, E., MENDEZ, J. (fina@udc.es), 2004. Evaluation of PAH bioaccumulation and DNA damage in mussels (*Mytilus galloprovincialis*) exposed to spilled Prestige crude oil. *Comparative Biochemistry and Physiology*, Vol 138, pp 453-460.

31. Effect of copper on mussels

The interactive effects of temperature and copper on immune function and consequently disease susceptibility of the marine mussel, *Mytilus edulis* were investigated. Two studies were carried out, the first involved sequential exposure to copper at 0.02 and 0.05 ppm followed by the bacterium *Vibrio tubiashii*. In the second study, mussels were simultaneously exposed to copper and *V. tubiashii*. Both studies were carried out at 10 and 15°C, to ascertain whether temperature had an additional effect on immunocompetence.

Significant effects on immune parameters of sequential and simultaneous exposure to copper and *V. tubiashii* at 10 and 15°C were demonstrated. Each of the factors considered were shown to have a significant effect on at least one of the immune parameters measured. There were also significant effects due to the interaction of these factors. The response of total and differential blood cell counts to copper was shown to alter, if mussels were exposed in a sequential manner as opposed to simultaneous exposure. The results confirmed that the immune system of *M. edulis* is susceptible to copper at relatively low concentrations. Furthermore, the effects of copper alter with environmental variables, including temperature and the presence of a potential pathogen. The complexity of the interactions demonstrate that extrapolation of data obtained from single stressor studies into field situations could give a misleading picture.

Reference

PARRY, H.E., PIPE, R.K. (rkpi@mba.ac.uk), 2004. Interactive effects of temperature and copper on immunocompetence and disease susceptibility in mussels (*Mytilus edulis*). *Aquatic Toxicology*, Vol 69, pp 311-325.

32. Effect of atrazine on oysters

Widespread use of the herbicide atrazine has stimulated much research on its toxicity in aquatic systems, where it is routinely detected due to runoff from cultivated fields. Moreover, the determination of the genotoxic effect of such pollutants in the marine environment has become a major requirement for ecosystem protection.

Hypodiploid aneuploid cells have regularly been reported in the Pacific oyster. There is a negative correlation between this phenomenon and growth. A positive relationship between atrazine and aneuploidy has previously been demonstrated in Pacific oyster adults and juveniles. To evaluate the persistence of this impact, our study examined the offspring of the same adult population previously treated with different atrazine doses. We observed that these offspring exhibited significantly higher aneuploidy levels when their parents had been exposed to atrazine (14.9-16.9% in comparison with the control where the levels ranged from 11.4% to 12.8%). In addition, the present study examined the aneuploidy level of a sample of juveniles, previously exposed for 3.5 months to the same doses of atrazine, then transferred to non-polluted conditions for an additional period of 2.5 months; this aneuploidy level remained significantly different between the treatments applied. These results demonstrate the persistence of an atrazine impact on Pacific oyster aneuploidy in time, within and between generations, indicating that this widely used compound may represent an important factor causing at least medium-term damage to genetic material.

Reference

BOUILLY, K., MCCOMBIE, H., LEITAO, A., LAPEGUE, S. (slapegue@ifremer.fr), 2004. Persistence of atrazine impact on aneuploidy in Pacific oysters, *Crassostrea gigas*. *Marine Biology*, Vol 145, pp 699-705.

33. Environmental effects of relaying cultch

We examined the impact of adding scallop shells (byproduct of the fisheries) to sandy and rocky sea bottoms in the northern Gulf of St. Lawrence. The effect of adding shells was greatest on sandy bottoms where species richness increased 3.7-fold and species diversity 1.9-fold. The increase in most species was due to immigration rather than new settlement. Trials

examining the effect of different densities of shells in plots of the same size (4 square metres) showed that species diversity increased rapidly with shell abundance and levelled off when shells covered half of the bottom, whereas species richness only levelled off when shells almost completely covered the bottom. Trials examining the effect of the size of the shell patches (shell density being kept constant) showed that species diversity was already maximal in 1 square metre plots, whereas species richness only attained a plateau at 4 square metres. Our small-scale trials indicate that the addition of shells would have a positive impact, increasing numerous invertebrates, including commercial species (scallops, whelks and urchins).

Reference

GUAY, M. (mguay@hotmail.com), HIMMELMAN, J.H., 2004. Would adding scallop shells (*Chlamys islandica*) to the sea bottom enhance recruitment of commercial species? *Journal of Experimental Marine Biology and Ecology*, Vol 312, pp 299-317.

