AQUACULTURE AND MARICULTURE

Gail E. Greening
Communicable Disease Group, Institute of Environmental Science and Research Ltd, Porirua, New Zealand

Gillian D. Lewis
School of Biological Sciences, University of Auckland, Auckland, New Zealand

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Summary

The global aquaculture industry is increasing annually, with 31 million tonnes of seafood produced in 1999. The greatest risk to public health risk is from outbreaks of

food poisoning, hepatitis A and gastroenteritis resulting from consumption of bivalve mollusks, especially oysters and clams, contaminated with marine toxins or pathogenic microbes from sewage. Poor growing water quality, sporadic fecal contamination of shellfish growing areas and poor food handling are recognized as the most important sources of pathogens and toxins in shellfish. Sewage and fecal material present major problems, as they are the main sources of contamination of shellfish-growing waters. The diseases most commonly associated with consumption of contaminated bivalve mollusks are of viral rather than bacterial origin. International regulations, through the European Community and United States shellfish quality assurance programs, ensure that mollusks meet safety criteria for public consumption. These programs use fecal bacterial indicators, but these indicators are not representative of viruses and so may not identify risks from viral contamination**.** Marine toxins resulting from algal blooms are the other significant cause of disease from shellfish. Deterioration of water quality in growing areas due to urbanization has increased pressures on farming of bivalve mollusks. New molecular methods have helped to better identify fecal contamination sources and characterize the microbial and viral pathogens implicated in outbreaks. In conjunction with quantitative risk assessments, these may in future provide environmental indicators representative of both bacterial and viral pollution. This will allow improved management strategies and food safety programs to be developed to assist the aquaculture industry and protect public health.

1. Introductory statement

Globally aquaculture and mariculture produce over 31 million tonnes of fish edible seaweed, crustaceans and mollusks per year. Of this, most is through freshwater culture of carp and other species (58.7%). Marine aquaculture accounts for approximately 35% of production – mainly of seaweed, mollusks (predominantly oysters) and some finfish – with the balance (approximately 6%) brackish water culture of shrimps, prawns and milkfish. Increasing globalization of the food industry and demand for niche and luxury seafoods has resulted in rapid expansion of the brackish and marine aquaculture industry beyond that traditionally seen as providing a basic food supply need.

Cultured seafood supports a global trade where consumers are often unaware of the country or even hemisphere in which the food is grown. Continuing success and support of such international trade requires that the seafood supplied be of good quality and engender a uniformly low risk of illness to consumers. The greatest risks to consumer health, and the associated market acceptability of seafood products, are found in mollusks, particularly those that are filter feeders such as oysters, clams and mussels. These shellfish concentrate materials including pathogens and toxins from their growing waters and are recognized as important risk foods in transmission of viral gastroenteritis, hepatitis A infection and algal toxin poisonings. Poor growing water quality, sporadic contamination of shellfish growing areas and poor food handling are recognized as the most important sources of pathogens and toxins in seafood.

The discussion set out in this chapter specifically investigates health risks associated with human infectious disease and poisoning from natural marine toxins derived from shellfish contaminated during culture. It does not address post-harvest contamination by process workers and materials or by food handlers.

2. Nature of the industry

The global aquaculture industry increased fourfold between 1984 (6.94 million tonnes) and 1999 (31 million tonnes). Most of the global aquaculture and mariculture occurs in Asia where it provides a valuable source of protein for the massive population and there are thousands of small-scale farmers.

The species cultivated include both finfish and crustaceans, and the range and size of cultivation systems are diverse. A comprehensive review of food safety and the potential health hazards arising from biological contamination of global aquaculture systems was published in 1999.

This article focuses mainly on molluskan shellfish because the most frequently reported public health risk has resulted from consumption of contaminated bivalve mollusks. According to early manuscripts, shellfish have been associated with disease for thousands of years.

These references are believed to relate to the unsanitary conditions where shellfish were harvested, and for this reason, some religions ban shellfish consumption. In recent times, shellfish were not associated with disease until the late nineteenth century, and basic flushing or depuration processes were carried out in France as a cleansing mechanism.

