

Epilogue: Aquaculture, Innovation and Social Transformation

Barry A. Costa-Pierce

Aquaculture, not the Internet, represents the most promising investment opportunity of the 21st Century.
Peter Drucker, Economist and Nobel Laureate

This pioneering volume is about two things: the poignant clashes of views regarding aquaculture, and the underlying question of how we are to make complex choices regarding use of new technologies to produce food for a hungry planet. As the editors put it, “The debate [over aquaculture] is at least emblematic of, if not literally about, the struggle over the place of technology in human life and the life of the planet.” The context of this volume’s approach to the debate could hardly be better suited to facing this two-layered question: the waning growth of aquaculture in Canada, a global small-player in aquaculture which nonetheless has huge potential to participate in aquaculture. The particular value of this volume lies in the way Culver and Castle have intentionally engineered a clash of cultures as they have asked the very diverse authors of this volume to take up various parts of a provocative question: “Does Canada – the world’s largest ocean nation – want to become an ‘aquaculture nation’?”

A tangled set of further questions lies beneath the challenge facing Canadians. What can the world learn from Canadian experience in aquaculture? In Canada, aquaculture is a controversial “new” use of aquatic ecosystems, and while the potential for aquaculture is significant, the sector flounders in a context in which political will is often enough to lead to substantial financial backing of innovation in a sector. What can the world tell Canada about how to face the question of whether, and in what way it can be, a global leader in aquaculture? What would it mean for other countries were Canada to face the social transformation caused by new technology innovation in an industry that competes, and threatens to replace, a capture fishery imbued with history and mythology about traditional practices? Can a new vision arise where innovative aquaculture businesses evolve into modern, 21st century, knowledge-based operations dedicated to pioneering the development of

B.A. Costa-Pierce

Professor of Fisheries and Aquaculture, Department of Fisheries, Animal and Veterinary Science and Director, Rhode Island Sea Grant College Program, Graduate School of Oceanography, University of Rhode Island, Narragansett, RI 02882-1197 USA

planned, well-integrated, socially acceptable aquaculture systems that have positive multiplier impacts on both natural and social ecosystems?

Aquaculture is nothing new. It arose multiple times in many indigenous societies where coastal population densities of “seafood eating peoples” increased beyond the carrying capacities of natural, aquatic ecosystems to provide for them. There have been many “blue revolutions” throughout history! But modern aquaculture is very different, being technologically complex, and, given a social makeup of a society (urban, rural, rich, poor, etc.) communities can either embrace such dramatic change, and accommodate the necessary social transformations, or reject such change and continue their social, cultural, and economic evolution without aquaculture. One of the fundamental problems of aquaculture development is the lack of understanding and planning for the social/community transformations wrought by aquaculture innovations, and the lack of knowledge on how to govern aquaculture innovations. The divergent and fascinating First Nations perspectives on aquaculture reviewed herein are a case in point, one that has fascinated me for a long time, namely, the evolution of aquaculture in ancient societies, and the use of that traditional knowledge to evolve an alternative path for coastal societies worldwide (Costa-Pierce 1987, 2002). Yet no matter the sources of the knowledge we use to chart a course for aquaculture – whether traditional knowledge, science, or some blend, well planned, transparent, participatory processes are required; ones that may drag out for longer than decision-makers want, but in the end will lead to some shared visions of more common futures.

In this regard, the nation-state has a particularly difficult time dealing with such long, oftentimes contentious local/regional participatory processes. Aquaculture planning issues are invariably tied to people’s visions of their communities, their past, and their ideas of the future of a working waterfront. Welcome the stark contrast in the social/community acceptance of salmon aquaculture in Newfoundland versus British Columbia where different regional visions of the past and the future drive the acceptability of innovations such as aquaculture. Matters become all the more complicated when community identities and aspirations for the future have to interact with and decide to use or step away technologies of uncertain merits, often under the pressure of advice from people who are not members of the affected community. Culver and Castle point out that Canadians’ favorite public value of consensus works poorly at the nation-state level, and hardly any better within the country’s diverse regions. Furthermore, aquaculture innovations are so diverse that no one pathway for coordinating social acceptance with technological innovation is possible. It may be the case that in each instance of technology uptake into the aquaculture industry, active social engagement – a learning community of sorts – needs to be developed to take stock of the wide diversity of aquaculture innovations.

There is an intriguing contrast visible in the difference between global opinion and what authors in this volume represent as an often negative Canadian public opinion of aquaculture. Most global analysts agree that a rapid acceleration of aquaculture – the “blue revolution” – is not only needed, but is a forgone conclusion given global demand for sustainable sources of food protein. In addition, any rigorous comparisons of aquaculture with other food protein production systems reveal

that aquaculture is a very efficient mass producer of animal proteins for a crowded, coastal planet, and also has great potential to transform coastal societies. Comparisons against an array of capture fisheries and terrestrial agriculture systems confirm that aquaculture – even as currently practiced (e.g. in its “current state of evolution”) is superior in terms of financial and social impacts (profit per ha; social multiplier effects), and energy and production efficiencies.

Aquaculture could mitigate the effects of the disastrous trajectory for terrestrial meat production and the capture fisheries. FAO (2007) estimate that 77% of all global fish stocks are either fully exploited with no room for further expansion; or are overexploited, depleted, or recovering from depletion owing to excess fishing pressure. FAO (2007) project that capture fisheries production from 2004 to 2030 will remain stable at 86–87 million metric tonnes, while aquaculture will almost double from 45 to 83 MMT during the same time. Much of the pressure to increase aquaculture production is derived from considerations of efficiency. Goodland & Pimental (2000) state, “In the worldwide effort to increase food production, aquaculture merits more attention than raising grain-fed cattle.” Production efficiencies of edible mass for aquaculture range from 2.5 to 4.5 kg dry feed/kg edible mass compared with 3.0–17.4 for conventional terrestrial animal production systems. Beef cattle require over 10 kg of feed to add 1 kg of edible weight, whereas catfish can add a kg of edible weight with less than 3 kg of feed. By comparison, wild, “capture” fisheries are less efficient from both trophic and energy efficiency perspectives.

