Risk Factors Associated with Cultured Shellfish – Project SARF013

Project Summary, Recommendations and Actions

Shellfish cultivation has seen a substantial increase in recent decades and is an important industry for some coastal rural communities. Molluscan shellfish such as mussels and oysters feed by filtering out and concentrating suitably sized particles from the surrounding water. Suspended particles can occasionally contain faecal bacteria (such as *E. coli*) and viral pathogens (such as the enteric norovirus) which may originate from a variety of human and other animal sources. Consumption of shellfish containing these harmful microorganisms may pose a significant human health risk. As a result, the shellfish industry together with Regulators applies rigorous water quality and end product standards to ensure that shellfish are safe to eat.

It is important for the industry and regulators to understand the real and perceived frequency, scale and nature of shellfish microbial contamination to improve regulation and fulfill the requirements of stringent EU Directives. The objectives of this study were to identify key pollution sources and conditions contributing to microbial contamination of cultured shellfish in Scottish Coastal waters using Loch Etive as an example. Loch Etive was chosen as the survey site for this project because it supports a vibrant shellfish sector which, in common with many other areas in Scotland, is subject to periodic episodes of reduced water quality. Because of its close proximity to the Scottish Association for Marine Science laboratory at Dunstaffnage near Oban, Loch Etive is also probably one of the most studied sea lochs in Scotland in terms of its hydrography and general ecology. The project consisted of three key elements – a sanitary survey; a 12 month monitoring programme together with a source apportionment study of faecal indicator bacteria.

The sanitary survey consisted of a detailed review of available information and data related to all domestic, agricultural and other inputs to the loch. A Geographic Information System was used to map the entire catchment for Loch Etive and to overlay land use and all the point source inputs to the loch identified in the review.

This information, together with analysis of historic Food Standards Agency Scotland (FSAS), Scottish Environment Protection Agency (SEPA) and industry data was used to set up an intensive field sampling programme. Evidence suggested that periodic reduction in water quality occurred seasonally and following periods of high rainfall. Over a 12 month period, weekly water and shellfish samples were tested using approved methods for detecting faecal coliforms and *E. coli* as well as norovirus and bacteriophage. Weather patterns were carefully monitored and intensive (round the clock) sampling was conducted immediately following high rainfall that occurred after periods of two to three weeks of relatively dry weather. The weekly samples provided a picture of the background levels of potentially harmful microorganism, whilst the intense sampling provided a timeline showing the observed increase and subsequent decline in bacterial and viral counts following these “trigger” weather events.

Whilst the 12 month sampling programme provided an excellent description and understanding of the nature and duration of reduced water quality, it was not designed to identify possible sources of contamination. Using information gathered from the sanitary survey a range of private and water company outfalls together with river and stream inflows to the loch were monitored to provide estimates of flow and specific bacterial counts. Using these data, it was possible to calculate the proportion of bacteria that each of the sampled inflows contributed to the overall bacterial loading in the loch during the summer sampling periods observed. These results proved pivotal in determining the most significant sources of contamination.

At the start of the project, a number of divergent views were expressed as to the nature and possible causes of reduced water quality in Loch Etive which might result in periodic non-compliance with shellfish hygiene regulations. Suggestions ranged from inadequate sewage provision to unmanageable diffuse pollution as a result of run-off from local hillsides and agricultural land.

The results confirmed that high bacterial loads followed heavy rainfall after periods of two to three weeks of dry weather particularly during the summer period. The duration of subsequent shellfish contamination with *E.coli* was generally a few days. The incidence of viral contamination of shellfish in the study area was very low which fits with relatively low human population density and recent upgrades in the local sewerage system. The use of microbial source apportionment proved to be a cost effective way of quantifying the sources of bacterial contamination and led to the discovery that three relatively small streams were significant sources of the total bacterial load flowing into the study area. Further investigation suggested that hard standing used by cattle and a local silage pit, drained directly into the streams and represented significant point sources of pollution.

The project has resulted in strategic recommendations which are being taken forward by Government, Regulators and industry. In addition, local remedial action has been initiated by SEPA in Loch Etive to address the 'hot spots' of pollution identified as part of this project.