34. Eutrophication effects on clams

Growth and survival of clams and their habitat were compared across estuaries receiving different Nitrogen loads to define how land-derived nitrogen and any resulting eutrophication affects bivalves.

The major effects of nitrogen enrichment on near-bottom seston and surface sediment were to (1) increase microalgal concentrations and reduce carbon to nitrogen ratios, increasing quantity and quality of available foods, and (2) reduce oxygen content in sediments, potentially reducing habitat quality.

Shell growth of juvenile and native clams increased with increasing food supply, driven by Nitrogen enrichment. Growth of soft tissue followed growth of shell, and %Nitrogen content of soft tissue increased across Nitrogen loads, providing direct evidence of a link between Nitrogen loads and growth responses in clams. In some locations, low salinity limited growth and low oxygen concentrations may have reduced survival. Despite these factors, our data indicate the major effect of Nitrogen enrichment on clams was increased secondary production in terms of shell and soft tissue growth.

Reference

CARMICHAEL, R.H. (rherrold@alum.bu.edu), SHRIVER, A.C., VALIELA, I., 2004. Changes in shell and soft tissue growth, tissue composition, and survival of quahogs, *Mercenaria mercenaria*, and softshell clams, *Mya arenaria*, in response to eutrophic-driven changes in food supply and habitat. *Journal of Experimental Marine Biology and Ecology*, Vol 313, pp 75-104.

35. Temperature stress in Pacific oysters

Temperature and quality of the available food are important factors that influence the physiology of oysters. We evaluated the impacts of the temperature on the growth, survival and biochemical composition in Pacific oyster spat cultured in the laboratory for 8 weeks at 23, 26, 29 and 32°C and fed two diets: *Isochrysis* plus *Pavlova lutheri* (Diet IP) and *Dunaliella tertiolecta* (Diet Dt).

The growth and biochemical composition showed a pattern, which changed in response to rising temperature. Spat fed the IP diet grew better, as expected, except at 32°C, where both diets produced poor growth results. The survival was <50% after 5 weeks at 32°C, whereas at all other temperatures it was >88%. High temperatures directly increased lipids and saturated fatty acids, while the proteins, carbohydrates and unsaturated fatty acids decreased. High temperatures achieved in the environment, as those reached on clear summer days during low tides, are an important stressor in oyster spat, especially when the quality of the available food is poor.

Reference

FLORES-VERGARA, C., CORDERO-ESQUIVEL, B. (bcordero@cicese.mx), CERON-ORTIZ, A.N., ARREDONDO-VEGA, B.O., 2004. Combined effects of temperature and diet on growth and biochemical composition of the Pacific oyster *Crassostrea gigas* (Thunberg) spat. *Aquaculture Research*, Vol 35, pp 1131-1140.

36. Treating oysters for polychaete worms

This study evaluates the effect of weekly immersion baths in fresh water and a 0.2% solution of calcium hydroxide (lime) on the intensity of fouling polychaete worms in *Crassostrea gigas* oysters. Initially, 135 juvenile oysters were randomly assigned to three groups with three replicates each. Two groups were treated for 10 minutes with lime and fresh water, respectively, and a third group remained as a control. Fouling polychaete intensity and bivalve length and weight were obtained every 15 days. Every week oyster survival was registered for each treatment and water parameters were measured at the culture site.

Significant differences in worm intensity were found between the two bath treatments and the control. The lime treatment showed the lowest intensity (number of mud tubes/oyster) in all the sampling days, with no increase in intensity during the last experimental month. There were no significant differences in final survival, final length, final weight and final condition index of the oysters among treatments after 112 days of study.

Reference

GALLO-GARCIA, M.D. (carmengallo@starmedia.com), GARCIA-ULLOA-GOMEZ, M., GODINEZ-SIORDIA, D.E., 2004. Evaluation of two treatments in polychaete worm intensity associated with *Crassostrea gigas* (Thunberg, 1873) oyster valves. *Ciencias Marinas*, Vol 30, pp 455-464.

37. Alien oyster drill

Two marine gastropods - an invader, *Ocenebrellus inornatus*, and a resident, *Ocenebra erinacea* - co-occur on French Atlantic coasts and probably have economical impacts on oyster farming areas of the Charente-Maritime region of France.