Coastal and oceanic ecosystems have trophic efficiencies of 10–15%, and mean trophic levels of 3.0–5.0 (Ryther 1967), whereas mean trophic levels in aquaculture systems range from 2.3 to 3.3, with highest aquaculture trophic levels in North America and Europe (Pullin 2001). Pullin (2001) state that “most ocean fish consumed by humans have trophic levels ranging from 3.0 to 4.5 (Pauly et al. 1998); that is 0–1.5 levels above that of lions.” Vernon (2007) completed an analysis of salmon ranching versus salmon farming in the north Pacific Ocean, and concluded that salmon ranching as practiced currently in British Columbia, Alaska, and Japan, introduces 250 times more smolts and consumes 70 times more feed to produce less than 10 times the volume of marketable salmon than salmon farms. To produce 1 kcal of catfish protein about 34 kcal of fossil fuel energy is required; lobster and shrimp capture fisheries use more than 5 times this amount of energy. Energy costs for even the most intensive salmon cages are three times less than lobster and shrimp fishing, and are comparable to beef production in feedlots.

In light of the superior efficiency of aquaculture, the sometimes negative public view of aquaculture in Canada appears for a moment to be a strange anomaly – until we bring to mind again the observation of Culver and Castle that the debate over aquaculture is simultaneously a debate about the place of technology on our coasts and in our lives. If aquaculture is to be a vital part of the knowledge-based, innovation economy for coastal societies in Canada, and worldwide, aquaculture must be better integrated into social life. Aquaculture is technology intensive and rapidly evolving, and so those who wish to use it must keep follow the pace of change. What is required is an entirely new view of what the blue revolution is not, to clear away false expectations and misconceptions, but also what it can be:

a new pathway to sustainable development for aquaculture – an alternative path to wasteful food production techniques – and the birth of new institutions to help direct and support the massive social transformation of some coastal societies dealing with new aquaculture proposals. It is crucial to remember when thinking of coastal societies that like the rest of us, most are not keen to become historic theme parks where fishermen’s wharves are devoid of fishermen. Coastal societies are typically intent on both preserving their glorious past, and securing the future of their working waterfront.

The Green Revolution is Not a Model for the Blue One

In my opinion, aquaculture’s future growth as projected by FAO will not occur in Canada or elsewhere unless aquaculture developers choose a route other than the failed “green” revolution with its adverse environmental, ecological, community, social, and ethical impacts.

The Green Revolution raised agricultural yields, especially in India, but did not strive to involve agribusiness and multinational food corporations with communities, farmers, or local governments to build, invest in, and nurture change in local institutions, communities and cultures. As a result, accelerated production did not alleviate poverty or eliminate hunger, and production gains damaged the environment. Numerous multidisciplinary studies, especially in Mexico and India, have shown that the Green Revolution’s expensive seed, fertilizer, pesticide and irrigation “packages” favored a minority of economically-privileged farmers (Rosset 2006). Environmentally, the green revolution produced a well-documented litany of “externalities”: accelerated pollution of rivers and water tables, widespread soil degradation, losses of biodiversity, and occupational pesticide poisonings. In India, the Green Revolution’s “technology packages” required irrigation; so the government subsidized the digging of tens of thousands of wells which pumped many water tables dry, forcing vast areas to return to traditional, dryland farming systems. Most of India’s grains were exported, so national elites profited mightily. The local, hydrological result of the Green Revolution’s technology packages was “the sacrifice of India’s ancient aquifers to the international grain trade” (Rosset, 2006).

My Crystal Ball is Blue... If Viewed Through the Right Lens

Aquaculture developments are rarely planned as social transformations. Modern aquaculture is still new to our policy institutions, governments and universities. Aquaculture is rarely considered as a part of social design and transformation; and is rarely thought of as an exciting new field of multidisciplinary scholarship having its own merits in the context of innovation, cultural evolution, knowledge systems, knowledge acquisition and management. Discussion of advances in the field of aquaculture is similarly at an early stage of development, largely dominated

by technological and natural science findings while the relatively few social researchers interested in aquaculture struggle to keep up with the sheer volume of the science and its interaction with social issues. Aquaculture developments today are commonly considered as “industrial primary production.” Metrics of “success” rarely include anything other than exports of tons of fish produced. In the face of what is presented as “success” we are now facing concerns that can no longer be ignored: charges that aquaculture’s current mode of industrial expansion is leading to a failed pathway of “boom and bust” cycles. Such cycles have plagued the development of shrimp, tilapia, and salmon aquaculture worldwide. Why have these occurred?

The relative narrowness of aquaculture research is unfortunately paralleled in many governments by equally narrow expertise and responsibility for aquaculture. Aquaculture impacts many sectors of society, but aquaculture is rarely considered comprehensively by government. Decision-making about its future is currently made principally by the minds of a few specialists in governments who oftentimes are untrained in aquaculture; these power-brokers are routinely ensconced in the bowels of government agriculture or fisheries departments. As a result, “boom times” get much attention by important people; “bust times” are those where a few specialists are left to clean up the mess.

Inadequate training and knowledge are often at the root of poor planning and exaggerated claims regarding the merits of aquaculture. Too often, aquaculture comes into coastal communities with great promises of innovation amid projections of positive impacts on the local economy. Aquaculture’s extraordinary potential for generating large scale multiplier impacts are rarely achieved, however, or if they are, they are achieved as poorly planned afterthoughts, not as well planned, collaborative developments that have at the outset included a broad range of local stakeholders, policy-makers and allied supply-side businesses. According to Dicks et al. (1996), aquaculture production in the USA accounted for only 16,500 jobs and just 8% of the income. Aquaculture goods and services (feeds, fertilizers, processing, transport, equipment, supplies, etc.) accounted for 92% of the income and about 165,500 jobs.

Multidisciplinary Aquaculture Social Science Needs

In my view, we have yet to take two crucial steps needed to develop the alternative path for aquaculture development as social transformation: (1) industry commitment to implementation of an ecosystem approach to aquaculture (EAA); (2) development of alternative institutions that would team government, universities and industry, whose mission would be to multidisciplinary learning, social transformation, and the aquaculture “innovation portfolio.” University involvement is essential as a “keeper of the flame” since neither government nor industry can effectively play the role of an honest broker. What is required is a neutral convener and purveyor who can help lead the integration of an EAA with institutions committed to social change who pay close attention to market and societal transformations (such as progress towards: internationalization and multiculturalism, sustainability, bioregionalism,

carbon footprints/trading/food miles). Societal transformations need time and stable funding bases to foster unique partnerships. Such type of leadership is fully underway in agriculture, and could be an important model for aquaculture. I hope and anticipate that this seminal volume will, in and of itself, go a long way towards developing further a cadre of multidisciplinary scholars in aquaculture; and additionally stimulate formation of new institutions committed to developing cadres of science-policy-innovation experts.

