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A Scientific Review of the Potential Environmental Effects of Aquaculture in Aquatic Ecosystems

Volume II

Disease Interactions Between Wild and Cultured Shellfish
(S.M. Bower and S.E. McGladdery)

The complete papers can be found in the following document:

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FOREWORD

Context

The Government of Canada is committed to ensuring the responsible and sustainable development of the aquaculture industry in Canada. The Minister of Fisheries and Oceans' announcement of the $75 M Program for Sustainable Aquaculture (PSA), in August 2000, is a clear expression of this commitment. The objective of the PSA is to support the sustainable development of the aquaculture sector, with a focus on enhancing public confidence in the sector and on improving the industry's global competitiveness. Ensuring the sector operates under environmentally sustainable conditions is a key federal role.

As the lead federal agency for aquaculture, Fisheries and Oceans Canada (DFO) is committed to well-informed and scientifically-based decisions pertaining to the aquaculture industry. DFO has an ongoing program of scientific research to improve its knowledge of the environmental effects of aquaculture. The department is also engaged with stakeholders, provinces and the industry in coordinating research and fostering partnerships. As a contribution to the Federal government's Program for Sustainable Aquaculture, DFO is conducting a scientific review of the potential environmental effects of aquaculture in marine and freshwater ecosystems.

Goal and Scope

Known as the State-of-Knowledge (SOK) Initiative, this scientific review provides the current status of scientific knowledge and recommends future research studies. The review covers marine finfish and shellfish, and freshwater finfish aquaculture. The review focuses primarily on scientific knowledge relevant to Canada. Scientific knowledge on potential environmental effects is addressed under three main themes: impacts of wastes (including nutrient and organic matter); chemicals used by the industry (including pesticides, drugs and antifoulants); and interactions between farmed and wild species (including disease transfer, and genetic and ecological interactions).

This review presents potential environmental effects of aquaculture as reported in the scientific literature. The environmental effects of aquaculture activities are site-specific and are influenced by environmental conditions and production characteristics at each farm site. While the review summarizes available scientific knowledge, it does not constitute a site-specific assessment of aquaculture operations. In addition, the review does not cover the effects of the environment on aquaculture production.

The papers target a scientific and well-informed audience, particularly individuals and organizations involved in the management of research on the environmental interactions of aquaculture. The papers are aimed at supporting decision-making on research priorities, information sharing, and interacting with various organizations on research priorities and possible research partnerships.

Each paper was written by or under the direction of DFO scientists and was peer-reviewed by three experts. The peer reviewers and DFO scientists help ensure that the papers are up-to-date at the time of publication. Recommendations on cost-effective, targeted research areas will be developed after publication of the full series of SOK review papers.

State-of-Knowledge Series

DFO plans to publish 12 review papers as part of the SOK Initiative, with each paper reviewing one aspect of the environmental effects of aquaculture. This Volume contains one paper: Disease interactions between wild and cultured shellfish.

Further Information

For further information on a paper, please contact the senior author. For further information on the SOK Initiative, please contact the following:

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DISEASE INTERACTIONS BETWEEN WILD AND CULTURED SHELLFISH

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EXECUTIVE SUMMARY

This paper reviews the knowledge available on the wild-cultured host dynamics of shellfish infectious agents. As with finfish, shellfish health profiles are based mainly on knowledge derived from cultured stocks. This reflects an ease of access to cultured stock, which can introduce a sampling bias that complicates accurate pinpointing of disease sources.

Serious disease in shellfish caused by enzootic organisms generally arises from sub-optimal growing conditions, which render the animals more susceptible to opportunistic indigenous infectious agents. Alternatively, exposure of naïve and susceptible populations/species to 'exotic' infectious agents can also cause serious diseases. Differentiating opportunistic from 'exotic' infections is controversial when determining the aetiology of a 'new' disease. The emergence of an indigenous disease does not implicate accidental or deliberate introduction of animals from unscreened sources, as may be the case if an 'exotic' disease was detected. The evaluation of 'new' diseases depends on the ability to: i) identify the cause of the 'new' disease, especially because not all diseases are caused by pathogens; ii) develop or validate sensitive diagnostic techniques to accurately assess the distribution of the pathogen and ascertain if other hosts are involved; iii) trace the source (introductions, transfers, changing husbandry practices or changing environmental conditions, previously undetected 'background' infections); and iv) determine the relative significance of host physiology, genetic and ecological factors involved in the expression of the disease. Since shellfish culture is rarely practised in isolation from wild shellfish, the introduction of a new infectious agent into open-water shellfish culture can impact sympatric wild resources. Also, transplanted wild shellfish can be asymptomatic carriers of infectious agents that may infect cultured populations.

Opportunistic infections are most commonly documented in flow-through or semi-closed circulation facilities, where water exchange is limited, stocking densities are high and artificial feeding regimes are required. This provides the substrate for proliferation of ubiquitous aquatic microbes that would otherwise be benign (Elston 1984, 1989). The most frequently occurring opportunistic group are the Gram-negative Vibrionaceae bacteria (Walne 1958; Tubiash et al. 1965, 1970; Elston et al. 1981, 1982, 1987; Lodeiros et al. 1987; Dungan and Elston 1988; Dungan et al. 1989; Elston 1989, 1990; Nicolas et al. 1992). Sensitivity to Vibrio spp. varies among species and larvae are generally more susceptible than adult shellfish. Threshold tolerances vary and need to be established for individual holding systems, shellfish species and seasonal cycles of production (Sindermann 1988; Perkins 1993).

