

Feasibility of Pacific Oyster and California Sea Cucumber Polyculture

Growth and production of California sea cucumbers (*Parastichopus californicus*), co-cultured with suspended Pacific oysters (*Crassostrea gigas*), were investigated in a 12-month study conducted at two sites of deep-water, suspended oyster culture in British Columbia. Rates of oyster biodeposition (faeces and pseudofaeces), and the utilization of this particulate material as a food source by *P. californicus*, were also examined.

Peaks in sedimentation rates (93.6 g dry wt m⁻² d⁻¹) through 8.5 m water depth were observed in April and July 2004. At the two study sites, maximum mean fluxes of total organic carbon in sediment traps at 8.5 m depth occurred in July 2004 and amounted to 3,123 and 4,150 mg dry wt C m⁻² d⁻¹. Maximum mean fluxes of total nitrogen at the two sites were 633 and 441 mg dry wt N m⁻² d⁻¹ which occurred in July and November 2004, respectively. Mean C/N ratios of particulate material in the sediment trap samples collected at the two sites ranged between 5.93 and 8.39 and may be classified as being of high nutritional value.

Sea cucumbers grown in trays at both sites successfully utilized biodeposits from the cultured oysters and showed a mean weight increase of 42.9 g in approximately 12 months (average growth rates for both sites ranged from 0.061 to 0.158 g d⁻¹). Over-

all growth was affected by the absence of visceral organs and the cessation of feeding activity in the November 2004 sampling period. Mean values for organic content were significantly higher in the foregut of the sea cucumbers (233.0 mg g dry sediment⁻¹) than in the sediment (64.3 mg g dry sediment⁻¹) or in the hindgut (142.8 mg g dry sediment⁻¹), showing both active selection of organic material from the sediments and digestion/assimilation of these organics in the gut. Organic material deposited in the trays was assimilated by *P. californicus* with an average efficiency of 48.4%.

The successful utilization of the naturally-available biodeposits from the cultured oysters by sea cucumbers suggest the feasibility of developing a commercial-scale co-culture system that would both reduce the amount of organic deposition underneath shellfish farms and produce a secondary cash crop.

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Debbie Paltzat examines trays in which oysters and sea cucumbers are being cultured together

Integrated multi-trophic aquaculture making headway in Canada

Integrated multi-trophic aquaculture (IMTA) holds great potential for improving the sustainability of aquaculture. Based on an age-old, common sense, farming practice, the wastes from one species become inputs for another: fed aquaculture (finfish) is combined with extractive inorganic aquaculture (seaweed) and extractive organic aquaculture (shellfish). With the support of AquaNet between 2001 and 2006, and now the Atlantic Innovation Fund (from the Atlantic Canada Opportunities Agency), an interdisciplinary team of scientists from the University of New Brunswick in Saint John, and the Department of Fisheries and Oceans in St. Andrews, is developing such a system at an industrial pilot scale by co-cultivating salmon (*Salmo salar*), kelp (*Laminaria saccharina* and *Alaria esculenta*) and blue mussel (*Mytilus edulis*) at several aquaculture sites in the Bay of Fundy. The industrial and government partners associated with the project are Cooke Aquaculture

Inc., Acadian Seaplants Limited and the Canadian Food Inspection Agency.

After five years of research, our findings support the establishment of IMTA systems for environmental sustainability (bioremediation), economic diversification (from fish filets to bioactive compounds) and social acceptability (better management practices). Innovative kelp culture techniques have been developed and improved both in the laboratory and at the aquaculture sites. Increased growth rates of kelps (46%) and mussels (50%) cultured in proximity to fish farms, compared to reference sites, reflect the increase in food availability and energy.

Nutrient, biomass and oxygen levels are being monitored to estimate the bioremediation potential of an IMTA site. Salmonid solid and soluble nutrient loading is being modelled as the initial step towards the development of an overall flexible IMTA model. The extrapolation of a mass balance approach using bioenergetics is being

juxtaposed with modern measures of ecosystem health such as exergy.

None of the therapeutants used in salmon aquaculture have been detected in kelps and mussels collected from the IMTA sites during the last five years; levels of heavy metals, arsenic, PCBs and pesticides have always been below regulatory limits. A taste test at market size conducted on site grown versus reference mussels showed no discernable difference. *Alexandrium fundyense*, the dinoflagellate responsible for producing paralytic shellfish poisoning (PSP) toxins, occurs annually in the Bay of Fundy and mussels can accumulate these toxins above regulatory limits in the summer/early fall. However, PSP toxin concentrations in mussels decreased readily as the blooms of *A. fundyense* diminished. Domoic acid, released by the diatom *Pseudo-nitzschia pseudodelicatissima*, was never above regulatory limits over the five years. All of these results indicate that, with the proper monitoring and depuration management, mussels and seaweeds from the IMTA operations can be safely harvested for human consumption.

A survey of aquaculture attitudes found that the public is more negative towards current monoculture practices and feels positive that IMTA would be successful. A focus group social study revealed that most participants felt that IMTA has the potential to reduce the environmental impacts of salmon farming, benefit community economies and employment opportunities, and improve the 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 labelled as such.

A bio-economic model is being developed in which net present value



Culturing mussels close to fish farms increases growth rates by 50% due to increased food and energy availability.

calculations are conducted. Variable data manipulation is incorporated and the model is stretched over 10 years to portray long-term variability. Preliminary findings show that the addition of both seaweed and mussel farming to existing salmon farming is profitable and can help reduce risks.

We are now in the process of scaling-up experimental systems and working with DFO, CFIA, EC and NBDAA on an appropriate food safety regulatory and policy framework that will allow the development of commercial scale IMTA operations.

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Innovative kelp culture techniques have been developed and improved, increasing growth rates by 46% in proximity to farms.