NBSGA

Research & Development to Support Implementation of the Atlantic Canada Salmon Farming Sustainability Plan in Southwest New Brunswick.

Friday, December 9, 2005
St. Mark's Anglican Church
St. George, NB

Research and Development to Support Implementation of the Atlantic Canada Salmon Farming Sustainability Plan in Southwest New Brunswick

Summary and Presentations from the

New Brunswick Salmon Growers Association 2005 Annual General Meeting Technical Session

December 9, 2005
St. Marks Church, St. George, NB

Presented with Financial Assistance from

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Aquaculture Collaborative Research and Development Program

Prepared for:
New Brunswick Salmon Growers Association
226 Limekiln Road
L'Etang, NB, E5C 2A2
nbsga@nb.aibn.com

Prepared by:
Jamey Smith, Ph.D.
NBSGA Research and Environmental Management Coordinator
CoastalSmith Inc.
50 Birdie Court
Fredericton, NB, E3B 6A7
coast@nbnet.nb.ca

Research and Development to Support Implementation of the Atlantic Canada Salmon Farming Sustainability Plan in Southwest New Brunswick

The Technical Session of the 2005 New Brunswick Salmon Growers Association (NBSGA) Annual General Meeting was conducted in support of implementation of the *Sustainability Plan for Atlantic Canada Salmon Farming*. The Federal/Provincial Task Force on Fostering a Sustainable Salmon Farming Industry for Atlantic Canada has accepted this Sustainability Plan, prepared by the salmon farming industry. This *Sustainability Plan* describes a reformation of salmon farming from a production-driven to a market-driven structure, the overall intent of which will be to eliminate the requirement for forced-selling of fish and the resulting unacceptable market conditions. The *Sustainability Plan* establishes the need to apply environmental and fish health PBS in a 3-site rotational system that would have one site of every 3 fallowed for up to one year.

The 2005 NBSGA AGM Technical Session focused on research and development to support implementation of the *Sustainability Plan*. The session was organized by the staff of the NBSGA, with **financial assistance provided by the Fisheries and Oceans Canada Aquaculture Collaborative Research and Development Program (ACRDP)**. The assistance of ACRDP is greatly appreciated.

Five presentations were made at the Technical Session that covered overall research and development requirements, fish health and genetics, environment, alternate species, and the role of the DFO St. Andrews Biological Station in future aquaculture research. The agenda for the session, a summary of each presentation, and speaker biographies are provided in this report.

Dr. Jamey Smith, the NBSGA Research and Environmental Management Coordinator chaired the Technical Session and provided an overview of research and development priorities for implementation of the *Sustainability Plan* that were prepared by the NBSGA Science Committee. Priorities were established according to specific components of the plan, such as governance, performance based standards, fish health, codes of practice, bay management areas, site consolidation, new site development, alternate species, and stakeholder interactions. Priorities were also established for short term or applied science and longer term work in the categories of fish, health, environment and oceanography, and genetics. A summary of the research priorities prepared by the NBSGA Science Committee is provided at the end of this report.

Dr. Pascale Nerette of the Atlantic Veterinary College (AVC) Centre for Aquatic Health Sciences (CAHS) gave a presentation on new research related to strategies for ISA testing and implications for a control program. Dr. Nerette found that different ISA tests (IFAT, VI, and RT-PCR) have very different levels of sensitivity and specificity. She also concluded that results may differ between laboratories and tests. With the existing testing strategy she concluded that ISA cases have rarely been misclassified as positive, although cases may have been missed. She suggested that increasing the number of moribund fish sampled may improve this situation.

Dr. Rachael Ritchie, Head of the Food, Fisheries, and Aquaculture Group of the Research and Productivity Council gave an overview of their work on genetics and fish health. She reported on the ACRDP funded project underway with the NBSGA and DFO to standardize industry and regulatory genetic screening to detect non-local strains in farmed and wild salmon. This project has relevance to management of farmed salmon and protection and recovery of wild salmon populations. Dr. Ritchie also brought the session up to date on efforts to develop collaborative research between Canada, Norway, and the United States. She has been working with this tri-lateral group to develop projects related to diagnostic tests for commercially relevant pathogens for salmon and cod. Finally, Dr. Ritchie discussed ongoing diagnostic and research work related to ISA strain typing and characterization. She concluded that this work is necessary to support a healthy aquaculture business and keep NB at the forefront of these issues.

An interesting presentation on perceptions and perspectives of aquaculture and the ecosystem was given by Dr. Chris McKindsey of the DFO in Rimouski, Quebec. Dr. McKindsey presented results from his work on mussel farms that indicated increases in abundance and perhaps the productivity of macrofauna around the farm sites. He suggested that the perception of negative effects of aquaculture is not supported by this science, rather the opposite may occur. Dr. McKindsey is planning to do work around salmon farms, and has suggested that a similar relationship may be seen.

Dr. Jane Symonds of the Huntsman Marine Science Centre gave an update on the Atlantic Code Genomics and Broodstock Development project. On behalf of Frank Powell of Cooke Aquaculture, she also gave an update of recent progress in commercial cod farming. Cooke Aquaculture Inc. stocked its first cod in sea cages in late 2003 and continues to build on these stocks with an anticipated stocking of 300,000-400,000 cod in 2006. Cooke along with researchers at DFO (ACRDP) as well as UNB are currently investigating light manipulation to curb early maturation; selective breeding/ family rearing (a pre-cursor to the Cod Genome Project; and investigations into potential pathogens of cod. In addition, Cooke is completing sea cage feed trials, comparison of nursery technologies, and development of a seawater recirculation suitable for cod. They anticipate harvesting and marketing our first cod in February 2006, results of initial taste and texture tests have been excellent.

The Atlantic Cod Genomics and Broodstock Development project (www.codgene.ca) was awarded $6.45 million by Genome Canada over the next three years towards a genomics research project on cod aquaculture in Atlantic Canada. This $18.2 million program, led by researchers at Huntsman Marine Centre and The Atlantic Genome Centre in partnership with Genome Atlantic, will develop tools that will allow the aquaculture industry to identify cod with traits of commercial importance. It will develop family based selective breeding programs in New Brunswick and Newfoundland to identify cod families that grow well, show good resistance to disease and stressors in the marine environment, and provide a high quality product with improved fillet yield. In parallel, several thousand cod genes will be sequenced to look for differences in these genes between individual fish. This will allow a set of molecular markers to be identified for use in cod, and to associate these markers with fish that perform well under aquaculture conditions. The data generated through this program represents a unique and specific resource to the aquaculture industry in Eastern Canada. It will build upon pioneering cod aquaculture and broodstock development R&D carried out by project partners in Newfoundland (Northern Cod Ventures, the Ocean Sciences Centre at MUN, and Fisheries and Oceans Canada, NL) and more recently in New Brunswick (Fisheries and Oceans Canada's St Andrews Biological Station and Cooke Aquaculture Inc.) and in New Hampshire (Great Bay Aquaculture).

The luncheon speaker for the session was Dr. Rob Stephenson, Director of the DFO St. Andrews Biological Station (SABS). Dr. Stephenson gave an overview of past and present SABS work in support of aquaculture, most of which has been done in collaboration with the industry. He talked about early trials with farmed salmon, environmental interactions, fish health, marine resource stakeholder interactions, and alternate species. Dr. Stephenson also gave insights into the future of aquaculture research and development in DFO and at SABS. He discussed efforts to plan research based on needs for managing all human activities in the marine environment, not just aquaculture. This includes balancing needs for development and conservation, and for supporting effective decisions. Dr. Stephenson concluded with a commitment to continue working together in support of sustainable aquaculture.

Technical Session for the 2005 Annual General Meeting
New Brunswick Salmon Growers Association

Research and Development to Support Implementation of the Atlantic Canada Salmon Farming Sustainability Plan in Southwest New Brunswick

December 9, 2005
St. Marks Church, St. George, NB

AGENDA

9:30am – 10.00am: Coffee and Mixer

10.00am – 11.30am: **Presentations** ***Chaired by Jamey Smith, NBSGA Research and Environmental Management Coordinator***

Introduction – Identification of Research and Development Priorities
Dr. Jamey Smith, NBSGA

The Evaluation of Testing Strategies for ISA
Pascale Nerette, PhD Candidate, Atlantic Veterinary College, PEI

Science in Support of a Sustainable Aquaculture Industry
Dr. Rachael Ritchie, RPC, Fredericton, NB

Habitat Productivity around Aquaculture Sites
Dr. Chris McKindsey, DFO, Mont Joli, QC

Atlantic Cod Genomics and Broodstock Development
Dr. Jane Symonds, Huntsman Marine Science Centre, St. Andrews
Frank Powell, Cooke Aquaculture Inc.

11:30am – 12.00pm: **Discussion Period** – Feedback from participants on research and development priorities

12:00pm – 1:00pm **Luncheon Speaker**
Dr. Rob Stephenson, Director, St. Andrews Biological Station

SPEAKER BIOGRAPHIES

Dr. Pascale Nerette

The interest of Dr Pascale Nerette in fish health started when she was a student at the University of Montreal, Faculty of Veterinary Medicine. During her third year in vet school, she participated in the Aquavet summer program at Woods Hole. After graduation from vet school, she ran a successful small animal veterinary house-call practice in Montreal. While in practice, her interest in fish health grew and she wanted to learn more about aquaculture fish health. In 1999, she began a six-month veterinary aquaculture internship in Florida. In 2000, she started work as an aquaculture veterinarian working with the Atlantic salmon farms in New Brunswick. Her experience in the aquaculture field has led her to the conclusion that epidemiology was crucial to providing health care service to fish farmers. Thus in 2001, she started her PhD in epidemiology in the Department of health management at the Atlantic Veterinary College. The title of her project was "Evaluation of diagnostic tests for Infectious Salmon Anemia (ISA). She recently defended her PhD thesis.