An Ecosystem Approach to Aquaculture (Natural and Social Ecology)

Implementing an ecosystem approach to aquaculture (EAA) is a major global trend (FAO, 2007). At an FAO Workshop on EAA in Mallorca, Spain in 2007, an EAA was defined as “a strategy for the integration of the activity within the wider ecosystem such that it promotes sustainable development, equity, and resilience of interlinked social-ecological systems.”

Soto (2008) has defined an ecosystem approach, like any systems approach to management, as accounting for a complete range of stakeholders, spheres of influences and other interlinked processes. Applying an ecosystem-based approach must involve physical, ecological and social systems in the planning for community development, while also taking into account stakeholders in the wider social, economic and environmental contexts of aquaculture. Soto (2008) developed the following three principles and key issues of an EAA at the different scales:

Principle 1: Aquaculture should be developed in the context of ecosystem functions and services (including biodiversity) with no degradation of these beyond their resilience capacity. The key issue here is to define and estimate resilience capacity or the limits to “acceptable environmental change.” A range of terms has been used to characterize the appropriate limits, including “environmental carrying capacity,” “environmental capacity,” “limits to ecosystem function,” “ecosystem health,” “ecosystem integrity,” “fully functioning ecosystems,” all of which are subject to a specific social, cultural, and political context.

Principle 2: Aquaculture should improve human-well being and equity for key stakeholders. This principle ensures that aquaculture provides equal opportunities for development, and that the benefits from aquaculture are properly shared while not resulting in detriment to society, especially the poor. Both food security and safety are key components of societal well-being.

Principle 3: Aquaculture should be developed in the context of other sectors, policies and goals. This principle recognizes the important interactions between aquaculture and the larger ecosystem, in particular, the influence of surrounding natural and social environments on aquaculture. Aquaculture does not take place in isolation from other activities, and, in is usually not the only human activity impacting water bodies that are otherwise more severely affected by agriculture, industrial activities, and human wastes. This principle acknowledges the opportunity

to couple aquaculture activities with other production sectors in order to promote material and energy recycling. Aquaculture sites are not only economic engines of primary production that work so long as they comply with local regulations. Aquaculture sites can also be sources of innovation and pride if they can be designed, community-based, farming ecosystems. Regular reviews of progress towards an ecosystems approach to aquaculture are necessary to inspire planners and environmental decision-makers (at many societal scales – national, regional, local) to use new, innovative approaches. Sophisticated site planning of aquaculture can occur so that farms “fit with nature” and do not displace or disrupt invaluable aquatic ecosystems or conservation areas, and also contribute to the local economy and society.

In as much as EAA calls for technological solutions that fit aquaculture technology into ecological constraints, it also requires social change for the acceptance and wise use of innovations. All too often, aquaculture comes into coastal communities so poorly planned that its extraordinary potential for generating large scale multiplier impacts is recognized only as an afterthought and by accident, not as the result of well-planned, collaborative developments involving from the outset a broad range of policy-makers and allied supply-side businesses. Authors of this book make a strong case that aquaculture’s future in Canada, as an example nation, is tied to this “innovation portfolio.” Aquaculture’s future is much more than a simple technological exercise—it is an exercise in multidisciplinary, multi-institutional, environmental scholarship—requiring aquaculture developers to devise planned, systems approaches that include communities and their traditional knowledge systems to insure their “coastal futures.”

Felt in this volume points out “it all depends on the lens, b’y.” Indeed, at the community level, science facts may mean little to policy decisions; communities can find it difficult to separate societal values from science. The precise meaning ascribed to key science and ecosystem terms is usually not a battle over science: ultimately, it is a debate over which policy option is selected. The debate over what might appear to be semantic nuances is really a surrogate debate over values and policy preferences. Words such as “degraded,” “damaged,” “healthy,” and the relative importance of natural versus altered environmental conditions are calibrated by societal values and preferences, not only science. One person’s “damaged” ecosystem is another’s “improved” one. A “healthy” ecosystem can be either a swamp infested with mosquitoes, or an intensively managed fish pond.

Ryan in this volume states that “The pro/anti approach is frustrating for resource managers to have to wade through rhetoric instead of spending precious resources on progressive innovation”. Such debates are rarely sophisticated enough, however, since the art and science of “the process” – of the proper design to air completely opposing views and bring them together (Martin 2007) – is rarely considered important enough to invest in. For example, we routinely review the “environmental impacts of aquaculture,” but fail to examine fully the environmental benefits of aquaculture (Rensel and Forster 2007), or the notion of aquaculture ecosystems (Costa-Pierce 2003), similar to the popular ideas of “agroecosystems” (Gliessman 2006). As a more provocative example, there are reports of land-based salmon aquaculture being not economically feasible but there are few visionary,

multidisciplinary, social-ecological, economic feasibility studies on how it to make it viable. Scientists also say that other industries release more nitrogen to the BC marine environment than aquaculture (Cubitt et al., Chapter 9), but we never discuss these other industries, and their plans for the future. Continuing on, we know that salmon escapees of non-indigenous salmon species seed the marine environment with an exotic species that Mother Nature never intended to be there, but we rarely discuss how the use of indigenous salmon species in aquaculture may be a higher risk to the genetic integrity of native salmon (Fleming 2005). Plus, we know that billions of salmon smolts are seeded into the Pacific Ocean from salmon hatcheries – can these produce more detrimental food chain impacts than aquaculture (Vernon 2007)? All of these examples support the argument of Antle and Wagenet (1995) who emphasized, over a decade ago, that systematic frameworks are required, so that economic data and data from other, interacting disciplines can be collected and integrated using common units of measurement.