3. Sources of Fecal Contamination Impacting Water Quality

Human fecal waste is the most important source of pathogenic viruses, bacteria and parasites that may contaminant shellfish growing waters. Treatment of these wastes will reduce the presence of pathogens but is unlikely to remove them entirely.

Bacteria are often removed more effectively than human enteric viruses by waste treatment systems. Viruses associated with enteric infections are physically robust and less susceptible to oxidation, lysis and predation than are bacteria.

Animal and bird fecal material are also an important source of bacteria and pathogens which may infect humans in shellfish growing waters. Animal wastes are often discharged to water with little or no treatment and the pathogens may be readily transported from pasture to coastal waters via streams and rivers.

The relative importance of human and animal waste as contaminants of shellfish growing waters will depend on the specific topography and adjacent land uses of the region.

The number and size of human settlements in a river catchment or coastal area, the nature quality of sewage collection, treatment and disposal, the population of livestock or feral animals and the management of animal manure will all directly affect coastal waters used for aquaculture. Figure 1 shows a diagrammatic model of the diverse sources of contamination impacting on an oyster farm or bed in the intertidal zone.

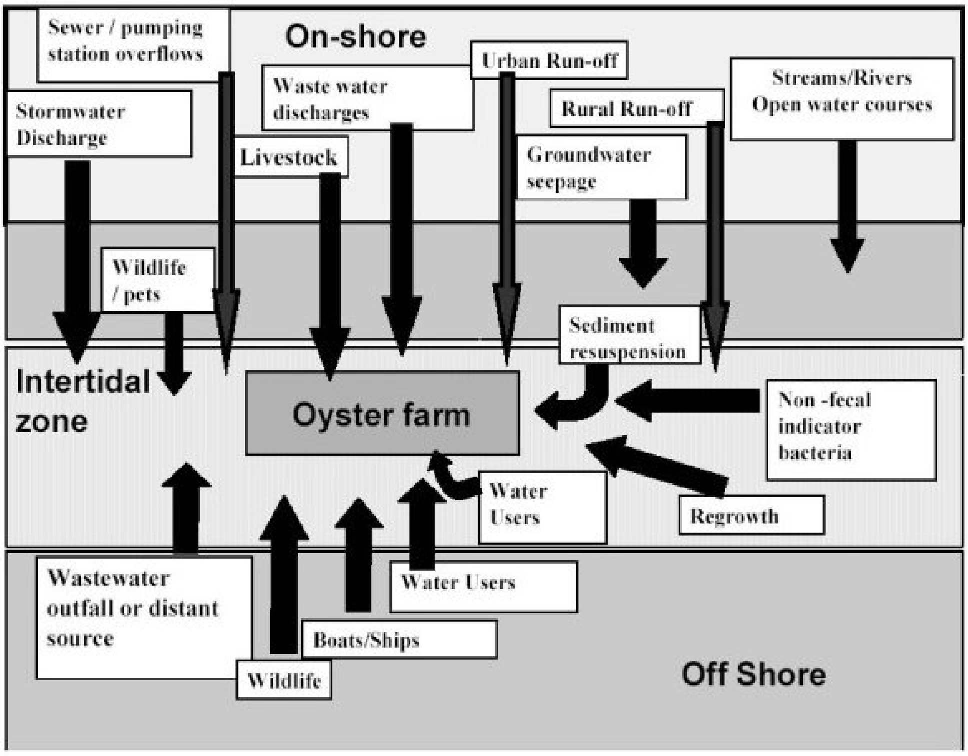

Figure 1. Conceptual model for microbiological contamination of oyster-growing waters.

Bacterial and viral pathogens discharged into water supplies are a threat to human and animal health. Once in a water body, the microbes may survive for long periods (especially spore-forming bacteria) and travel long distances. Often they adsorb to sand, clay and sediment particles that settle on the bottom leading to the accumulation of microbes in river, lake and marine sediments.

This also occurs with viruses that bind tightly to clay and sediment particles. Virus survival in water depends on a range of physical, chemical and biological factors, including water temperature, UV radiation, salinity, pH, presence of particulate matter and natural microbial activity. Shellfish living in the marine or estuarine sediments will be exposed to these microbial and viral contaminants.