Most shellfish hatcheries use landfill sites to dispose of infected stocks rather than discharging them into the surrounding waters that supply the facility. Antibiotics may be applied, but the efficacy and expense of such treatments for ubiquitous opportunistic bacteria is questionable and has a direct and cumulative environmental impact (Plumb 1992). Uncontrolled antibiotic applications provide interim suppression, but not eradication, of losses and have led to rapid development of drug resistance in both pathogenic and non-pathogenic Gram-negative aquatic bacteria (OIE 1992; Plumb 1992; Subasinghe et al. 1995; Boyd 1999; FAO 1999).

KNOWLEDGE AND GAPS

There is little specific knowledge on the life cycle and ecology of most serious shellfish pathogens. In Canada, some effort has been directed towards understanding diseases of commercially exploited shellfish. The rapid development of shellfish aquaculture around the world, along with an increased demand for live shellfish, has escalated the need to prevent the spread of shellfish diseases. The risks associated with uncontrolled transfer and introduction of live aquatic organisms have long been recognised (Anon 1984; ICES 1988, 1995), especially for finfish species (FAO 1995; Humphrey 1995; Chillaud 1996; Humphrey et al. 1997; AQIS 1998; FAO/NACA 2000; OIE 2003a). In the last 20 years, the frequency of shellfish transfers has increased, due to the development of hatchery-based seed production, remote setting, and the increasing use of non-indigenous species in aquaculture (Kern 1994; Hine 1996; Minchin 1996, 1999; Bartley and Minchin 1996; Elston 1996).

Introductions and Transfers

- *Lack of baseline health data for local pathogens of 'new' species under culture, may impede accurate disease risk analysis, increase the difficulty of differentiating between exotic and endemic infections, and may hinder the identification of disease management options.*
- *Impacts on shellfish from accidental introduction of an exotic infectious agent could present consequences for both cultured and wild stocks under open-water culture conditions.*
- *Limited ability to detect sub-clinical carriers with subsequent development of more sensitive molecular tools may expedite turn-around time for diagnosis, but detection of other potential pathogens that may be significant to wild/cultured resources will not be possible, if detection is based solely on pathogen specific diagnostic tools.*
- *Lack of knowledge on the host ranges (i.e., all species susceptible to infection) for most shellfish pathogens seriously impedes the reliability of risk analysis results.*
- *Increasing dependence on remote processing and live-marketing facilities, usually not equipped with treated effluent or land-based waste disposal systems, complicates assessing the risk of inadvertent spread of infectious agents.*

Technological Constraints

- *Molecular tools to trace sources of infection are under development for only a few of the numerous shellfish pathogens of concern. These include probe production (Walker and Subasinghe 2000) for certain shrimp viruses (Lightner 1996b) and a few* *oyster pathogens (Stokes and Burreson 1995; Reece et al. 1997; Berthe et al. 1999; Berthe 2000; Carnegie et al. 2000; Russell et al. 2000). However, many of the procedures have not been fully validated (Cunningham 2002) and the interpretation of the results can be problematic (Bernoth 1999).*

- *Focus on diagnostic assays for specific pathogens can preclude the detection of other pathogens not yet recognised because of knowledge gaps. This is mitigated through the use of histopathology, a non-specific screening technique.*
- *Cell-lines routinely used to isolate intracellular pathogens of vertebrates are currently lacking for both marine molluscs and crustaceans (Mothersill and Austin 2000). This has been a significant constraint to the detection and understanding the epidemiology of viral and other intracellular microbial infections.*
- *Difficulties in isolation of shellfish pathogens have also proven problematic for their culture and use in controlled infection experiments. These are necessary to examine Koch-Henle's postulates (cause-effect measures for disease) as well as accurately assess risk of establishment and disease spread (via carrier and normal hosts).*

Diagnostic Sensitivity and Specificity Issues

- *The development of more sensitive diagnostic techniques has focussed on pathogens that have a significant economic impact on production and trade. New pathogens, or those of more regional significance, rely on more 'traditional', but less sensitive diagnostic tests.*

RECOMMENDATIONS

- *Research is required to allow effective development of risk analysis procedures pertaining to shellfish diseases.*
- *Surveillance programs to assess the presence and prevalence of pathogens in wild and cultured shellfish in Canadian territorial waters are needed to protect Canadian aquatic resources from infectious diseases where early detection and intervention can significantly reduce impact and losses.*
- *Research is needed to improve diagnostic tools especially to enhance detection capability for significant sub-clinical microbial infections.*
- *Research is needed into pathogen life cycles. Information gained will be the basis of research into health management options and bolster risk analysis results.*
- *Research is needed on diseases of 'new' culture species, especially those with negligible or no health information.*
- *Assessment of factors associated with 'Introduction and Transfer' risks (especially fouling organisms and 'hitch-hikers') that may pose indirect health risks (e.g., as carrier reservoirs).*
- *Environmental suppression/exacerbation factors associated with disease expression are notably lacking in most shellfish health literature. The impact of disease under 'new' habitats or geographic conditions requires more detailed examination.*

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