An Integrated approach to improve food security and promote healthy communities in the North

FRQ Inter-sectorial project proposal

Grant Vandenberg, PhD. Dép des sciences animales,
Faculté des sciences de l’agriculture et de l’alimentation
Université Laval
Team Vandenberg: a short bio

Integrated research program related to freshwater aquaculture biotechnology:

- NSERC Industrial Research Chair, Sustainable Aquaculture development
  - PerOs Systems Technologies (co-founder, CSO: 2000-2012)
- Director: GRoupe de Recherche en REcherche Biologique et Aquiculture (GREREBA)
- Founding member RAQ; Associate member INAF
- Founding President: IPSFAD; Poisson pour l’Afrique

Mission: to develop technological tools to assist the freshwater aquaculture industry to overcome critical bottlenecks and pursue sustainable development
Project Concept: An integrated approach to improve food security and promote healthy communities in the Far North

- Situation for populations in Far North
  - Food availability issues, particularly related to quality/healthy food
    - Environmental contamination of indigenous food supply
    - Required transportation significantly increases food costs
  - Lack of quality/healthy food leads to problems related to human health: obesity and diabetes

- Objective: Produce a range of locally-produced healthy food to improve access to Northern populations, and improve health status of people in the North
  - Project centred around land-based production of Arctic char
    - Using a novel recirculation system, based on Canadian Model AquaFarm (CMAF) design
  - Effluents from the recirculation system used for greenhouse-based aquaponic production
    - Lettuce, tomatoes, peppers, cucumbers, strawberries
    - Aquaponics well-established in Québec

- Critical is understanding of the human health and social implications of this paradigm shift in food production and supply
  - Measure impacts, ensure long-term viability of this new approach
Interprovincial Partnership for Sustainable Freshwater Aquaculture Development (IPSFAD):  

- Initially emerged in 2001 from a joint initiative of:  
  - Various professional Associations across Canada: AAQ, OAA, NOAA & AAA  
  - Fisheries and Oceans Canada  
  - SORDAC Inc.  
- Partnership incorporated as a not-for-profit organisation in 2006
IPSFAD Mission & Objectives

**Mission:**
- Promote sustainable development of freshwater aquaculture in Canada.

**Objectives:**
1. Create a consensus around R&D and scale-up / commercialization priorities identified by the Canadian industry.
2. Promote R&D to scale-up and commercialize projects

Since 2001, more than $7.6 million in funding has been committed to applied RDC initiatives under three Action Plans.
Canadian Model AquaFarm: Rationale

- Considerable capacity to expand freshwater aquaculture through traditional agriculture
- Industry needs comprehensive information
  - production technologies and practices
  - costs and benefits
  - training & skills development

Objective:
Model Farm Planning Workshop 2005

Scope of the Model Farm

- To optimize productivity, economic prosperity and environmental sustainability

- Species
  - *Salmonids* (rainbow trout)

- Product
  - *Food fish* / stocking / baitfish

- Scale
  - Minimal commercial size (100-200 tonnes)
  - >98% recirculation
Model Farm Layout

- Moving Bed Biofilter
- LHOs
- Pumps
- Internal Curved Wall
- CO2 Stripper / Pumps
- Drum Filter
- Fixed Media Filter
- Sludge Cones

130 tonnes / year
Total Flow ~20,500 Lpm
New water ~227 Lpm
~200’L x 34’W x 5½’D
Simple, efficient design to fit in a typical swine/PMU barn
Production Strategy

- Year-round production
  - 30,000 20g fry every 3 months
  - 12 months to ~1200g @ ~10°C
  - Harvest ~10,800 kg per month
Manitoba-CMAF Construction
Manitoba-CMAF Operational
Demonstration & Validation

- Intensive operational monitoring program
  - 3-year performance monitoring and management program established
  - Farm Manager hired to oversee fish culture operations and compile performance management data and information
Performance Management

Canadian Model Aqua-Farm

OPERATIONAL SUSTAINABILITY

Production
- Fingerlings
  - Number
  - Size
  - Timing
- Feed / Diet
  - Formulation
  - Ration
- Inventory
  - Number per Lot
  - Avg fish size
  - Total biomass
  - Harvest
- Temperature
  - System
- Energy
  - Electricity
  - Diesel

Productivity
- Growth Rate
  - SGR
  - TGC
- Mortality
  - Number
  - Size
- Fish Health
  - Diagnoses
  - Treatments
- Feed Conversion
  - Biological
  - Economic
- Carrying Capacity
  - Water
  - Energy
  - Volume
- Water Use
  - Total Flow
  - Exchange

Economics
- Fingerlings
- Feed
- Labour
- Supplies & Repairs
- Power
- Skills Training
- Indirect Costs
- Capital