Rachael Ritchie

Dr. Rachael Ritchie is Head of the Food, Fisheries & Aquaculture Department at RPC, a research & development, and technical services organization. Rachael joined RPC as a post-doctoral scientist just as RPC scientists had identified ISAV in New Brunswick in the late 90's. She spent several years researching ISAV and is the author of several ISAV journal papers and patents. Five years ago, she established genetics and genotyping expertise at RPC which has helped industry address recent challenges in these areas. She oversees a team of fish health scientists and technicians working with a variety of partners in industry, government and academic sectors, to bring microbiology and molecular advances in the areas of fish health and stock sustainability to the aquaculture industry.

Chris McKindsey

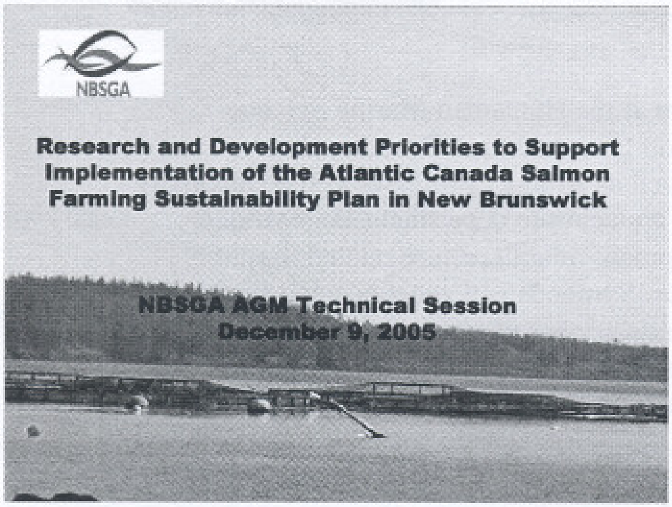
Dr. Chris McKindsey did his undergraduate (1990) and MSc (1993) studies at Concordia University in Montreal. Following this, he went to Université Laval for his PhD (1999) where he studied intertidal ecology of mussel beds with Edwin Bourget. After working for a year as a consultant in Moncton, he was a postdoctoral fellow at the Centre for Research on the Ecological Impacts of Coastal Cities with Gee Chapman at the University of Sydney, Australia, where he worked mostly on concepts relating to restoration and experimental design. Since 2001, he has worked as a research scientist with Fisheries and Oceans Canada in Mont-Joli, Quebec. There, his studies have focused mostly on the interactions between mussel aquaculture and the environment and more recently invasive species. Most of his work has been in the Magdalen Islands and Prince Edward Island where he and his team have been trying to get a more holistic idea of the role of bivalve farming on the functioning of the ecosystem.

Jane Symonds
Dr. Jane Symonds is the Director of Aquaculture at the Huntsman Marine Science Centre, the lead organization of the "Atlantic Cod Genomics and Broodstock Development" program (www.codgene.ca) as well as Adjunct Professor at the University of New Brunswick, Fredericton. As head of the aquaculture department Dr. Symonds manages the facilities and staff, plus the development of aquaculture related research, education and technology transfer to industry. Dr. Symonds is a geneticist and finfish broodstock specialist and has over 12 years of industry based expertise in selective breeding, broodstock management and biotechnology. This includes successfully establishing the first commercial family based all-female chinook salmon selective breeding program in New Zealand

Frank Powell
Mr. Frank Powell is currently Manager of Alternate Species Development at Cooke Aquaculture Inc. The primary focus of the program at the current time is the development of Atlantic cod farming in the Bay of Fundy. Mr. Powell is responsible for: coordinating the stocking of cod fry at both the sea cage sites and land-based nursery in NS; directing research and development trials; and preparing R&D proposals for potential funding agencies. Mr. Powell has completed a BSc, MSc, and Advanced diploma in aquaculture all at Memorial University on Nfld. Prior to joining Cooke Aquaculture Inc. in 2004. Mr. Powell spent the previous 8 years working on halibut aquaculture development with Maritime Mariculture Inc. St. Andrews.

Rob Stephenson
Dr. Robert Stephenson received his BSc (Hons) from Trent University in 1976 and his PhD in 1981 from University of Canterbury (Christchurch, N.Z.). He has served as a Research Scientist with DFO since 1984 and as the Director of the St. Andrews Biological Station since April 2005. Rob is the former chair of ICES Pelagic Fish and Resource Management Committees, and member of ICES Advisory Committee on Fisheries Management. He is active in research in fisheries research in the Gulf of Maine for over 20 years, including work on fisheries/aquaculture interactions.

Jamey Smith
Dr. Jamey Smith is an environmental scientist specializing in assessment and monitoring of coastal ecosystems. Jamey received his BSc (Hons) from UNB in Saint John in 1985 and his PhD from the University of Stirling in 1990. He has provided services in pulp and paper/mining aquatic environmental effects monitoring, environmental impact assessments, marine and freshwater aquaculture, ports and harbours, commercial fisheries, integrated management, and research and development. He has extensive experience in program and project management, teaching, and facilitation. Dr. Smith presently operates the consulting firm CoastalSmith Inc. and serves as the Research and Environmental Management Coordinator for the New Brunswick Salmon Growers Association.



Overall Objective of the Sustainability Plan

- Further establish a sustainable, environmentally responsible salmon farming industry to produce healthy, safe, and affordable food
- Support development of a market-driven industry
- Recognize evolution of the industry and in particular recent changes based on market requirements
- Three main components – marketing, system framework, and business risk management

System Framework Components

- Communications
- Government Harmonization
- Performance Based Standards
- Fish Health
- Codes of Practice
- Site System
- Site Consolidation
- New Sites
- Research and Development
- Alternate Species
- Stakeholder Interactions

Near Term/Applied Research

Fish Health	PBS	Codes of Practice	New Sites
ISA Distribution BKD issues Other pathogens • Screening • Techniques • Introductions Effects of • Stress • Smolt transfer • Superchill [illegible]	[illegible]	SOPS need to be developed that consider Auditing and Reporting Data analysis to improve understanding of cause-effect relationships and to provide confidence to a PBS program Issues related to implementation	Mapping and conflict determination and resolution What are appropriate monitoring programs

Near Term/Applied Research

BMA System	Site Consolidation	Alternate Species	Stakeholder Interactions
Best alternative site separation distance What are appropriate levels • BMA level • Sites level Need to establish criteria • Health [illegible] How to incorporate alternate species • Crop rotation • Integrated What are appropriate monitoring programs	Consider as part of the BMA system work [illegible] Scale Site fallow What are appropriate monitoring programs	Consider to diversify salmon industry Criteria to fit into BMAs? Economic factors and assessment [illegible] Infrastructure requirements	Mapping and conflict determination and resolution

Short Term New Science

ISA strain pathogenesis Stress/wellness Smolt transfer Superchill Fish health - environmental quality connection	[illegible]	Data analysis regarding cause-effect - what are best responses?	Implement projects related to the 5 concepts developed for the Offshore Project • [illegible] • Mapping and conflict resolution • [illegible] • [illegible] • Economic

Short Term New Science

Today's Opportunity

- Communicate the Sustainability Plan and research and development priorities
- Presentations on recent R&D projects on fish health, genetics, and environment
- Feedback from the NBSGA membership and colleagues on moving ahead

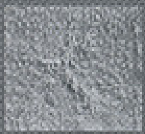
Evaluation of testing strategies for infectious salmon anaemia (ISA) and implication for a control program

Dr Pascale Nérette
AVC-Centre for Aquatic Health Sciences
Atlantic Veterinary College, UPEI

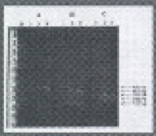
Background Knowledge

Available Diagnostic Tests

IFAT



Virology



RT-PCR

Background Knowledge

Problematic

- Limited information on
  - Sensitivity and specificity
  - Reproducibility and repeatability
- Reduce ability to
  - Conduct efficient epidemiologic research
  - Develop efficient control mechanisms

Background Knowledge

Nomenclature

- Sensitivity (Se): Probability that an infected fish will test positive
- Example: Se = 62%

	D+	D-
T+	**62**	
T-	38	
	100 fish	

Background Knowledge
Nomenclature

- Specificity (Sp): Probability that an uninfected fish will test negative
- Example: Sp = 98%

	D+	D-
T+		2
T-		**98**
		100 fish

Overall Objectives

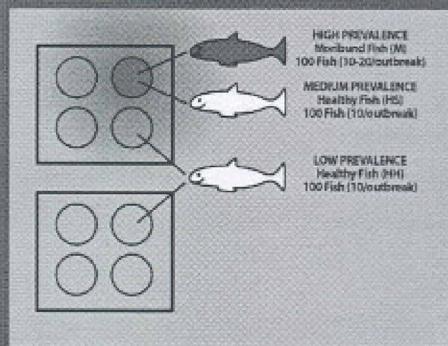
Determine the operating characteristics of current diagnostic tests for ISA

Develop a rational testing strategy for use in control programs

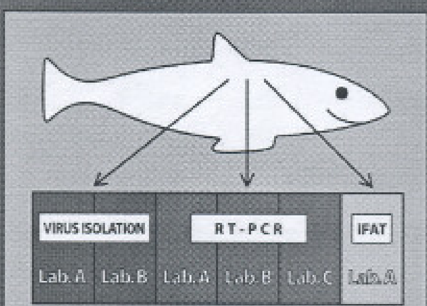
Overall Study design
Study population

- Four populations
  - high prevalence (n=100)
  - moderate prevalence (n=100)
  - low prevalence (n=100)
  - zero prevalence (n=100)

Overall Study design
Study population



Study design
Tissue sampling



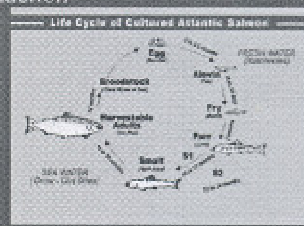
Keys findings
Sensitivity and Specificity