The project was sponsored by SARF, SEPA, FSAS, Scottish Government, Scottish Water and the shellfish industry. The research team was lead by the Scottish Association for Marine Science and included the Centre for Research into Environment and Health and CEFAS.

The full report for project SARF013 is available on the SARF website at: http://www.sarf.org.uk/Downloads.htm

Strategic recommendations included in the project final report are as follows:

1. For waters at risk of non-compliance a quantitative microbial source apportionment exercise is an essential foundation for any sanitary survey exercise.

2. Design of any remediation strategy to reduce sewage fluxes to impaired waters should be undertaken only after a source apportionment study as suggested above is undertaken

3. Source apportionment requires targeted high flow sampling (i.e. responsive aseptic sampling capacity on a 24 hour basis) and this should be built in to any sampling programme to inform management decisions designed to effect improvement.

4. When the shellfish harvesting is compliant with the coliform parameter but still exhibits virus–positive periods, then additional evaluation of specific anthropogenic point source discharges of sewage would be prudent.

5. Historical monitoring data should not be used in isolation to estimate pollutant loadings unless it contains information on high flow water quality or is augmented by additional targeted sampling.

6. Information on all domestic sources (including raw sewage discharges, private and public sewage systems) should be centralised and readily available. In addition, access to more detailed livestock census data and management information at the catchment, or even individual farm, level would facilitate a greater evaluation of diffuse sources.

7. High intensity sampling events, targeted to capture high flow episodes, should be included in the microbiological assessment phase of the sanitary survey in order to a) aid selection of routine monitoring points and b) assess the impact of high flow events on shellfish production areas (particularly new designations and areas at risk from non compliance).

8. Research aimed at quantifying the relationship between norovirus levels in shellfish and the associated health risk is vital in order truly to evaluate any potential risks. Further, standards and guidelines are required both for regulators and industry to assess the suitability of areas for shellfish production.

9. Neither *E. coli* nor FRNA+ bacteriophage should be considered as reliable quantitative risk indicators of norovirus contamination in shellfish on the west coast of Scotland. However, research to clarify the potential of these indicators in areas thought to be under greater influence from domestic sewage is required.

10. Further studies in Loch Etive are recommended to (i) clearly establish the possible risk of human virus contamination from the sewage infrastructure and (ii) discount the possibility of a major, but unmeasured, flux of faecal pollution from the upper basin.

Specific actions taken by SEPA, FSAS and Scottish Water partly or wholly in response to the results of this project:

Scottish Water have completed wastewater improvements at Connel, Dunbeg, and North Connel as part of the Q&S2 investment programme; and are upgrading treatment for Bonawe (first time treatment, extended sewer network and disinfection), and Taynuilt (disinfection for continuous discharge, storm screening and storage).

In conjunction with SEPA and as agreed by the Scottish Government and the Water Industry Commission for Scotland, is additional work in the current investment programme to undertake feasibility studies for extensive first time sewerage schemes for Connel, North Connel (Black Crofts, Achnacree,etc), and Lochawe Village; all of which are seen as potential contributory sources of faecal bacteria.

SEPA has organized visits to the sites identified in the project as being significant contributors to the bacterial loading at certain times to ensure that SEPA's requirements for slurry containment are met.

SEPA is meeting with the Scottish Government to discuss policy implications in the light of the information now available as a result of this project and a related faecal source tracking project.

FSAS has provided detailed clarification of the rationale underpinning its monthly sampling regime for classification purposes.

Since the project started, there have been a number of developments in the FSAS monitoring regime which have gone some way towards addressing several of the conclusions and recommendations made in the report. These include the setting of representative monitoring points for classifying harvesting areas, and the use of dedicated sampling officers to ensure monitoring points are consistent and samples are handled appropriately prior to arriving at the laboratory for testing. These changes have greatly improved the quality of data employed for classification purposes.

As part of a data sharing agreement, where appropriate, SEPA now use FSAS *E.coli* data to designate shellfish growing waters.

The FSA has recently commissioned a programme of research to improve our understanding of the prevalence and distribution of norovirus in shellfish harvesting areas across the UK and to improve our understanding of the risks posed by norovirus levels in shellfish.