Environment
- Metabolic Wastes
  - Solids
  - Phosphorus
  - Nitrogen
  - BOD
  - Carbon Dioxide
- Other Factors
  - Dissolved Oxygen
  - pH
  - Temperature
- Chemicals
  - Therapeutics
- Waste Managmt
  - Solids
  - Mortalities
Integrated Aquaculture - Aquaponics

- Fish excrement, ammonia
- Bacteria converts ammonia to nitrite
- Bacteria converts nitrite to nitrate
- Nitrates in the water absorbed by plants
- Plants use CO₂, produce O₂
- Plants grow and produce food
- Water run off from plants
  Drains back through filter
- Filter removes surplus solids that plants did not take up
- Additional CO₂ removal, O₂ added
- Biogas from residues
- Feed
- Fish growth, consume O₂ produce CO₂
Production technologies

Team leaders: Vandenberg, LeFrançois, Dorais, Greig

- Design parameters permitting integration of aquaculture/aquaponic systems
- Choice of species raised based on system and local constraints: feasibility study
- Diet development to optimise production
  - Fish and vegetables/fruit
- Adding value to waste streams (effluent, biomass) to minimise environmental footprint
  - Production of biogas to produce electricity to promote autonomous operations
Public health: impact of healthy foods

Team leaders: Dewailly/ Lemarche/ Déry

- Measuring key nutrient levels in food derived from the integrated system
- Develop food intake guidelines, awareness
- Outcomes of improved access to healthy foods
  - Documenting dietary changes
  - Measuring heath impacts
    - Specific health parameters (cardiovascular, diabetes), disease prevalence, contaminant burdens etc
Social impacts

Team leaders: Fletcher, Desbiens, Rodon

- Study sensitivity and vulnerability of peoples, livelihoods and institutions to changes in food supply
- Document pressures of economic development on cultural diversity and adaptive capacity of Northern communities
- Study the cultural and social perspectives of fish farming as an evolution from fishing.
- Measure extended impact of project implementation on employment within local communities
Training and knowledge transfer

Team leaders: Fletcher, Desbiens, Rodon, Makivik

- Develop applied training programs
  - Production techniques, processing, marketing etc
- Reinforce partnership with pertinent Northern organisations
  - Work with and benefit from traditional knowledge and existing programs
- Production facilities will serve as demonstration sites
  - Outreach platform to raise program awareness (technical aspects of food production and healthy eating)
  - Material developed to target school-aged children, in-school presentations to introduce topics related to development and maintenance of healthy lifestyle
Sustainable development & economics

Team leaders: Rodon, Vandenberg, Lambert

- Measure typical indices related to sustainability of the production facility in the context of the unique challenges in the North
  - Ensure that the project contributes to the social and economic sustainability of Northern communities
- Analyse energy and nutrient budgets to develop strategies to limit local impacts
- Compare utilisation and emission of CO2 and energy
- Life cycle analysis
  - Permit assessment of environmental impacts at all stages of infrastructure development
  - Potential impacts of inputs and releases using advanced environmental accounting approaches
Figure 2: Overview of proposed collaborative R&D themes and inter-sectorial project details.

*Partner list is non-exhaustive—numerous additional collaborations are currently being developed (e.g. ArcticNet, Centre d’Études Nordiques, various strategic Northern partners, and private industries).
Potential Partners

- **Academic partners**
  - Université Laval (FSAA, INAF, IBIS, CHUL, ArcticNet, Centre d’Études Nordiques)
  - UQAR (RAQ)
  - Université de Montréal (École polytechnique, Microbiologie, Vet Med)
  - INRS (Armand Frappier); Institut des zones cotières, U Moncton

- **Aquaculture Industry**
  - Arctic charr producers: (Aquaculture Gaspésie Inc et Pisciculture des Monts de Bellechasse),
  - SORDAC, AAQ
  - IPSFAD

- **Industry service companies**
  - Recirculation technology (Veridis, PRA-Aqua, Water Management Inc)
  - Feed companies (Skretting, EWOS, Corey)
  - Animal health companies (Novartis, Merial)
  - Greenhouse industry partners (TBD)

- **Government partners**
  - Makivik, Kativik Regional Govt
  - MAPAQ/InnoMer
  - Santé publique Québec
  - Agriculture Canada
Expected outcomes

- Increased access to locally-produced food (quality, variety, year-round availability)
  - Arctic charr (source of quality protein and healthy fatty acids)
    - Impact on cardiac health, diabetes, neurological development in infants
  - Aquaponically-produced vegetables (tomatoes, peppers, cucumbers, lettuce)
    - Reduction of obesity, overall health status
- Employment opportunities for local residents
- Reduced CO2 emission related to food (reduced reliance on transportation)
- Reduction of contaminant loading from food due to control related to production techniques
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