- Sensitivity
  - IFAT: 62%
  - VI: 80-88%
  - PCR: 77-99%
- Specificity
  - IFAT: 98%
  - VI: 100 %
  - RT-PCR: 84-99%

Evaluation of testing strategies

Current Testing Strategies
Introduction

- Populations
  - Broodstock
  - Pre-smolt
  - Pre-markets
    - moribund/4 weeks
- Tests
  - Screening tests: IFAT and PCR
  - Confirmatory tests: VI
  - Result positive
    - Individual-level: Two tests positive
    - Group-level: Two fish positive



Testing Strategies
Introduction

- Efficiency of the New Brunswick surveillance program
- Recently determined operating characteristics

Study 5-Testing Strategies
Objectives

Analyze the cost-effectiveness of strategies to identify the lowest cost testing strategy, which would achieve a GSe and GSp of 95% for each

Nomenclature

- Group sensitivity (GSe): Probability that an infected group yields a positive group test result
- Example: GSe = 95%

	D+	D-
T+	**95**	
T-	5	
	100 cages	

Nomenclature

- Group specificity (GSp): Probability that an non-infected group yields a negative group test result
- Example: GSp = 95%

	D+	D-
T+		5
T-		**95**
		100 cages

Factors affecting group-level sensitivity and group-level specificity

- Sensitivity and specificity
  - Individually
  - Combinations of multiple tests
    - Parallel interpretation
    - Serial interpretation

Parallel and Serial Testing

Strategy	Assays	Sensitivity	Specificity
Individual	IFAT		
	VI	89	100
	PCR	93	99
Parallel	IFAT_VI		
	IFAT_PCR		
	VI_PCR	99	99
Serie	IFAT_VI		
	IFAT_PCR		
	VI_PCR	83	100

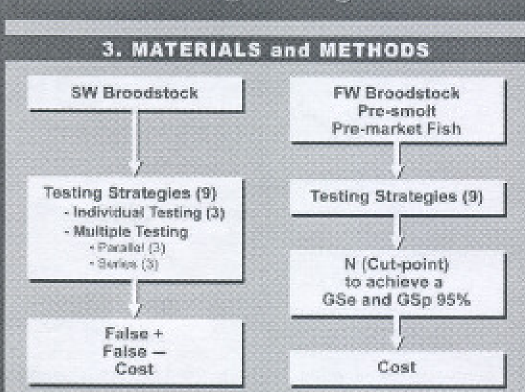
Parallel and Serial Testing

Strategy	Assays	Sensitivity	Specificity
Individual	IFAT	62	98
	VI	89	100
	PCR	93	99
Parallel	IFAT_VI	90	98
	IFAT_PCR	95	97
	VI_PCR	99	99
Serie	IFAT_VI	61	100
	IFAT_PCR	60	99.5
	VI_PCR	83	100

Factors affecting group-level sensitivity and group-level specificity

- Number of animals tested
- Within-group prevalence
- Number of positives used to classify the group as positive

Testing Strategies



Results-Pre-Market fish

Prevalence	10%		50%	
Assays	N (c)	Cost	N (c)	Cost
Individual Testing				
IFAT	141 (7)	3,525	13 (2)	325
VI	33 (1)	1,581	**6 (1)**	**381**
PCR	60 (3)	2,640	**5 (1)**	**220**
Parallel Testing				
IFAT-VI	81 (5)	5,395	9 (2)	550
IFAT_PCR	85 (6)	5,556	8 (2)	439
VI_PCR	56 (3)	4,692	5 (1)	343
Serial Testing				
IFAT-VI	**48 (1)**	**1,502**	**9 (1)**	**472**
IFAT_PCR	96 (3)	2,748	9 (1)	352
VI_PCR	35 (1)	1,824	6 (1)	497

Results-Pre-Market fish

Prevalence	50%		90%	
Assays	N (c)	Cost	N (c)	Cost
Individual Testing				
IFAT	13 (2)	325	7 (2)	175
VI	6 (1)	381	2 (1)	158
PCR	5 (1)	220	**2 (1)**	**88**
Parallel Testing				
IFAT-VI	9 (2)	550	2 (1)	111
IFAT_PCR	8 (2)	439	4 (2)	178
VI_PCR	5 (1)	343	2 (1)	107
Serial Testing				
IFAT-VI	9 (1)	472	**4 (1)**	**294**
IFAT_PCR	9 (1)	352	4 (1)	198
VI_PCR	6 (1)	497	3 (1)	341

Strengths of current surveillance program

- Perfect CSp = No false positive cage
- Sample moribund fish
- Frequent testing

Deficiencies of current surveillance program

- Not the most cost efficient approach
- Low CSe = Missing infected cage
  - Cut-point too high
  - Not enough moribund are sampled

Not the most cost efficient

CSe=95% and CSp=100%
Prevalence = 50%

Strategy	Test	N	Cut-point	Cost
Suggested	VI	6	1	$ 381
	IFAT_VI (S)	9	1	$472
NBDAFA	IFAT_PCR (P) VI (S)	8	2	$904
		5	1	$565

Low CSe

Prevalence = 50%

NBDAFA = IFAT,PCR (P) + VI (S)				
N	Cut-point = 2		Cut-point = 1	
	CSe	CSp	CSe	CSp
8	95	100		
7	92	100		
6	87	100		
5	78	100	96	100
4	65	100	92	100
3	46	100	86	100
2	23	100	73	100

Conclusion 1

- Interpretations are based on using the best performing tests (not necessarily the tests / labs that were used in NB surveillance program)
  - Conclusions may be different if use different tests
    - e.g. currently NBDAFA doing RT-PCR (they were not available when this assessment was done)

Conclusion 2

- ISA cases have rarely, if ever, been misclassified as positive
- ISA cases have likely been missed

Acknowledgment

- Aquanet
- NADAFA
- DFO
- Cook Aquaculture
- Stolt Sea Farm
- Fish samples from many salmon farmers

More Slides

Keys findings

Repeatability and Reproducibility[1]

	IFAT	PCR labA	PCR labB	PCR labC	VI labA	VI labB
Repeata-bility	High	Low	Moderate	High	High	High
Reprodu-cibility	N/A	Moderate			High	

1 Nerette P, Dohoo I, Hammell, Gagne N, Barbash P, MacLean S, Yason C. Estimation of the repeatability and reproducibility of three diagnostics tests for ISAV in the absence of a gold standard. Journal of Fish Diseases 28:101-110

Factors affecting group-level sensitivity and group-level specificity

- Sensitivity and specificity
  - Individually
  - Combinations of multiple tests
    - Parallel interpretation
    - Serial interpretation
- Number of animals tested
- Within-group prevalence
- Number of positives used to classify the group as positive

Not cost efficient

CSe=95% and CSp=100%
Prevalence = 90%

Strategy	Test	N	Cut-point	Cost
Suggested	VI	2	1	$158
	IFAT_VI (S)	4	1	$294
NBDAFA	IFAT_PCR (P) VI (S)	4	2	$592
		2	1	$297

Low CSe

Prevalence = 90%

NBDAFA = IFAT,PCR (P) + VI (S)				
N	Cut-point = 2		Cut-point = 1	
	CSe	CSp	CSe	CSp
6	100	100	100	100
5	99.8	100	100	100
4	98.9	100	99.7	100
3	94.3	100	98.9	100
2	73.1	100	97.9	100

Pathogenic Strain Differentiation

- Strain differentiation is same as "new test"
  - Need to quantify Se / Sp and repeatability / reproducibility

Conclusion 3

- ISA infection prevalence is likely high when current strategy detects ISA
- Detecting lower level prevalence (i.e. earlier in outbreaks)
  - Need to test more moribund more frequently

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Science in Support of a Sustainable Aquaculture Industry

The Technical Solutions Centre

Topics:

- Genetic Stock Project (ACRDP)
- Fish Health Meeting (Washington, DC)
- Current ISAV R & D

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Genetic Stock Project (ACRDP)

Context:
- Increasing concerns regarding protection of wild salmon stocks in US and Canada.
- USFWS requires genetic testing to ensure North American ancestry of fish stocked in Maine.
- No Canadian genetic testing standard.

Project objective:
To standardize industry and regulatory genetic screening tests for detection of non-local strains in aquaculture and wild populations of Atlantic salmon in the Bay of Fundy area.

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Project overview

Aquaculture (RPC)

USFWS 'ancestry' panel
• microsatellites

Wild (BIO-DFO)

DFO - genetic markers
• SNPs

TECHNOLOGY EXCHANGE

DFO - genetic markers
• SNPs

USFWS 'ancestry' panel
• microsatellites

Comparison of results...

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1. Choosing representative study populations

- Focus on 2003 broodstock YC
- ~ 400 fish/population

Aquaculture	Wild
(NBSGA) You know who you are.	Upper Salmon River Magaguadavic River Point Wolfe River Saint John River Petitcodiac River Gaspereau Harrington Apple Big Salmon

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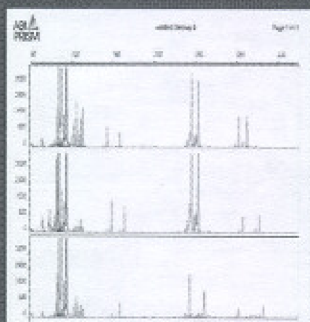
2. Genotyping study populations

Aquaculture (RPC)

USFWS 'ancestry' panel
• microsatellites

TECHNOLOGY EXCHANGE

DFO - genetic markers
• SNPs



Comparison of results...

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Trilateral Fish Health meeting

Washington, November 2-3

Norway-Canada-USA

Scientific-technical working groups:

Escapees, Feed, Genomics & Fish health

Goal:

- Discussion of common international research priorities.
- Development of collaborative research proposals.