The quality of the growing waters is important for maximum shellfish harvest and quality as well as general environmental quality. Shellfish growing in sewage or fecally contaminated waters will accumulate particles and pathogens from the waters as they filter feed and can be used as biomonitors to determine the quality of recreational and growing waters at different seasons of the year.

This is especially relevant in summer when many shellfish growing regions have an influx of visitors to the beaches and on boats for marine recreational activities. There is evidence that presence of bacterial and viral contaminants can increase the numbers of natural marine pathogens such as *Vibrio spp.* in the environment.

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Bibliography

Anon. (1996). Report on the equivalence of EU and US legislation for the sanitary production of live bivalve mollusks for human consumption. EU Scientific Veterinary Committee Working Group on Fecal Coliforms in Shellfish, Aug. [Provides description, comparison and statistical analysis of EU and US FDA systems for classification of shellfish growing areas]

Centre for Food Safety and Applied Nutrition. (1992): Foodborne and pathogenic microorganisms and natural toxins handbook. USDA, Washington (Comprehensive review of the nature of foodborne pathogenic organisms and disease symptoms]

FAO (2000). The state of the world fisheries. Food and Agriculture Organisation of the United Nations, Geneva. [Biennial review of world fisheries including farmed and free harvest fisheries. The report also outlines the important global issues facing fishing]

Fields Virology (1996). 3rd Edition. Ed. Fields BN, Knipe,DM, Howley PM, et al., Lippincott-Raven Publishers, Philadelphia, USA.

Hackney, C. R., Pierson, M. D. (Ed) (1994) Environmental indicators and shellfish safety. Chapman & Hall, New York. P1-523. [Comprehensive general reference text on safety and public health risks related to shellfish].

Hay, B., Grant, C., McCoubrey, D. (2000): A review of the marine biotoxin monitoring program for non-commercially harvested shellfish. New Zealand Ministry of Health. Wellington. [Review of New Zealand monitoring programs containing an extensive general review of biotoxin information and state of the art knowledge. Also available online at www.moh.govt.nz]

Lees, D.N. (2000). Viruses and bivalve shellfish. International Journal of Food Microbiology 59, 81-136. [Comprehensive description of major issues relating to viral contamination of shellfish].

Reilly, A., Kaferstein, F. (1999). Food safety and products from aquaculture. Journal of Applied Microbiology Symposium 85, 249S-257S. [Review of microbial hazards, excluding viruses, associated with aquaculture].

Rippey, S.R. (1994). Infectious disease associated with molluskan shellfish consumption. Clinical Microbiology Reviews 7, 419-424. [Overview of human diseases resulting from consumption of shellfish and the microorganisms responsible].

Biographical Sketches

Dr Gail Greening is a Science Leader in Environmental and Food Virology at the Institute of Environmental Science and Research (ESR) in Wellington, New Zealand. She has a BSc Hons from the University of Newcastle-upon Tyne, an MSc from the University of Western Ontario and a PhD in medical microbiology from the University of Otago, Dunedin, New Zealand. Dr Greening began her career as a microbiology lecturer at Massey University before moving to ESR. She has extensive expertise in microbiology and virology, especially the development of molecular assays for environmental, clinical and food virology applications. Her research interests include the molecular epidemiology of noroviruses associated with outbreaks of gastroenteritis and the occurrence, transmission and persistence of enteric viruses in shellfish, foods and the environment.

Dr Gillian Lewis is an associate professor of Microbiology at the University of Auckland, Auckland , New Zealand. She graduated with PhD from the University of Otago, New Zealand and has since worked as an academic and applied environmental scientist and environmental microbiologist in New Zealand and the USA. Dr Lewis has also had experience as both an industry and university based environmental consultant. Gillian is an active teacher, researcher and consultant in the occurrence and ecology of human viruses and indicator organisms outside the human host and specifically in environmental waters and shellfish and aquaculture systems She works extensively in the management of these contaminates through modification of contaminant generation, optimized waste treatment systems and specific aquaculture management approaches.