A comparison of life-history traits between the introduced and resident species showed that *O. inornatus* has faster growth and higher reproductive rates, in comparison with *O. erinacea*. These traits may explain the establishment of the invader and, partly, its spread along the coast of France. However, the resident species drilled a higher rate of oysters than the invader. Finally, the establishment of *O. inornatus* in France does not seem to be at the expense of *O. erinacea* because: (1) resources are not limiting in oyster farming areas and (2) there does not appear to be competition by interference between the species.

Reference

MARTEL, C., GUARINI, J.M., BLANCHARD, G., SAURIAU, P.G., TRICHET, C., ROBERT, S., GARCIA-MEUNIER, P. (pgarciam@univ-lr.fr), 2004. Invasion by the marine gastropod *Ocenebrellus inornatus* in France. III. Comparison of biological traits with the resident species *Ocenebra erinacea*. *Marine Biology*, Vol 146, pp 93-102.

38. Exploitation of oyster beds

Estuarine ecosystems have changed dramatically from centuries of fishing, habitat disturbance, sedimentation, and nutrient loading. Degradation of oyster reefs by destructive fishing practices in particular has had a profound effect on estuarine ecology, yet the timing and magnitude of oyster-reef degradation in estuaries is poorly quantified. Here, the expansion and collapse of oyster fisheries in 28 estuaries along three continental margins is evaluated through the analysis of historical proxies derived from fishery records to infer when oyster reefs were degraded.

Exploitation for oysters did not occur randomly along continental margins but followed a predictable pattern. Oyster fisheries expanded and collapsed in a linear sequence along eastern North America, western North America, and eastern Australia. Fishery collapse began in the estuaries that were nearest to a developing urban centre before exploitation began to spread down the coast. As each successive fishery collapsed, oysters from more distant estuaries were fished and transported

to restock exploited estuaries near the original urban centre. This moving wave of exploitation travelled along each coastline until the most distant estuary had been reached and over fished.

Reference

KIRBY, M.X. (kirbym@ancon.si.edu), 2004. Fishing down the coast: Historical expansion and collapse of oyster fisheries along continental margins. *Proceedings of The National Academy of Sciences of The United States of America*, Vol 101, pp 13096-13099.

39. Management of non-commercial cockle harvesting in New Zealand

Quantitative assessment of the sustainability of non-commercial harvests from urban shellfish populations is rarely possible, as the scale of these fisheries does not usually warrant extensive research. Management is generally based upon a paucity of information, possibly resulting in the implementation of inappropriate controls.

In this study, comparatively comprehensive data are used to assess the likely short-term sustainability of non-commercial cockle (*Austrovenus stutchburyi*) gathering at three beaches, by comparing harvest, biomass and yield estimates. Although harvest estimates were broadly similar to estimates of yield, these findings were sensitive to assumptions about size at recruitment to the fishery, temporal changes in biomass, and possible changes in the selectivity and behaviour of fishers. Because of this uncertainty, we conclude that management on the basis of sustainable yield is inappropriate given the unpredictable nature of non-commercial gathering effort and shellfish population dynamics. Further, we conclude that the current management regime of daily bag limits per gatherer may be inadequate. Daily bag limits fail to constrain annual non-commercial harvests to appropriate levels when accessibility and interest is high, yet gathering is one of the main determinants of urban shellfish abundance.

In the absence of intensive monitoring and management, a precautionary minimum legal size limit based on a species reproductive biology, appears to be the most promising means of ensuring the viability of a shellfish population when its abundance is low. Other management measures such as daily bag limits and beach closures also have their role to play, but are not in themselves sufficient.

Reference

HARTILL, B.W. (b.hartill@niwa.co.nz), CRYER, M., MORRISON, M.A., 2005. Estimates of biomass, sustainable yield, and harvest: neither necessary nor sufficient for the management of non-commercial urban inter-tidal shellfish fisheries. *Fisheries Research*, Vol 71, pp 209-222.

40. Maerl grounds as scallop refuges

Human damage to substrata such as maerl has been receiving increasing attention recently. Maerl forms highly biodiverse and heterogeneous habitats composed of loose-lying coralline red algae, which provides nursery areas for queen scallops (*Aequipecten opercularis*) and other invertebrates. The benefits obtained by queen scallops utilising maerl were poorly understood, so we used both laboratory predation and field tethering experiments to investigate the refuge and growth potential provided by pristine live maerl (PLM) grounds over other common substrata.