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Fish Health Working Group

Diagnostics (Diagnostic techniques)
Basic immunology (Reagents and tools)
Applied Immunology (Rational vaccine design)

- Surveillance
- Disease tracking
- Wild-aquaculture fish interactions
- Determination of disease free status
- Regulatory requirements

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Diagnostic working group

Identified needs:

- To provide a formal process for validation of diagnostic tests.
  - ✓ specificity,
  - ✓ sensitivity
  - ✓ reproducibility
  - ✓ reliability
  - ✓ predictive value of diagnostic tests
- To develop new and innovative tests.

Focus:

- Atlantic salmon and cod
- Commercially important pathogens : ISAV and nodavirus

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Current ISAV R & D

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Number of Farms Infected with ISA by Year Class in New Brunswick

updated October 2004

from: NB Department of Agriculture, Fisheries & Aquaculture

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ISA can be controlled . . . managed

- True single year class farming
- Control vessel movements (harvest boats)
- Wharf use controls/restrictions
- Processing plant controls
- Fallowing, cleaning and disinfection critical
- Maintain high level of biosecurity
- Early detection and removal of infected stocks

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ISAV—Control and Management Relies on Continued R&D

(the 'flu' virus of fish world)

Diagnostics
Improved diagnostics
Epidemiology
Strain typing

Research
Strain characterization
Epidemiology
Hydrography

Management
Monitor / ensure best practices
Prevention strategies

Current ISAV work

rpc

Why do we care about ISA strain typing? (1)

Differentially detected by diagnostic techniques

- Cell culture replication / CPE variation between different viral strains ('hpr').
- PCR differences between strains.
- IFAT difference between strains?

Differentially associated with disease

- Hpr0 strain not associated with disease.
- Anecdotal differences in virulence between strains.

Epidemiology

- Allows virus tracking
- Inform ISA management

rpc

Why do we care about ISA strain typing? (2)

Avian / human flu

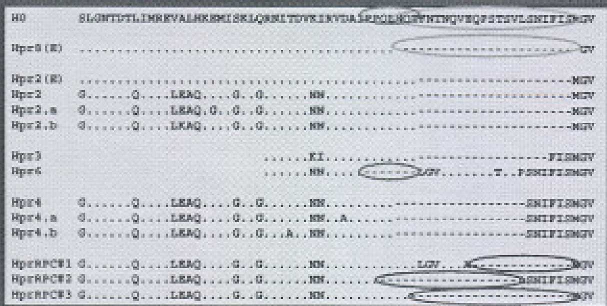
- "Substantial genetic differences" between subtypes.[1]
- Classified by variants on HA and NE (H_5N_1).
- High-pathogenic to low-pathogenic subtypes.
- Pathogenicity determined on the basis of genetic features of the virus.

One approach:
Molecular typing

[1]Centers for Disease Control and Prevention

rpc

Molecular typing of ISAV ('H')



ISAV 'H' variants appear to have a common source

rpc

Examples from the field...

Seg 6	Seg 8	# Cases	BMA's	Comments
H0	Euro	27	9,3,4,13,18,17,12,1b	Oct-May (1X2+IFAT)
H2	N.A.	6	3,2,14(1)	3 sites
H2	Euro	1	12	
H2.a	N.A.	4	3	1 site (Apr-May)
H2.b	N.A.	4	3	1 site (May-July)
H4	N.A.	13	10,8,7,5	Strong IFAT all 03
H4.a	N.A.	9	10,9,14(1)	Strong IFAT all 03
H4.b	N.A.	4	4,1a(1)	Weak IFAT 2 sites 04
H8	Euro	2	12	1 site July 05 same site H2 E
H RPC1	N.A.	1	2	1 site 04
H RPC2	N.A.	3	5	Strong IFAT all 03 Oct-Mar
H RPC3	N.A.	2	21	1 site Mar

HA ('H') variants exist

Diagnostics differences

Variable distribution and prevalence

rpc

ISAV Strain Research

- Molecular characterization of 'H' and 'N' regions of ISAV strains in NB.
- Looking for ways to define a 'strain' e.g., H_xN_y
- Correlating strains with field data (mortality, disease progression, etc.).
- Planning virulence challenges of different strains.

Goal:
Incorporate this information into management practices → reducing impact of infection.

rpc

Future Research

- Continued ISAV research.
- R&D on emerging pathogens and strains.
- Development of new technologies for diagnostics & research.
- Multidisciplinary approaches to fish health and genetics research, diagnostics and management.

Helping ensure a profitable, healthy and environmentally sustainable aquaculture industry.

rpc

Conclusions

✓ Investment in fish health and genetics contributes to healthy aquaculture businesses.

✓ Ongoing projects and sustained investment will keep NB at the forefront of fish health and genetics.

rpc

Acknowledgments

RPC:
Rachael Ritchie, Marcia Cook-Versloot, Sherry Binette, Rebecca Liston, Eric Johnsen, Erin MacDonald, Ali Johnson

Colleagues:

Bedford Institute of Oceanography, Department of Fisheries and Oceans
Department of Fisheries and Marine Biology, University of Bergen
National Veterinary Institute, Norway
Norwegian School of Veterinary Science
FRS Marine Laboratory, Scotland

Financial Support:

New Brunswick Department of Agriculture, Fisheries & Aquaculture (NBDAFA)
Department of Fisheries and Oceans (ACRDP)
New Brunswick Salmon Growers Association (NBSGA)

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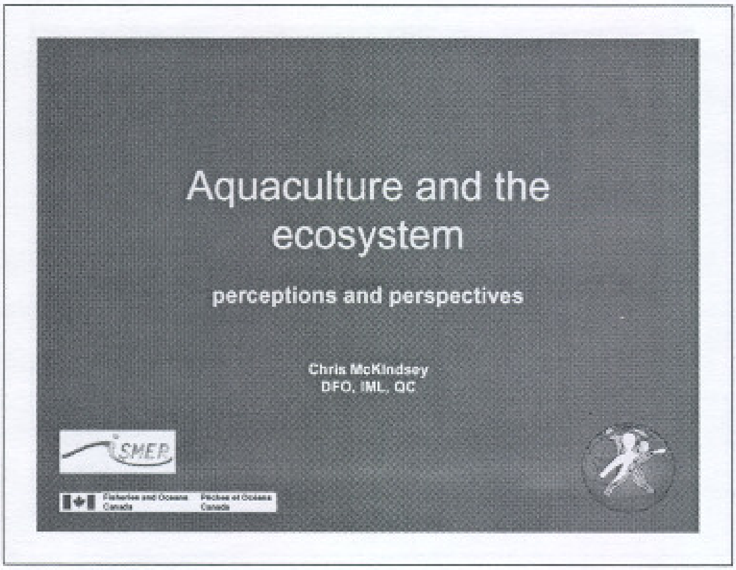
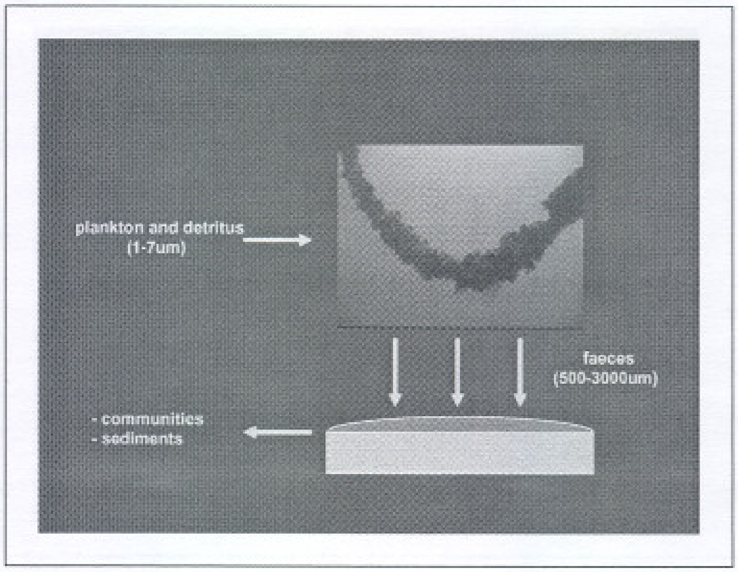
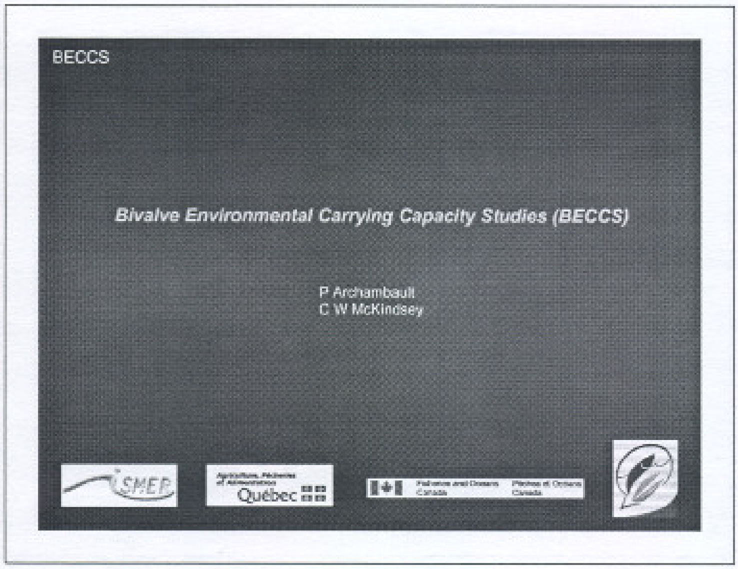
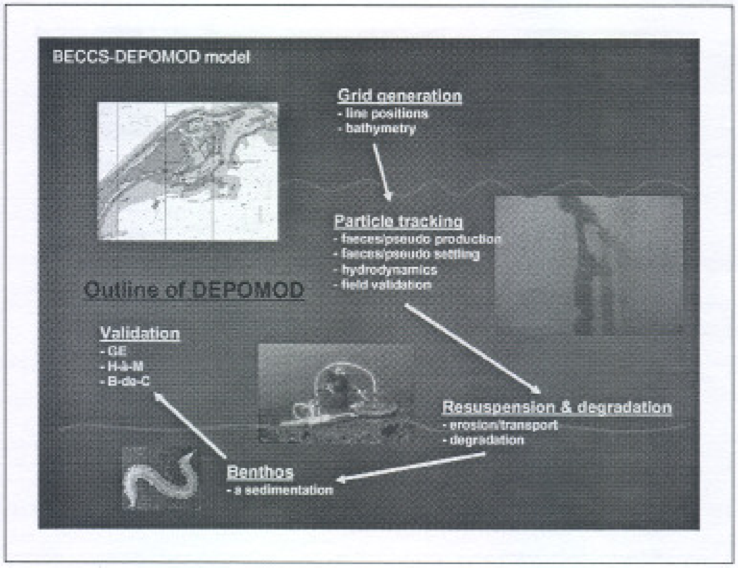
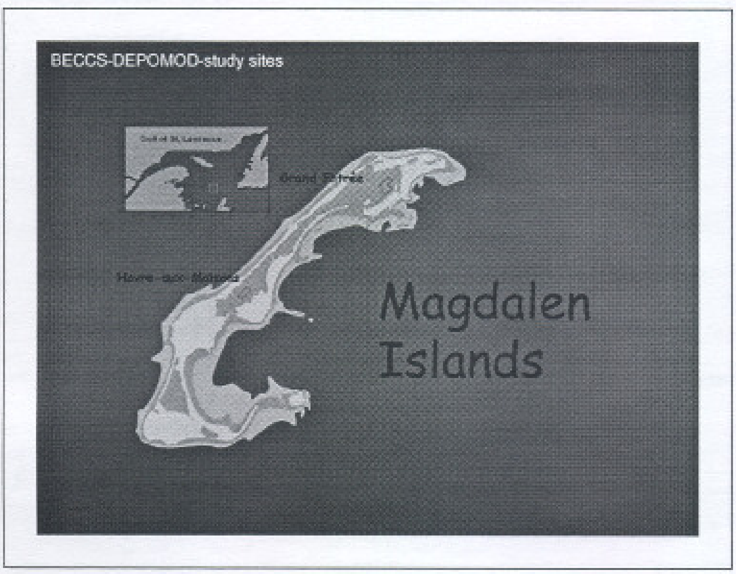
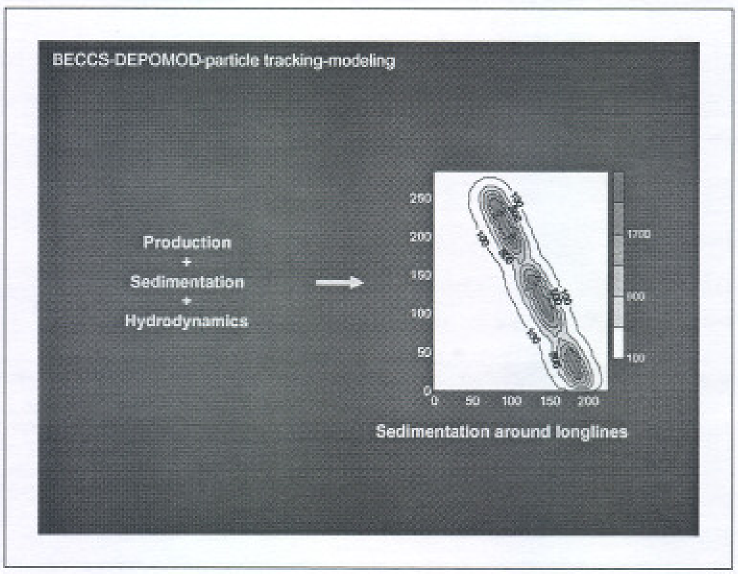

