Integrated Multitrophic Aquaculture

Canadian Project Combines Salmon, Mussels, Kelps

Summary:
A project in New Brunswick, Canada, is assessing the industrial potential for integrated multitrophic aquaculture in raising kelps and blue mussels along with salmon. The IMTA concept increases profitability, reduces risks, and enhances public perceptions toward salmon farming. Initial biological results, financial feasibility, and societal attitudes are promising.

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In a commercial-scale pilot project in Canada's Bay of Fundy, cultivated kelps and mussels utilize by-product wastes from nearby salmon cages as major inputs. The salmon cages are shown in the background.

Worldwide expansion of Atlantic salmon, *Salmo salar*, farming has been rapid, with annual output exceeding 1.2 mmt and value over U.S. $4 billion in 2004. The industry growth is forecasted to continue into the future.

For independent farmers in a market that has become global and concentrated, and in locations where there is public participation in policy making, survival requires acquiring some competitive advantage while maintaining public support. Farms are under pressure to improve their economic performance with economies of scale while also enhancing the sustainable image of their industry. One option for salmon farmers to achieve these goals is to grow salmon with other species at the same site.

Integrated Multitrophic Aquaculture

Integrated multitrophic aquaculture (IMTA) systems combine fed aquaculture of fish with extractive inorganic aquaculture of seaweed and extractive organic aquaculture of shellfish. The approach is based on an age-old, common-sense recycling and farming practice: The by-product wastes from one resource become inputs for another.

In Canada, an industrial pilot project is cultivating *Saccharina latissima* and *Alaria esculenta* kelps, *Mytilus edulis* blue mussels, and *Salmo salar* salmon in the Bay of Fundy. When compared to reference sites, growth rate increases of 46% for kelps and up to 50% for mussels cultured in close proximity to the fish farms reflect increases in food availability and energy.

Over six years, none of the therapeutants used in salmon aquaculture has been detected in the kelps and mussels collected from the IMTA sites, and levels of heavy metals, arsenic, polychlorinated biphenyls, and pesticides have always been below regulatory limits. Biological results therefore support the establishment of IMTA systems.

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Critical to the project is cooperation from two industrial partners: Cooke Aquaculture Inc. and Acadian Seaplants Limited. In addition, the Canadian Food Inspection Agency and Environment Canada are testing the kelps, mussels, and seawater to ensure that all products are suitable for public consumption.

Social Sustainability

However, biological feasibility is not sufficient for a commercial operation to be sustainable. Sustainability also requires that economic and social criteria be met. An aquaculture operation must be economically viable without being too risky. In addition, attitudes of the public are important, because consumer perceptions influence the demand for and prices of products, and community attitudes affect the development of the sector.

Economic estimates with risk scenarios have been undertaken to compare the profitability of an IMTA system with salmon monoculture, and the public was surveyed for perceptions toward IMTA. It should be noted that all results are tentative, because the project only recently scaled up to a commercial operation.

Budgeting Model

Initially a capital-budgeting model was developed for a hypothetical salmon monoculture cage operation using parameters for the Bay of Fundy. To this were added fixed and operating costs for mussel and kelp cultivation, and potential additional revenues from these two species. Profitability was estimated by projections over 10 years using discount rates of 5 and 10%.

Since there is risk from disease and winter chill, it was imperative that a risk factor be added into the calculation of the financial ratios. Each of three IMTA scenarios was given a probability of occurrence.

Scenario 1 had salmon coming to harvest every second year and a mortality rate of 11%. This would give five successful harvests in the 10-year span with a probability of occurrence of 20%. Scenario 2 had only four successful harvests, with all fish assumed destroyed in one harvest. This scenario, which is plausible because of the potential effects of infectious salmon anaemia or winter chill, received a 40% probability. Finally, an intermediate scenario 3 had four successful harvests and one in which only 30% of the fish survived. This final scenario was also given a weighting of 40%.

Income from the sale of blue mussels supplements salmon profits and would cushion the impacts of salmon losses.