In aquaria, more juvenile queen scallops survived on PLM than on gravel in the presence of the crab or the starfish. Field tethering experiments indicated similar survivorship of juvenile queen scallops on PLM and gravel; additionally, their growth rates were similar on both substrata. PLM allows scallops to seek refuge from predators and position themselves to optimise their food supply. Other bivalve refugia have been shown to provide poor food supply as a consequence of their high heterogeneity, yet maerl grounds provide a 'win-win' scallop nursery area coupling refuge availability with high food supply.

Reference

KAMENOS, N.A. (nick.kamenos@millport.gla.ac.uk), MOORE, P.G., HALL-SPENCER, J.M., 2004. Maerl grounds provide both refuge and high growth potential for juvenile queen scallops (*Aequipecten opercularis* L.). *Journal of Experimental Marine Biology and Ecology*, Vol 313, pp 241-254.

41. Aerial photography on inter-tidal shellfish beds

The study shows aerial photography has the potential to be an aid in surveying inter-tidal Pacific oyster beds.

Pacific oysters were introduced into the Eastern Scheldt in 1964 for breeding purposes. The first spatfall of wild Pacific oysters was recorded in 1976, and a second larval outburst in 1982 also resulted in settlement of wild Pacific oysters in the Eastern Scheldt waters. Oyster beds on inter-tidal and sub-tidal areas have been growing since.

The objective of this study was to research the potential of aerial photography for estimating surface areas of inter-tidal Pacific oyster beds. Black and white and false-colour aerial photographs were used to locate Pacific oyster beds. For verification purposes, oyster bed contours were measured in the field. The accuracy of the method used was comparable with accuracies found in other studies, with a chance of underestimating the surface areas in the field. Using aerial photographs of 1980 and 1990 the surface areas of Pacific oysters in both years were reconstructed, showing an increase.

Reference

KATER, B.J. (b.j.kater@rikz.rws.minvenw.nl), BAARS, J.M.D.D., 2004. The potential of aerial photography for estimating surface areas of intertidal Pacific oyster beds (*Crassostrea gigas*). *Journal of Shellfish Research*, Vol 23, pp 773-779.

42. Slipper limpet distribution

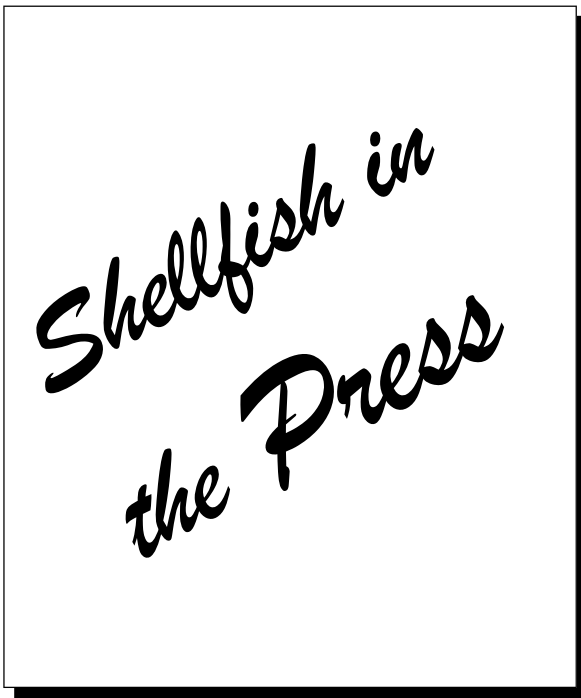
The distribution of the introduced American slipper limpet *Crepidula fornicata* on the Atlantic coast of Europe shows a clear latitudinal gradient. In the south, *C. fornicata* may reach abundances of several thousand individuals per meter squared. In contrast, abundances in northern waters as in Germany, Denmark and Norway barely reach 100 per meter squared, indicating one or several limiting factors for population increase.

By studying a population in the northern Wadden Sea of Germany, we examined four factors that we regarded as likely to potentially limit population increase of *C. fornicata*: (1) high predation by the main predators of benthic mollusc, (2) high infestation by parasites, (3) low reproductive output and growth in cold waters and (4) high winter mortality during freezing winters.