Aquaculture and the ecosystem
perceptions and perspectives
Chris McKindsey
DFO, IML, QC
ISMER
Fisheries and Oceans Canada
Pêches et Océans Canada

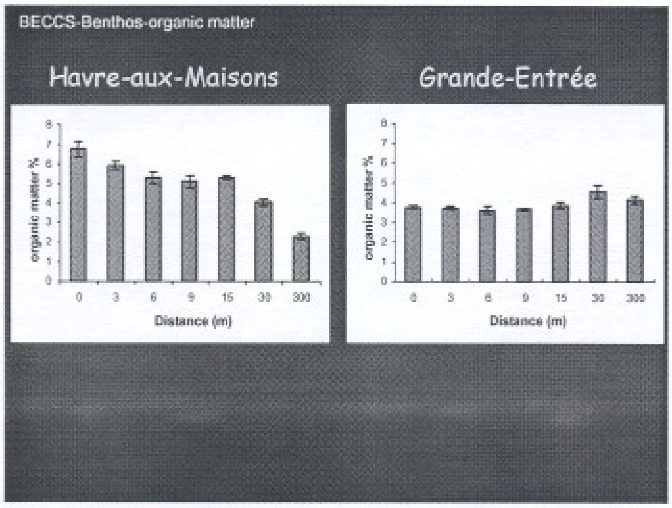

plankton and detritus
(1-7um)
faeces
(500-3000um)
- communities
- sediments

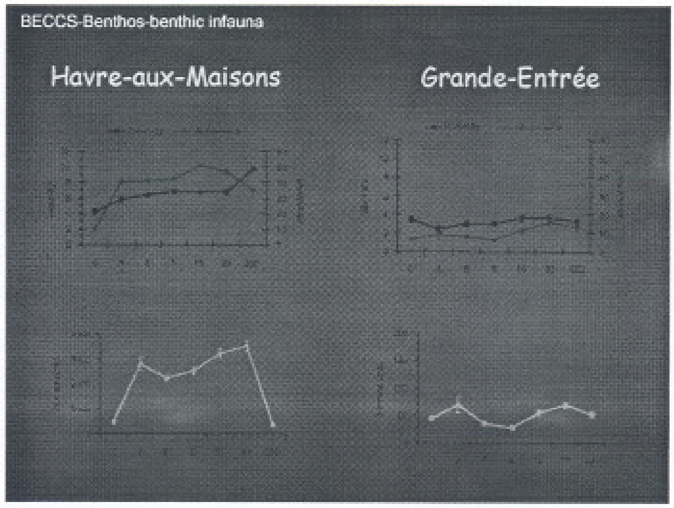

BECCS
Bivalve Environmental Carrying Capacity Studies (BECCS)
P Archambault
C W McKindsey
ISMER
Québec
Fisheries and Oceans Canada
Pêches et Océans Canada

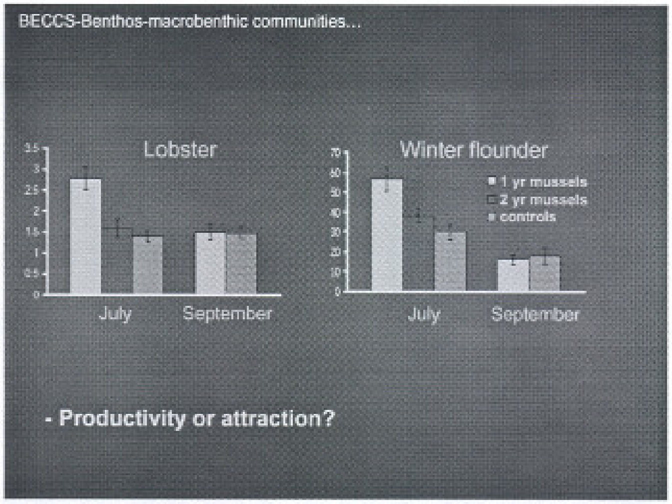

BECCS-DEPOMOD model
Grid generation
- line positions
- bathymetry
Particle tracking
- faeces/pseudo production
- faeces/pseudo settling
- hydrodynamics
- field validation
Outline of DEPOMOD
Validation
- GE
- H-à-M
- B-de-C
Resuspension & degradation
- erosion/transport
- degradation
Benthos
- a sedimentation

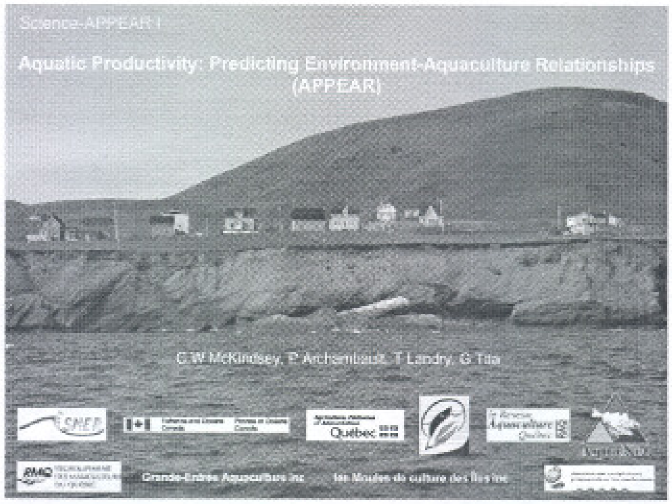

BECCS-DEPOMOD-study sites
Gulf of St. Lawrence
Grand Entrée
Havre-aux-Maisons
Magdalen
Islands

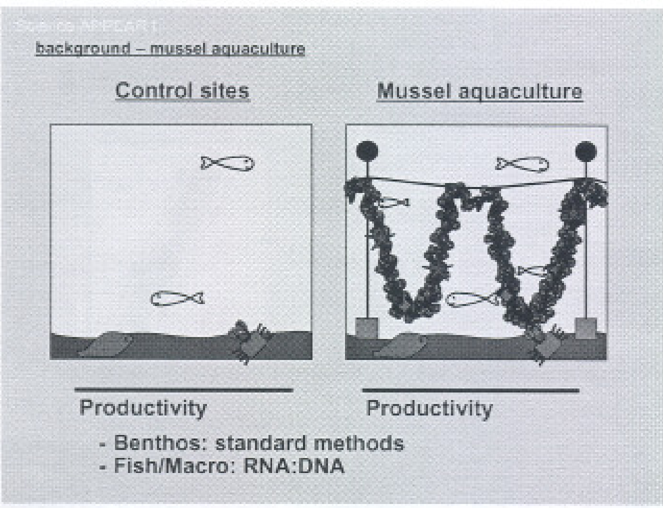

BECCS-DEPOMOD-particle tracking-modeling
Production
+
Sedimentation
+
Hydrodynamics
Sedimentation around longlines