Aquaculture knowledge is fluid, international and innovation is at its heart. The fascinating topic of “intangible assets” in this book reminded me of how poorly we plan for innovations in aquaculture. Much of aquaculture’s true worth is not in fish or clams; it is in the intellectual capital that moves freely across borders. Culver calls these “national and supra-national systems of innovation,” and applied aquaculture scientists/outreach specialists know exactly what he is talking about. Western scientists have lived for years in the major aquaculture growth regions of the world and have brought with them not only their brains, but also their attitudes, habits, families, Many stayed, “went bush,” and became essential parts of the cultural evolution of aquaculture in those societies. “Outsiders” became “insiders” and grew to know as much (or more) than many native-born about the local, cultural development of aquaculture, aquaculture families and communities in those societies.

Institution-Building

Alternative paths must be nurtured by alternative institutions capable of translating research into action and governance of action. Fostering an alternative path to aquaculture development will require the design and development of alternative institutions committed to developing the “innovation portfolio” and charting the future development of socially and ecologically responsible aquaculture industries that are well integrated into coastal societies. Globally, we do not have these institutions yet, and where they made baby steps forward, they have ultimately failed. The causes of institutional failure in aquaculture need further investigation before we can say with certainty what went wrong. Yet that need should not stop us from trying to be clearer about the conditions for success. Sustainable aquaculture needs well-designed, facilitative, collaborative (industry, government, universities, NGOs) institutions working with adequate funding, using multidisciplinary approaches to setting research and outreach priorities, and assessing research and outreach impacts. This “triangulated” approach to the problems, and some of the pitfalls, is

usefully displayed in this book's model of contested exchange between interested and affected stakeholders in aquaculture.

There are several lessons to be drawn from this experiment with a model of contested exchange, but perhaps one of the most important is this: As aquaculture continues to expand, the role of research and development will be key and will perhaps increase, contrary to the "once and done" attitudes which sometimes plague bureaucrats looking for single-step innovation which will then provide a durable socio-economic base for some society. Globally, aquaculture development has been hampered by three factors relating to the fundamental requirements of research and development: insufficient funds, lack of core research staff, and weak research infrastructure (FAO 2007). An increase in the quantity and quality of human resources focusing on aquaculture innovation is essential in the search for new aquaculture opportunities. Successful human resources development will trigger the development of more efficient aquaculture-related technology, legislation, and management (FAO 2007).

The International Agriculture Research Centers allied under the CGIAR network (Consultative Groups in International Agriculture Research) are good models to consider, since these institutions develop research priorities that are driven not only by science needs but also economic efficiency, equity, internationality and sustainability (Kelley et al. 1995). Such characteristics are very important to support the development of an ecosystem approach to aquaculture, especially in a time of intense competition for scarce funds. It is important when laying out research priorities that anticipated benefits flowing from additional investments as well as the opportunity costs are made explicit. Kelley et al. (1995) state how ICRISAT (International Crops Research for the Semi Arid Tropics) provided clear criteria for establishing choices among competing research activities, that were analytically rigorous, drew on scientists' empirical and intuitive knowledge base, and were transparent and interactive. ICRISAT developed themes for collaborative, multidisciplinary research that were impact-oriented, and projected clear milestones against which progress was measured and evaluated. In the US, the Land Grant and Sea Grant College Programs is another model, not only for aquaculture, but also for many diverse aquatic/ocean/coastal disciplines with which it interacts. Sea Grant connects universities to industry and government in a collaborative manner to address integrated, multidisciplinary, multi-stakeholder problems; and is a proven commodity; but also is vastly underfunded (OSB/NRC 1994).

Collaborative research designs are needed to meet the standards of good science while also satisfying the standards of accountability and policy relevance. As scientists become involved in the priority setting process, they become aware of the ways that their research can contribute to the mission of publicly funded research. Proper valuation of the economic, environmental, and human health impacts of aquaculture production systems is essential for priority setting and impact assessment; multidisciplinary collaboration is also a critical element of the valuation stage of impact assessment.

The coastal zone management (CZM) and site selection chapters by Lane et al., Smith and Chopin emphasize the many aspects of this practical need for proper valuation. Smith calls CZM "a tidy process for an untidy reality." Much discussion over the impacts of aquaculture is based on its siting, and any process that determines

siting is, by definition, multi-issue, multi-stakeholder, multi-institutional, and multi-jurisdictional. Smith questions if a multi-criteria approach could ever meet the needs of aquaculture when it involves multiple stakeholders, each of whom have different concepts about what counts as meaningful data, and how the sites current and future use should be valued. Chopin et al. (2004), the pioneer of the Integrated Multi-trophic Aquaculture concept where disparate aquaculture systems are integrated into a designed ecosystem, has brought great attention to this as an alternative model of aquaculture development which could include recreational, tourism, and other stakeholders. Chopin's view of the complementarity of uses and the importance of scientific validation of that complementarity resonates with a future of aquaculture as a vital part of coastal communities that are proud of its new, exciting, knowledge-based future.

Funding for innovation is always a major issue, but fostering the long-term development of such innovative institutions for aquaculture is impossible on competitive funding alone. Huffman and Just (1994) argue that with respect to the development of agricultural experiment stations at US universities, directed ("formula") funding was more productive than competitive grant funding, and that "heavier administrator involvement... enhanced productivity of applied research where approaches and products were specified in advance." One take home message could be that the demise of AquaNet in Canada leaves a vacuum that cannot be filled with many disconnected, short-term projects.

A larger take home message must, however, return to the two-layered problem with which Culver and Castle began. This volume's authors demonstrated convincingly that it is a serious mistake to take a one-dimensional view to aquaculture, whether that view sees aquaculture as a tool of regional development, as a threat to ecosystem health, or something else. Aquaculture is itself multi-dimensional and making the best use of its potential to contribute to global food security will require far more than the knowledge and skills of natural scientists. Once the multi-dimensional nature of aquaculture is recognized and widely accepted, it is much easier to understand the second layer of this volume's motivating problem. Aquaculture is just one among many complex technologies vying for support in national systems of innovation, and there are lessons to be learned by aquaculture advocates from understanding national systems of innovation, and advocates and operators of those systems can learn about the adequacy of those systems from the way they handle scientifically and socially complex topics such as aquaculture. It's all in the lense, as Felt argues here, and we need to work together – aquaculture advocates, global food security advocates, national science, social science, humanities and other researchers – to develop a point of view we can all live with into the future.