Perception Surveys

To study public attitudes toward IMTA, the authors adopted two methodologies. Initially in 2003, a random survey was undertaken in the Bay of Fundy region to determine attitudes toward general aquaculture before focusing on salmon monoculture and IMTA. Two study sessions were run in Charlotte County in southwestern New Brunswick.

A total of 165 participants responded from three populations. The response rate of 11.4% for the general public group of 110 was typical for survey research. A total of 53 respondents were from the 15 professional organizations and companies surveyed to date. Two respondents came from the two environmental organizations invited to participate.

Because many respondents were unaware of IMTA, a 12-minute video presentation was shown before focus groups were asked their opinions. The focus groups were differentiated according to interests. One was composed exclusively of "white table cloth" restaurateurs, another of the general public within the Bay of Fundy region, and the last a more geographically dispersed group of fish consumers. The aim of this second approach was to qualitatively gauge

Table 1. Ten-year profitability, discounted at 5%, of salmon monoculture and integrated multitrophic aquaculture scenarios.

Operation	Scenario 1, Optimistic (Can $)	Scenario 2, Worst Case (Can $)	Scenario 3, Intermediate (Can $)
Salmon monoculture	8,961,125	55,933	2,930,523
IMTA	9,797,078	742,038	3,625,641

Table 2. Survey responses to the question "How do you think you would feel about IMTA?".

Response	General Public (102 Participants)	Aquaculture Industry (53 Participants)	Environmental Organizations (2 Participants)
Very positive	12%	36%	50%
Positive	46%	38%	–
Neutral	36%	15%	50%
Negative	4%	11%	–
Very negative	2%	–	–

perceptions toward IMTA after informed discussion.

Model Results

As Table 1 shows, additional revenues from mussels and seaweeds more than compensate for additional costs with a resulting 9.3% higher profitability for IMTA than salmon monoculture. As one would expect with diversification, IMTA results in higher profitability in all three scenarios of risk.

Mussels and seaweeds provide alternative sources of income, thereby softening the damaging effect of salmon losses. Just one bad harvest in which all fish are lost moves profitability toward zero on the entire 10-year run of a monoculture salmon farm, whereas with IMTA, it remains positive by an order of magnitude.

Survey Data

In addition, both the survey and focus groups indicated perceptions toward IMTA were more favorable than those toward salmon monoculture (Table 2). This was particularly encouraging because those most informed about the principles behind IMTA, the industry and environmental group representatives, were the most supportive.

Table 3. Post-video focus group understanding of IMTA.

Do you think that IMTA has the potential for:	Yes (%)	Maybe/Not Sure (%)	No (%)
Reduce possible disease outbreaks?	21.7	28.5	34.8
Replenish natural stocks?	22.7	22.7	54.6
Improve food quality?	31.8	40.9	27.3
Reduce environmental impact of salmon farming?	65.2	30.4	4.4
Improve waste management in aquaculture?	100.0	0	0
Increase employment opportunities?	90.9	9.1	0
Improve community economies?	95.5	4.5	0
Increase food production?	100.0	0	0
Increase industry competitiveness?	95.5	4.5	0
Improve sustainability of aquaculture overall?	72.7	27.3	0

Participants in the focus groups all linked success of aquaculture with sustainability. The groups emphasized that making a profit, raising quality products, and not harming the environment were all key to making the aquaculture industry successful and improving its public perception.

After watching the video, a majority of participants appeared skeptical or unsure if IMTA could reduce disease outbreaks, replenish natural stocks, or improve food quality (Table 3). However, most participants said IMTA has the potential to reduce the environmental impacts of salmon aquaculture, improve waste management, and benefit employment and community economies; and improve food production, industry competitiveness and sustainability. All felt that seafood produced in IMTA systems would be safe to eat, and 50% were willing to pay 10% more for these products, if they were labeled as such. The next step is a marketing study to identify whether ecolabeled products could bear the price premium.