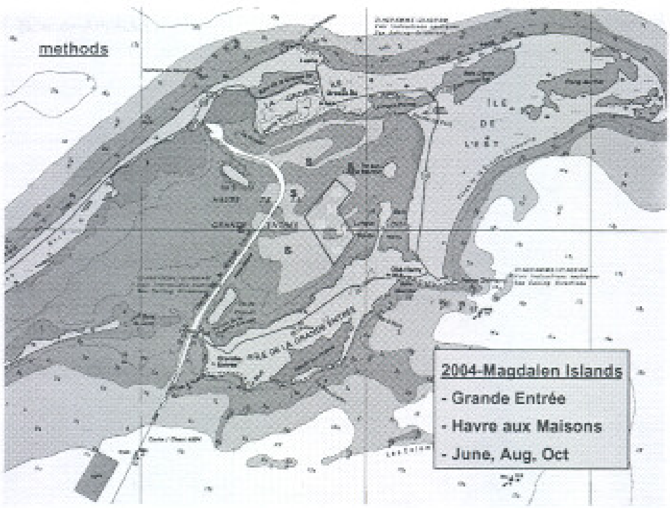

BECCS-Benthos-organic matter
Havre-aux-Maisons
Grande-Entrée
organic matter %
Distance (m)

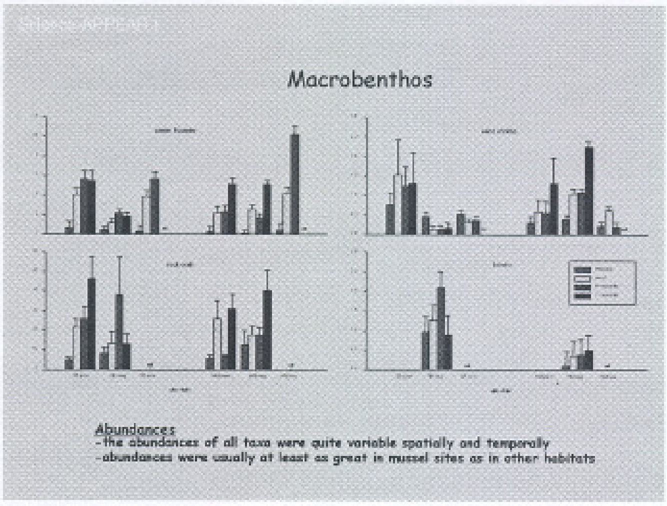

BECCS-Benthos-benthic infauna
Havre-aux-Maisons
Grande-Entrée

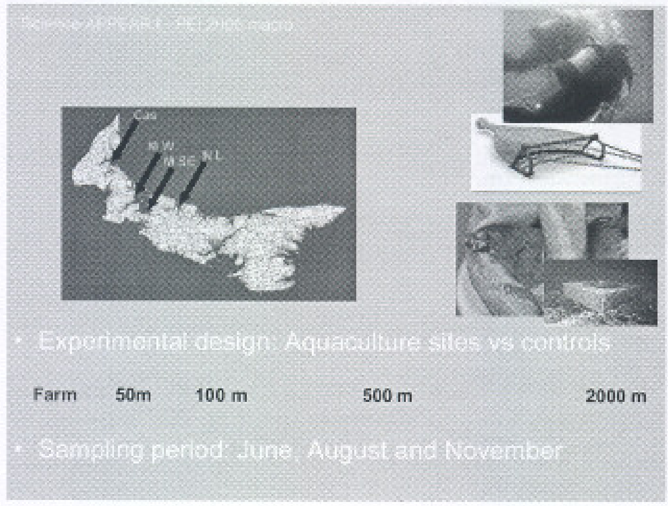

BECCS-Benthos-macrobenthic communities...
Lobster
Winter flounder
1 yr mussels
2 yr mussels
controls
July
September
- Productivity or attraction?

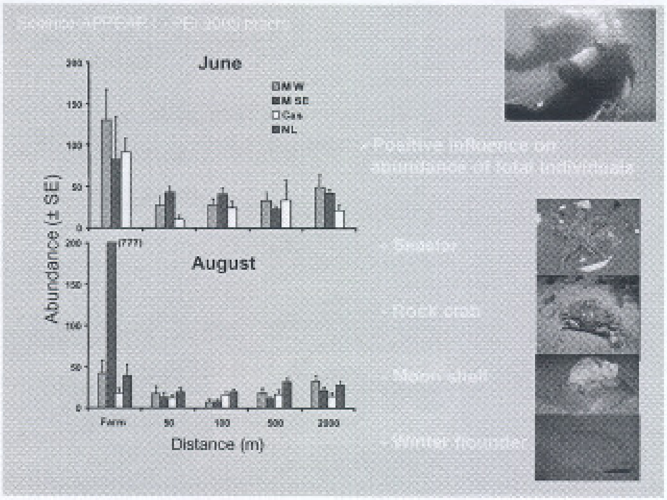

Science-APPEAR I
Aquatic Productivity: Predicting Environment-Aquaculture Relationships (APPEAR)
C.W McKindsey, P Archambault, T Landry, G Tita
Québec
Grande-Entrée Aquaculture inc
les Moules de culture des îles inc

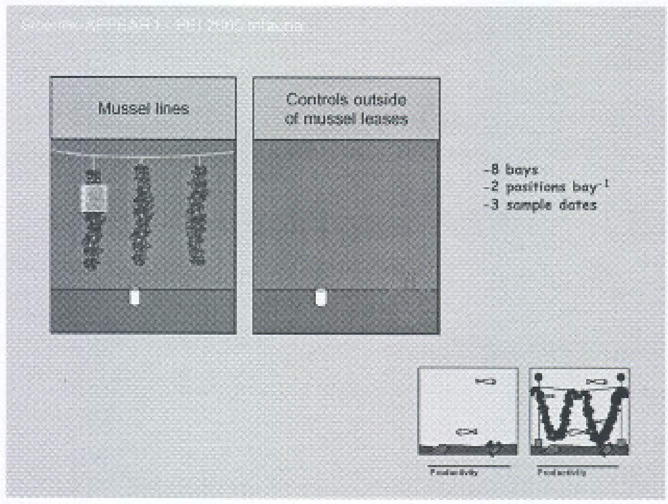

background – mussel aquaculture
Control sites
Mussel aquaculture
Productivity
Productivity
- Benthos: standard methods
- Fish/Macro: RNA:DNA

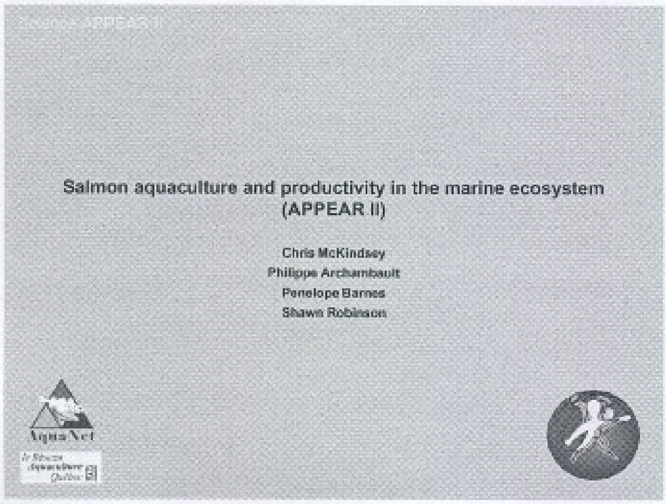

methods
2004-Magdalen Islands
- Grande Entrée
- Havre aux Maisons
- June, Aug, Oct

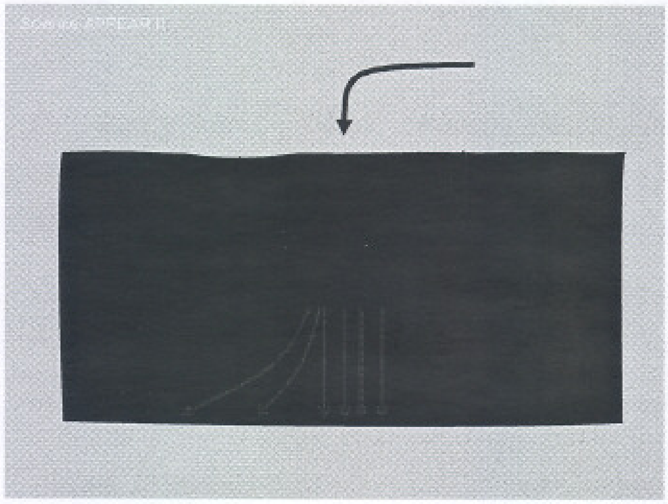

Macrobenthos
Abundances
-the abundances of all taxa were quite variable spatially and temporally
-abundances were usually at least as great in mussel sites as in other habitats

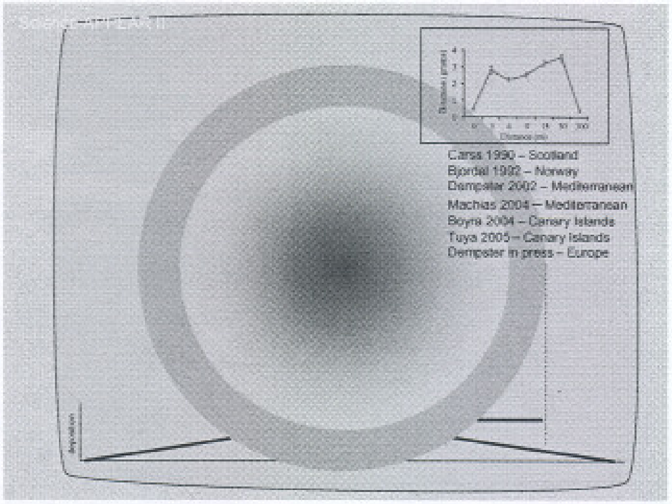

Cas
M W
M SE
N L
Experimental design: Aquaculture sites vs controls
Farm
50m
100 m
500 m
2000 m
Sampling period: June, August and November