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Aquaculture, Innovation and Social Transformation

**Workshop Proceedings
Montreal, Quebec
August 18 to 20, 2004**

Prepared for:

**David Castle
Department of Philosophy
University of Guelph**

**Keith Culver
Department of Philosophy
University of New Brunswick**

FINAL REPORT – October 25, 2004

Prepared by:

Jacques Paynter
AMEC Earth and Environmental,
A division of AMEC Americas Limited
25 Waggoners Lane
Fredericton NB E3B 2L2



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1.0 Introduction

1.1 Introduction

This report presents the results of the Aquaculture, Innovation and Social Transformation Workshop convened in Montreal on August 18–20, 2004.

The objectives of the workshop were to:

- Investigate the state and future of Canadian aquaculture from the perspective of policy-oriented social science and humanities research.
- Comprehensively identify emerging social issues arising because of innovation in aquaculture.
- Develop a forecast of responsible governance models for aquaculture innovation.

The workshop was co-sponsored by the Canadian Program on Genomics and Global Health and AquaNet, with additional support from the Department of Philosophy at the University of Guelph, the University of New Brunswick's Centre for Social Innovation Research and McGill University's Centre for Intellectual Property Policy.

The workshop was subdivided into seven sessions. For each session, two research papers were presented, followed by a critique and commentary by a designated participant. These presentations were then the subject of discussion oriented to exploring the issues in greater depth.

1.2 Participants

Attendance at the workshop was comprised of a broad representation from: University of Glasgow; University of Guelph; Aquaculture Innovation; University of New Brunswick; University of British Columbia; Fisheries and Oceans Canada; University of Ottawa; Fish Farming International; Norwegian Institute for Fisheries and Aquaculture; Malaspina University-College; Institute on Governance; McGill University; Carrier Sekani Tribal Council; Ocean Nutrition Canada; Networks of Centres of Excellence; and, New Brunswick Salmon Growers Association.



1.3 Structure of the Report

The remainder of this report is structured as follows:

- Chapter 2.0** Summary of Discussions on Animal Welfare in Aquaculture
- Chapter 3.0** Summary of Discussions on Knowledge Management and Intellectual Property Issues
- Chapter 4.0** Summary of Discussions on Environmental Sustainability of Aquaculture
- Chapter 5.0** Summary of Discussions on Interaction Between Traditional Knowledge and Modern Aquaculture
- Chapter 6.0** Summary of Discussions on Messages, Consumers, and Aquaculture
- Chapter 7.0** Summary of Discussions on Integrated Coastal Zone Management
- Chapter 8.0** Summary of Discussions on New Practices for Global Competitiveness
- Chapter 9.0** Conclusions

2.0 ANIMAL WELFARE IN AQUACULTURE

2.1 Discussion Results

- Definitions of Animal Welfare and Suffering

The need for a common definition of animal welfare was discussed. Specifically, most definitions relating to animal welfare fall into three broad categories:

- Feelings-based definitions
- Function-based definitions
- Nature-based definitions

Feelings-based definitions depend upon the controversial point that animals have conscious feelings, whereas function-based definitions are based on the

assumption that an animal whose physiological systems are poorly functioning is suffering. Nature-based definitions rely on the view that animals suffer if they cannot meet their behavioural needs.

As it is difficult to define animal welfare, an alternate approach is to identify the conditions that must be fulfilled to ensure that animals have a good quality of life (and death). These conditions fall under five “domains of welfare” which include the following:

- Domain 1: Water and food deprivation, malnutrition
- Domain 2: Environmental challenge
- Domain 3: Disease, injury and functional impairment
- Domain 4: Behavioural/interactive restriction
- Domain 5: Mental and physical suffering

- Measurement of Welfare

Natural responses of animals to adverse conditions, particularly changes in physiology, health, and behaviour, can be used to assess their welfare. Although links between these conditions and actual welfare are considered complex and none of these assessment methods can provide all the answers, welfare researchers tend to collect data on all three as they monitor health, physiology, and behaviour of their subjects. This provides a broad view, however it also presents the challenge of how to combine information from different biological systems.

- Fish Capacity for Suffering

Some information presented indicates that fish have limited behavioural capacities and are not capable of complex mental processes, and therefore tend to behave in a reflex-based manner. As such, it is not anticipated that fish can experience pain and fish welfare is a meaningless concept.

In opposition to the above, it was discussed that fish do indeed have pain receptors (nociceptors) that react in a similar fashion to those of humans and respond to a range of harmful stimuli. Their brains are organized differently than those of other vertebrates, but it is still possible to identify many of the same structures. Fish behaviour is highly complex and flexible as they have a capacity to learn and remember. For these reasons it was suggested that pain can be experienced by fish, and therefore fish welfare is meaningful.

- Fish Welfare Interest

It was expressed that responsible farmers are concerned for the well-being of their stock as a matter of professional integrity; good welfare results in good



production. Farmers and regulators are also responding to the increasing and legitimate public concern for the welfare of farmed fish. It is anticipated that welfare status will become an additional aspect of product quality from which responsible farmers will stand to benefit.

- Fish Welfare in Light of Production Systems

It can be argued that farmed fish experience better conditions than wild fish as they are continually supplied with high quality food, are protected from predators, and inoculated against disease. On the other hand, they are often disturbed by human activities, held at high densities that restrict space, are sometimes fed clumped food, which leads to aggression and competition among the caged fish, and are ultimately slaughtered. These activities may impair welfare, so it is important to consider methods conducive to responsible farming and alleviating stress of the fish. Simple changes to production systems and farm practices that reduce the adverse effects of the farm environment on fish welfare were considered. These include lower stocking densities for species where high stocking densities impair welfare and the selection of slaughter methods that reduce stress.

- A Response to Fish Welfare Issues

The response to the above-mentioned issues was provided from several perspectives:

Research approach – Is circumstantial evidence and analogy a sufficient motivator to attend to animal welfare?

Production approach – Does good welfare improve production or quality?

Ethical approach – Evidence of some degree of consciousness is not an indication of pain as suffering. What is the moral balance between fish interests before human interests?