Our results do not indicate biotic restrictions: The main benthic mollusc predators, shore crabs and sea stars strongly preferred the dominant blue mussel in choice experiments and no infestation with parasitic trematodes were observed. Further, there was no indication of limitation in reproduction and growth since abundant larvae were observed in the water column and the period of reproduction (April to September) as well as growth rates (recruits: 9-14 mm first summer) match with data from southern areas. In contrast, population dynamics of *C. fornicata* was strongly affected by cold winters: During the two winters investigated, mortality amounted to 56-64% with up to 97% on single mussel beds contrasting to 11-14% yearly mortality in areas without frost in southern Europe. Negative winter effects are also suggested by remarkably low larval abundances after an exceptionally severe winter. Our results suggest that winter mortality is the main limiting factor for population increase of *C. fornicata* in the study area. We propose that milder winters as a corollary of global warming may allow for an increase in the abundance of northern populations combined with a northward shift of the concomitant negative ecological and economic effects.

Reference

THIELTGES, D.W. (dthieltges@awi-bremerhaven.de), STRASSER, M., VAN BEUSEKOM, J.E.E., REISE, K., 2004. Too cold to prosper - winter mortality prevents population increase of the introduced American slipper limpet *Crepidula fornicata* in northern Europe. *Journal of Experimental Marine Biology and Ecology*, Vol 311, pp 375-391.



*Shellfish in
the Press*

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

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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, Area 5E, 3-8 Whitehall Place, London, SW1A 2HH (Tel. 020 7270 8227) (Fax. 020 7270 8827)

Shellfish Health - Fisheries Division II, Area 5E, 3-8 Whitehall Place, London, SW1A 2HH (Tel. 020 7270 8826) (Fax. 020 7270 8827)

Public shellfisheries, excluding Regulating Orders - Fisheries Division III, Area 6A, 3-8 Whitehall Place, London, SW1A 2HH (Tel. 020 7270 8256) (Fax. 020 7270 8310)

Shellfish Licensing Scheme - Fisheries Division IV, Area 7E, 3-8 Whitehall Place, London, SW1A 2HH (Tel. 020 7270 8128) (Fax. 020 7270 8146)

Grant Aid - Fisheries Division 1B, Area 6D, 3-8 Whitehall Place, London, SW1A 2HH (Tel. 020 7270 8041) (Fax. 020 7270 8019)

Marine Environment Protection and Pollution - Marine Environment Branch 2, Marine and Waterways Division, Area 2D, 3-8 Whitehall Place, London, SW1A 2HH (Tel. 020 7270 8642) (Fax. 020 7270 1036)

Monitoring of fishing activities, licensing - Sea Fisheries Inspectorate, Area 7A, 3-8 Whitehall Place, London SW1A 2HH. (Tel. 020 7270 8326/8160/8328) (Fax. 020 7270 8345)

Research and Development Programmes – Fisheries Science Unit, Area 6C, 3-8 Whitehall Place, London, SW1A 2HH (Tel. 020 7270 8274) (Fax. 020 7270 8020)

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,
CEFAS 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.cefass.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 – Inshore Group,
Aquaculture Development Advisors:
For Scotland and Northern Ireland: Craig Burton,
PO Box 3, Acharacle, Argyll. PH36 4YF
(Tel/Fax: 01967 431 573; Mobile: 078 760 35771)
(email: c_burton@seafish.co.uk)

For England and Wales: Martin Syvret,
40 Toronto Road, Mount Pleasant,
Exeter, Devon, EX4 6LF
(Tel/Fax. 01392 202043; Mobile: 078 760 35746)
(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.org>*

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, Ardsvar, 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,
6, Ashmeadow Road, Arnside, Via Carnforth,
Lancashire, LA5 0AE
(Telephone and Fax: 01524 761616)
(email: asfc.office@btopenworld.com)

Co-ordinator for Defra - CARD R&D -
Dr. Mark James, Fisheries Resource Management Ltd.,
Coillie Bhrochain, Bonskeid, Pitlochry, Perthshire,
PH16 5NP.
(Tel./Fax: 01796 474473)
(<http://www.frmltd.com>)

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
- Research on Shellfish Cultivation (1990-2003)

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.cefasc.co.uk/publications/default.htm>

Back copies of issues 8-18 of *Shellfish News* can also be viewed and/or downloaded as .pdf files from the CEFAS web site (http://www.cefasc.co.uk/publications/shellfish_news.htm). Many of the illustrations are in full colour in the web edition.

Seafish

Detailed information on the technical and economic aspects of cultivation for individual shellfish species is available from Seafish. 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 Advisor for your area (see above for contact details, or <http://www.seafish.org/sea/aquaculture.asp?p=ec200> for further information).

A full list of Seafish publications can be found on the Seafish web site at <http://www.seafish.org/resources/publications.asp>