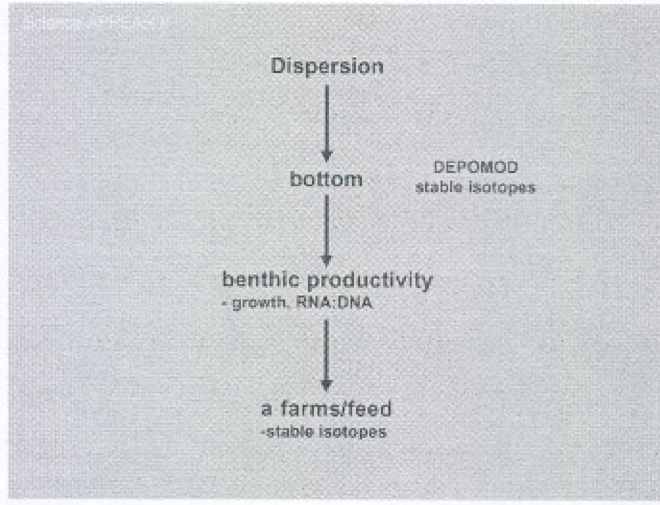

June
M W
M SE
Cas
NL
Abundance (± SE)
(777)
August
Farm
50
100
500
2000
Distance (m)
Positive influence on abundance of total individuals
Seastar
Rock crab
Moon snail
Winter flounder


Mussel lines
Controls outside of mussel leases
-8 bays
-2 positions bay-1
-3 sample dates


Salmon aquaculture and productivity in the marine ecosystem (APPEAR II)
Chris McKindsey
Philippe Archambault
Penelope Barnes
Shawn Robinson
AquaNet

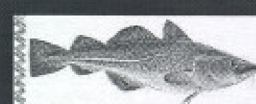






Perception	Perspective
- sediments	- not always
- infauna	- not always - productivity?
- macrofauna	- usually + - productivity?
- fish farms	- same as bivalves

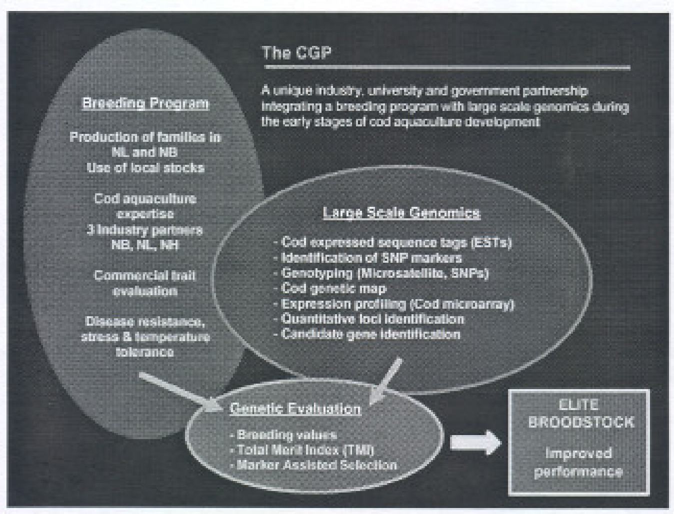
Atlantic Cod Genomics and Broodstock Development (CGP)

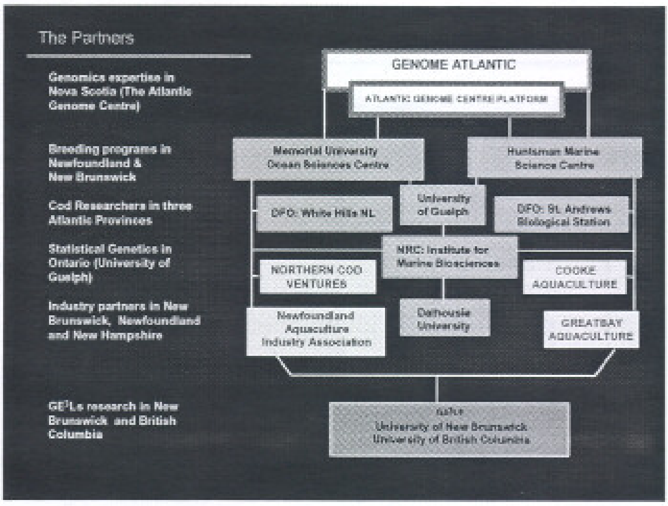


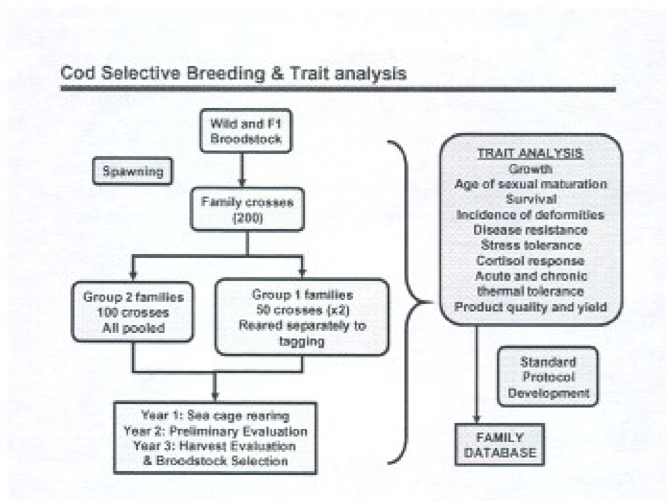
The overall goal

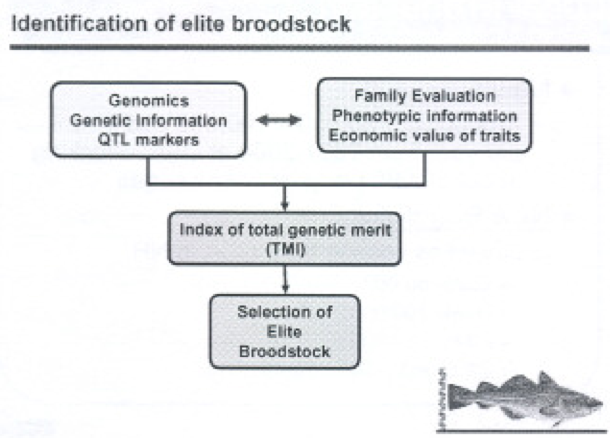
To develop a breeding program and a set of fundamental genomics tools which will be used to supply the developing Atlantic cod (*Gadus morhua*) aquaculture industry in Canada with improved broodstock

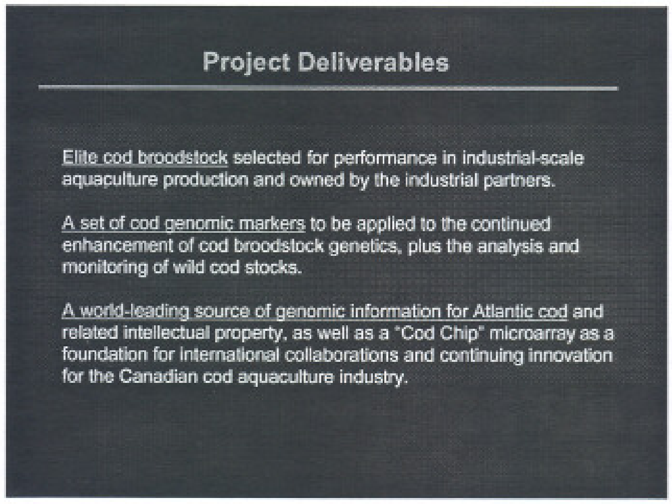
Cod broodstock and families at St. Andrew's Biological Station

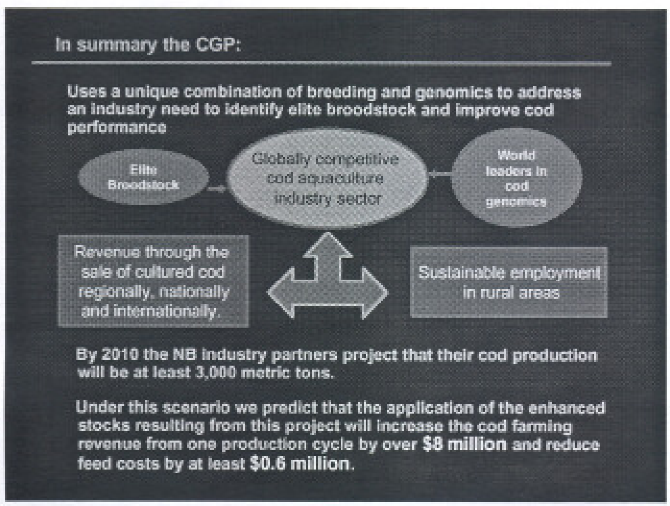


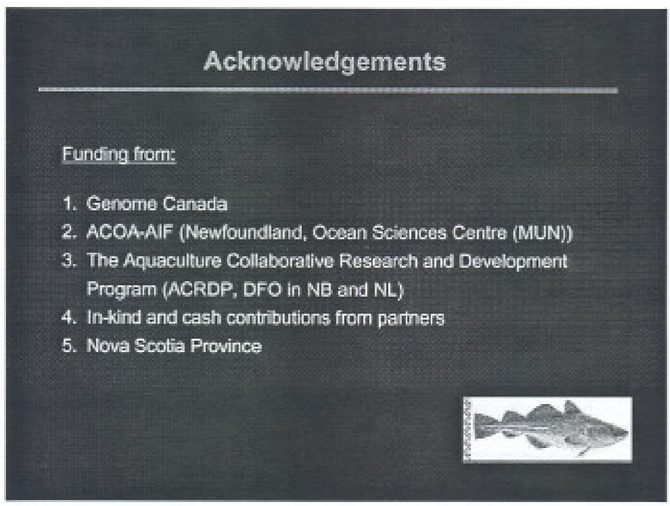

The Partners
Genomics expertise in Nova Scotia (The Atlantic Genome Centre)
Breeding programs in Newfoundland & New Brunswick
Cod Researchers in three Atlantic Provinces
Statistical Genetics in Ontario (University of Guelph)
Industry partners in New Brunswick, Newfoundland and New Hampshire
GE^{3}Ls research in New Brunswick and British Columbia
GENOME ATLANTIC
ATLANTIC GENOME CENTRE PLATFORM
Memorial University Ocean Sciences Centre
Huntsman Marine Science Centre
DFO: White Hills NL
University of Guelph
DFO: St. Andrews Biological Station
NRC: Institute for Marine Biosciences
NORTHERN COD VENTURES
COOKE AQUACULTURE
Newfoundland Aquaculture Industry Association
Dalhousie University
GREATBAY AQUACULTURE
University of New Brunswick
University of British Columbia