Evolutionary approach: – What evolutionary advantage would be gained by fish in developing an ability to suffer? Fish have a “fear and flight” mechanism that is not learned from past experience, cannot be shared and is not hereditary.

The application of animal welfare issues to the business of selling fish is considered to be dubious because there is no evidence to suggest the consumer really cares. To the contrary, the data indicates that farmed salmon sales are negatively affected by product quality concerns, and not welfare. Thus fish welfare does not appear to be a marketable trait unless it directly impacts on product quality.

Suggested actions include: regulations based upon actual experience developed in consultation with industry and other stakeholders; regulations based on sound



knowledge of the species and environments concerned; practical tools for on-farm assessment of welfare collaboratively developed by scientists and industry; and, industry initiated monitoring, overseen by regulators.

3.0 KNOWLEDGE MANAGEMENT AND INTELLECTUAL PROPERTY ISSUES

3.1 Discussion Results

- Performance Measurement

The need for aquaculture to demonstrate an acceptable balance between environmental impact and high-value economic output was discussed. To achieve this balance, innovation in products and processes is required as well as research and development (R&D) efforts beyond the private sector capacity.

- Evaluation of Intellectual Property

Arguments were provided for a shift from regarding intellectual property and patents as the measure of aquaculture R&D organizations' contribution to the Canadian system of innovation. It was suggested that organizations operating on short-term funding and evaluation systems should emphasize the value of the rivalrous non-intellectual property intangible assets they create, in human capital capable of solving emerging problems, and the variety of ideas and know-how which can be employed to benefit Canada without protection of intellectual property. This emphasis should require aquaculture R&D organizations to actively study their own contributions to innovation and to promote increased sharing of knowledge and transfer of innovations near to market to end users prepared to commercialize those innovations. This will require collaboration between governance and research elements of the national system of innovation, even possibly requiring routine secondments between governance and research elements to create a cadre of science-policy-innovation experts.



- Salmon Aquaculture Forum

A Salmon Aquaculture Forum has been created to resolve contentious issues surrounding industry by bringing together diverse interests. Creation of the Forum arose from the two-sided debate over salmon aquaculture in British Columbia (BC), with one side identifying salmon farming as a source of economic and food security and the other side typifying salmon farming as one of the greatest threats to the diversity and abundance of natural resources on the coast of BC (in particular to wild salmon stocks).

Numerous attempts to settle the debate in the Province through public consultation unfortunately were not successful. The Salmon Aquaculture Forum was proposed as a means of engaging people with different perspectives and backgrounds, including First Nations, stakeholders from industry, the environmental sector, and others, in an attempt to build common ground, implement best practices, and develop a consensus about the future of the aquaculture industry.

The Salmon Aquaculture Forum: Discussion Paper on Practices and Findings and *The Salmon Aquaculture Forum: Briefing Note to Ministers* are two reports produced by the Forum that provide recommendations to the two levels of government on the ways and means of creating a commission-style forum. To date, the governments have not implemented the Forum. However, participants discussed the need for such a forum, as salmon aquaculture appears to be here to stay while the debate surrounding industry continues.

The role of the Forum in consensus building within the Forum body and conflict resolution within the general public was also discussed. To accomplish this, the Forum must earn the trust and respect of a large and diverse stakeholder community, the general public, and the media.

4.0 ENVIRONMENTAL SUSTAINABILITY OF AQUACULTURE

4.1 Discussion Results

- Management for Survival vs. Management for Profit

Participants discussed farming approaches as management for survival or management for profit. Management for survival was considered to be production based on semi-intensive and extensive systems (i.e. providing finfish for rural markets and subsistence in developing countries); management for profit was considered to be intensive rearing (i.e. finfish such as salmonids for profit). It was suggested that to adequately address the issue of aquaculture sustainability, it is important to recognize and address the diversity of farming practices and economic and social factors influencing development.

It was also suggested that the concept of sustainable aquaculture must also address environmental, economic, and social issues, with each of these having equal importance.

- Goal of Environmental Sustainability

The goal of environmental sustainability was presented as the maintenance of the current level of environmental assets to ensure that future generations benefit from the same level of environmental goods and services presently available. In regards to aquaculture, accumulation of waste and pollution of aquatic habitats were identified as some of the major negative environmental impacts. Dependence on wild seed to establish new generations was also identified as a pressure point on already threatened stocks.

- Approaches to Successful Environmental Sustainability

The environmental sustainability of aquaculture is dependent upon intrinsic factors including water quality, species characteristics, availability of artificial and natural feeds, seed supply, and location of facilities, and extrinsic factors including natural hazards, climate change, pollution, the market, sociocultural conditions of



culture sites, and legislative control. In consideration of these factors influencing successful environmental sustainability, adoption of an integrated coastal management (ICM) scheme was suggested. The goal of the ICM would be to identify all economic activities within a coastal resource system in order to manage them in a sustainable manner to mitigate negative cumulative environmental impacts.

It was also suggested that the ICM be combined with Environmental Impact Assessments currently conducted for sites to form an Integrated Environmental Impact Assessment (IEIA). The IEIA would take into account all present and future economic development activities to ensure the sustainability of the coastal resources in a specific area.

Suggestions were made regarding proper planning and management policies on provincial and federal levels, whereby national policies should encourage sound practices, central government should increase awareness of environmental concerns, building capacity, and research and technical assistance, and local governments should develop an ICM specific to their environmental and economic activities.

5.0 INTERACTION BETWEEN TRADITIONAL KNOWLEDGE AND MODERN AQUACULTURE

5.1 Discussion Results

- Perception of Aquaculture and Aboriginal Resistance

A discussion was held regarding the perception of aquaculture by First Nations peoples as an extension of the historical process of colonialism. It was opined that salmon farming results from political processes involving traditional chiefs and new forms of authority that both integrate and clash with existing forms of Native self-government.

Main concerns of the Kwak'wakawakw (BC coast First Nations group) included the transfer of disease to wild stocks, interference with salmon and ooligan runs, and the emission of contaminants onto clam beds. Much of the strongest opposition to the industry comes from hereditary chiefs.



The coastal areas now considered under-developed and suitable for salmon farming were once considered areas of great wealth and prosperity and were used by aboriginal people prior to their relocation. Native economies are pressured by a new form of territorial expansion that brings with it few settlers, technology, exotic species, and extractive capacity.

- Government and Industry Perception

Government and industry claims have focused on past mistakes with respect to resource management. The perception was that the aquaculture industry was not sufficiently efficient, productive, and modern. This has led to the provision of leases to salmon farming companies in areas considered underdeveloped Native territories. This is viewed as a means to extend the network of bureaucratic control on the Pacific coast that began a century ago with the commercial fishery.

- History as a Part of the Present Approach

It has been suggested that an understanding of the cultural energy and sometimes individual heroism on the part of the hereditary chiefs (who continue their ancestors' struggles against settler encroachment on tribal lands and water) in their resistance to salmon farming, will help reveal the true extent of the barriers to a sustainable aquaculture sector in Canada in regards to current salmon farming practices and research on the Pacific coast.

- First Nation's Panel on Fisheries

A First Nation's Panel on Fisheries [<http://www.fns.bc.ca/pdf/FNFishPanelReport0604.pdf>] was established in BC to work independently to articulate a vision of a viable post-treaty fishery that addresses both fisheries management and allocation challenges. Goals for the Panel also include providing a description of a workable framework for fisheries management and principles to guide negotiations of both allocations and fisheries management between First Nations and Canada with a focus on migratory fish stocks that are subject to multiple users.

Meetings were held to determine the main issues for the First Nations in the current fishery. The main concerns included food and societal access, aboriginal rights, economic access, government policies and programs, licensing and quota systems, recreational fisheries and tourism, habitat protection and stewardship. Food and societal access, economic access, local management, coordinated management and treaty process were the issues of priority.



Following a review of these concerns, the Panel recommended the following priorities: stewardship of food fish, transfer fish for economic purposes, improve intertribal relations, provide major government commitment, and balance management interests.

Environmental sustainability, use of traditional resources, social stability, and economic well-being were identified as key aquaculture issues. The following effects of consolidation were identified: densely located farms, maximized fish densities in cages, automated equipment and methods that reduce employment, and perception of foreign ownership.

In regards to Aquaculture initiatives, increased opportunities for information sharing and dialogue have been conducted with two Aquaculture and Environment Summits held in 2002 and 2003. Continued environmental research and monitoring has been conducted with collaborative research on contaminant levels in marine species from fish farm wastes and environmental monitoring, planning and strategy development led by First Nations.

6.0 MESSAGES, CONSUMERS AND AQUACULTURE

6.1 Discussion Results

- Biotechnology and Public Acceptance

It was discussed that the greatest uncertainty associated with successful commercial uptake of new biotechnology is public acceptance. Advance inquiries with potential end-users of new biotechnology was suggested as a means of reducing this uncertainty, however proactive public involvement is not an integral part of Canadian agricultural biotechnology innovation. Participants felt that earlier and more earnest public consultation might have reduced existing tensions regarding agricultural biotechnology in Canada. The lack of public involvement was seen as a contributing factor to market failure of some products or nearly total opposition to the technology.

No genetically modified salmon have been approved for consumption in Canada to date. Given this, the opportunity exists to identify reactions of potential



consumers to the introduction of specific animal product biotechnologically developed prior to its commercialization.

Participants suggested that the development of transgenic salmon would address Canada's need for a rapid-growing, cold-water tolerant fish to be competitive with other countries where fish are farmed in warmer, more productive waters. A transgenic salmon which grows more rapidly than non-transgenic Atlantic salmon is currently under regulatory review in Canada and the United States.

- Consumer Perception and Potential Reception in Canada

Results from a recent survey conducted in eight Canadian cities indicated that the attitudes regarding salmon do not change significantly when information about biotechnological application is communicated. Although results clearly showed that consumers were not fully accepting of the introduction of transgenic salmon, responses were equal if not enhanced when disclosure occurred. This is thought to be a result of lack of confidence to evaluate the significance of the modification, however with disclosure, consumers with more awareness and understanding can do so. Results also indicated that consumers were equally if not more accepting if sufficient information about the technology was communicated prior to the introduction of the product.

Results indicated that upwards of 40% of consumers, especially women, would not accept biotechnology in the near future. This finding is hypothesized to be a function of the traditional domestic role occupied by women who continue to make the majority of the decisions regarding food purchases.

It was suggested that consumers should have the ability to obtain information they feel they require in order to make informed choices, especially regarding new technologies. Results from the survey seem to indicate that the provision of information does not decrease acceptance if an appropriate level of information regarding risks and benefits is provided. It was suggested that government and industry should take this into consideration when deciding best methods to inform consumers and when targeting messages to male and female audiences.

- Consumer Perception and Potential Reception in Three European Markets

Two additional surveys were conducted in three European markets (France, Germany, and Spain) to determine critical factors related to future market trends for farmed salmon and farmed salmon products. The survey involved professional purchasers for supermarkets, wholesale organizations, and restaurants (of varying quality). The findings of these surveys suggest that the general image of the Atlantic salmon product is positive and well received. However potential



environmental threats of widespread aquaculture activity and problems associated with genetically modified organisms have hampered some views.

The growing concern about food safety that has led to increased demand for quality guarantees and high consumer awareness on these issues was discussed. To meet future consumer demands, the industry should be encouraged to develop consistent production and processing strategies. Strong negative opinions are felt for the use of genetically modified ingredients in salmon feed by the trade and seafood business. Environmental effects, fish welfare, and genetically modified organisms remain the foremost concerns for the development of future farmed salmon. As such, increased communication and improved labelling of the fish and fish products will be needed.

7.0 INTEGRATED COASTAL ZONE MANAGEMENT

7.1 Discussion Results

- Integrated Coastal Zone Management Approach

It was suggested that a more integrated approach is required to promote sustainable development in the coastal zone and to identify solutions to the potentially negative impacts. The integrated coastal zone management approach is intended to be an integrated, multi-criteria decision support system for the evaluation of marine sites by multiple participants in support of governance and decision-making processes in the coastal zone.

- Integrated Coastal Zone Model and Framework

Marine site valuation analysis assigns relative values to the multiple, integrated components of the selected study area ecosystem. These values are designed to be comparable by using a yield-value framework. It is recognized, however, that alternative valuation schemes can be used in support for decision making in the generated model. The model provides a means of evaluating integrated marine activity and the procedure permits the comparison of traditional activities with other activities. Participants suggested that the objective of this work is to provide the opportunity for discussions among all parties involved to arrive at mutually acceptable decisions for the sustainable use of the coastal zone and its resources.



8.0 NEW PRACTICES FOR GLOBAL COMPETITIVENESS

8.1 Discussion Results

- Fundamental Problems Facing Aquaculture

Participants expressed the opinion that governance is the fundamental problem of Canadian aquaculture. It was suggested that to remedy these governance problems, an understanding must be gained of both the problems facing the industry and how these problems can best be addressed in the new political context in which aquaculture and other resource industries must operate.

- Suggestions for Proper Governance

A discussion was held regarding opportunities for appropriate governance in the promotion of sustainable aquaculture. Two proposals were presented to attempt to achieve promotion of sustainable aquaculture through proper governance. The first proposal included consideration of implications of new developments for governance, attempting to understand how such developments would be perceived by various sectors of the network, and identifying the risk of disturbing formal and informal arrangements, the soft law, and covenants and agreements that give the network its shape.

The second proposal suggested providing resources to understand the implications of the rapidly emerging tool of network management and benchmarking.

- Gaining Consumer Confidence

According to a recent study (Hites, R. A., et al., Global assessment of organic contaminants in farmed salmon. *Science* (303) 2004, 226–9), consumers believe farmed salmon to be high in toxins (including elevated levels of PCBs) that pose a risk to their health. Negative repercussions from these beliefs are loss of consumer confidence, weak markets in Canada and the United States, and increased pressure on wild product retailers.



Following a review of the study, it was determined that consumers feel betrayed by government and that government's reactions are insufficient to calm fears. Future steps proposed to gain consumer confidence include the following:

- study of risks by intervening parties;
- messages should be prepared in advance;
- Health Canada and Canada Food Inspection Agency need to show credibility;
- establish connections for complimentary efforts; and
- utilize resources to establish credibility and distribution channels.

9.0 CONCLUSIONS AND RECOMMENDATIONS

9.1 Research Recommendations

Awareness and understanding of Innovation and social transformation in aquaculture has progressed considerably in recent years and continues to evolve. However, much more work needs to be undertaken. Although not a specific topic of the workshop, several participants requested that recommendations for future research should be gleaned from the presentations and the open discussion. The following research recommendations, provided for the industry, academe and government sectors, have been identified by the facilitator and do not necessarily represent the views of the workshop participants.

9.1.1 Industry

Industry is interested in research on the following:

- Consumer perceptions regarding how farmed fish are cared for and managed – do they really care? There is a need for better understanding of the consumer purchase process, gender factors, credibility of the source and information distribution channels.



- Enhanced practices, based on emerging research on fish sentience, to manage farms in a manner that would boost productivity, lessen vulnerability to disease and lower costs.
- Means to implement and operationalize Integrated Coastal Zone Management, in the context of the need for site-specific data, and the multiplicity of stakeholder interests.
- Responsible farming methods and practices that would alleviate stress of the fish and reduce the adverse effects of the farm environment on fish welfare.
- Development of consistent production and processing strategies to meet future consumer demands.
- Investigate alternate antibiotic methods, utility and extent of buffer zones, impacts of antibiotics on the environment, results of feed testing and bioaccumulation/ biomagnification.

9.1.2 Academe

Research projects potentially suitable for academe include:

- Does academic research actually reach industry and the general public and do they understand it? How could research dissemination be improved?
- Greater understanding of fish sentience and welfare, and the implications for aquaculture practices.
- Consumer attitudes, preferences and purchase decision criteria (specific to regions, gender, etc.) related to aquaculture methods and products.
- Innovation in products and processes oriented to balancing environmental impact and high-value economic output.
- Means to increase sharing of knowledge and transfer of innovations amongst aquaculture R&D organizations, and industry and government.
- Development of practical guidelines, protocols and methods to promote and implement Integrated Environmental Impact Assessment (IEIA) in an aquaculture context.
- Elaboration of the concept of critical natural capital.

9.1.3 Government

Government research should focus on:

- Better understanding and management of citizen / consumer issues related to general food safety, inspection adequacy, and other environmental concerns.
- Better methods of risk communication. Better intelligence on “food scare” reporting in the media, including issues scanning to identify upcoming controversies and media concerns (what is media currently researching),



identifying what consumers are reading, and how to effectively communicate real meaning.

- Improved policy and regulatory frameworks for harmonizing (provincial and federal levels) the planning, management, environmental assessment practices.
- With respect to First Nations, develop better understanding related to food and societal access, economic access, local management, coordinated management, intertribal relations, and treaty processes.
- Develop best methods and media relations practices for informing consumers generally and dealing with crisis issues in particular about aquaculture food products, as well as considering gender biases. Develop methods to gain and enhance consumer confidence.
- Improved communication and labelling of the fish and fish products.
- Understanding of the implications of information in the public domain; how to be transparent yet maintain confidentiality of proprietary business data.
- The Environmental Impact Assessment process, particularly accepted siting criteria and effective public and stakeholder consultation.

9.2 Governance

Although one of the objectives of the workshop was to identify opportunities for appropriate governance in the promotion of sustainable aquaculture, this topic did not receive much attention or discussion from participants. Limited discussion took place regarding sensitivities of existing institutions to the possible disturbance of current formal and informal arrangements and network management.

It is evident that additional resources and research regarding adequate, workable and acceptable governance models is needed. Research is also required to develop new and appropriate structures to interface with First Nations; the traditional models (usually fraught with western culture biases) are not effective. Governance oriented research should take into account the current and future situation related to Health Canada and CFIA reporting procedures, enhanced and direct citizen engagement, the Aquaculture Policy Framework – Office of Sustainable Aquaculture; and the Responsible Aquaculture Industry Program – Global Aquaculture Alliance.

9.3 Going Forward

The Aquaculture, Innovation and Social Transformation Workshop was successful from several perspectives:

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- The participants have been afforded the opportunity to come together, increase their understating of current activities and discuss common concerns and potential solutions.
- All workshop participants expressed a desire to continue deliberations in the future through appropriate mechanisms.