Cod Selective Breeding & Trait analysis
Wild and F1 Broodstock
Spawning
Family crosses (200)
Group 2 families 100 crosses All pooled
Group 1 families 50 crosses (x2) Reared separately to tagging
Year 1: Sea cage rearing
Year 2: Preliminary Evaluation
Year 3: Harvest Evaluation & Broodstock Selection
TRAIT ANALYSIS
Growth
Age of sexual maturation
Survival
Incidence of deformities
Disease resistance
Stress tolerance
Cortisol response
Acute and chronic thermal tolerance
Product quality and yield
Standard Protocol Development
FAMILY DATABASE


Identification of elite broodstock
Genomics Genetic Information QTL markers
Family Evaluation Phenotypic information Economic value of traits
Index of total genetic merit (TMI)
Selection of Elite Broodstock

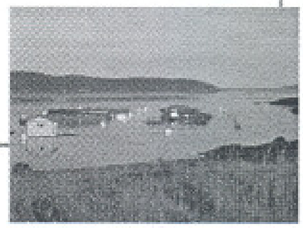

Project Deliverables
Elite cod broodstock selected for performance in industrial-scale aquaculture production and owned by the industrial partners.
A set of cod genomic markers to be applied to the continued enhancement of cod broodstock genetics, plus the analysis and monitoring of wild cod stocks.
A world-leading source of genomic information for Atlantic cod and related intellectual property, as well as a "Cod Chip" microarray as a foundation for international collaborations and continuing innovation for the Canadian cod aquaculture industry.


In summary the CGP:
Uses a unique combination of breeding and genomics to address an industry need to identify elite broodstock and improve cod performance
Elite Broodstock
Globally competitive cod aquaculture industry sector
World leaders in cod genomics
Revenue through the sale of cultured cod regionally, nationally and internationally.
Sustainable employment in rural areas
By 2010 the NB industry partners project that their cod production will be at least 3,000 metric tons.
Under this scenario we predict that the application of the enhanced stocks resulting from this project will increase the cod farming revenue from one production cycle by over $8 million and reduce feed costs by at least $0.6 million.


Acknowledgements
Funding from:
1. Genome Canada
2. ACOA-AIF (Newfoundland, Ocean Sciences Centre (MUN))
3. The Aquaculture Collaborative Research and Development Program (ACRDP, DFO in NB and NL)
4. In-kind and cash contributions from partners
5. Nova Scotia Province

Developing Atlantic Cod Aquaculture in the Bay of Fundy

Frank Powell
Cooke Aquaculture Inc.



Cod Farming- Worldwide

Future Forecasts

- 2008 40,000 tons (mostly Norway, some Scotland and Canada)
- 2013
  - ~100,000 tons (Norway)
  - ~ 100,000 tons (Scotland, Canada)

Local Production

- Newfoundland
  - Producing ~ 50,000 – 100,000 cod juveniles per year from 2001-2004 at OSC. Stocking about 50,000 per year in sea cages.
- New Brunswick
  - Juveniles coming from GBA in NH.
    - 2003- 80,000
    - 2004- 100,000
    - 2005- 230,000
    - 2006 (est.)- 300,000-400,000

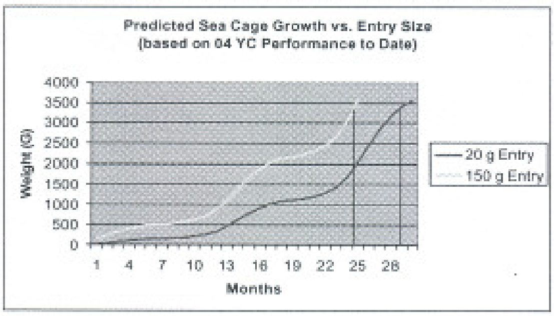
Stocking/ Grow-out Strategies

- Cod have been stocked at two sizes to date: 20 g and 7 g (this year)
- 70m circular cages have been used successfully
  - This spring we built a cage with smaller enclosures to allow better grading capability.
- Hand-feeding with Moist Diet
- Grading/ "splitting" after 1 year
- Plan on an initial 2.5-3 years from 7 g to market (~3 kg)

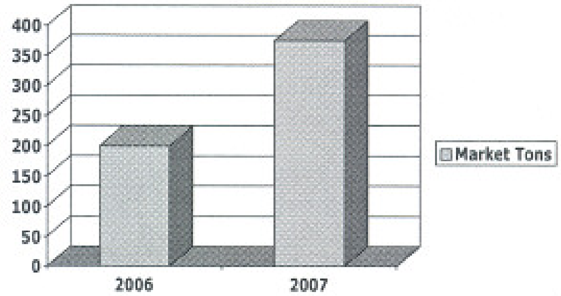
Growth/ Survival

- Good Survival: mortality in sea cages less than 4%.
- Growth
  - on par/ slightly above current models but expect improvements with:
    - More Experience
    - Improved Feed/ Feeding Techniques
    - Improvements through Selective Breeding

Growth Cycle



Projected Cod Production (Cooke)



R & D Projects

- Maximizing Production efficiencies through maturation control. (ACRDP)
- Optimal Sea Cage Transfer Size
- Family Rearing/ Broodstock Selection (ACRDP)
- Cage Site Feed Trials
- Screening for Infectious Diseases (NSERC)

R & D

Optimal Sea Cage Stocking Size

- 7 g vs. 20 g vs. 100 g
- Survival
- Vaccination Strategies
- Time to Market/ Cost to Market for Partial land-based Nursery Rearing vs. Entire Sea Cage Rearing

R & D

Cage Site Feed Trials

- A) Moist vs. Dry Diet
- B) Low Lipid vs. High Lipid Diet
  - Compare survival, growth, liver index on low lipid (12%) vs. high lipid diet (18%)
  - Norway – suggest liver index as high as 12% is OK. We have been finding 6-8% thus far – good.
- C) Feeding Techniques/ Practices
  - Determine optimal feeding frequency
    - Multiple daily meals ?
    - One meal daily ?
    - One meal every 2 days ?

R & D/ Fish Health

" Infectious Diseases of cod" – NSERC CRD Project (UNB- Marine Institute)

- Screen both wild and cultured cod to see what pathogens are out there.
- Establish experimental bacterial & parasitic models
- Assess treatment/ prevention protocols

Fish Health

- No Significant Disease- Related Mortality in Sea Cages to date.
  - Things to watch for:
    - Vibriosis
    - Parasites (eg. Trichodina, costia)
    - *Loma*- (microsporidian)
    - Atypical Furunculosis

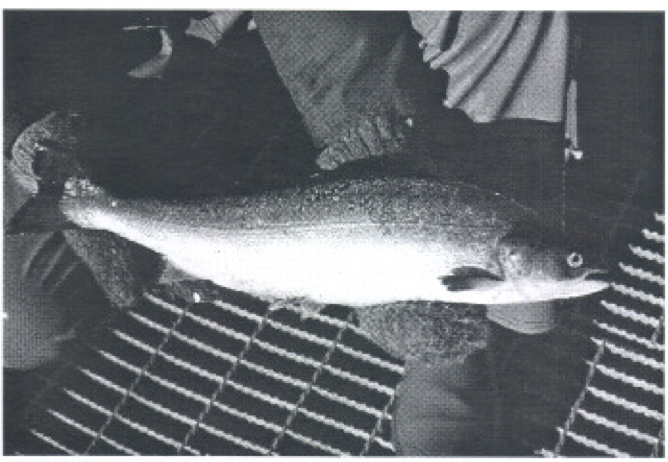
Marketing

- First Cod Harvests targeted for Feb 2006
- High Demand Present in the market place
- Recent taste/ texture/ colour tests results were excellent.

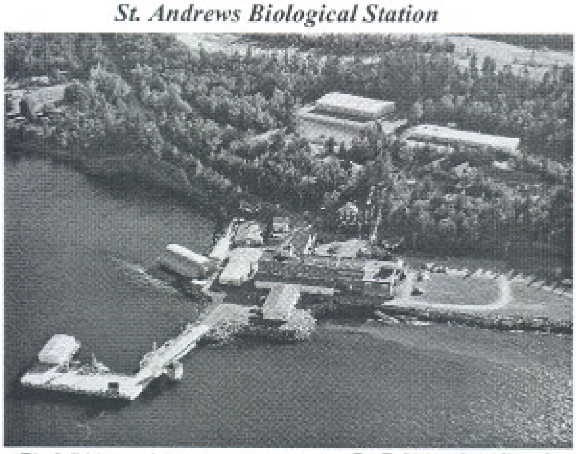
R&D in support of Sustainable Aquaculture

…a personal perspective

Rob Stephenson



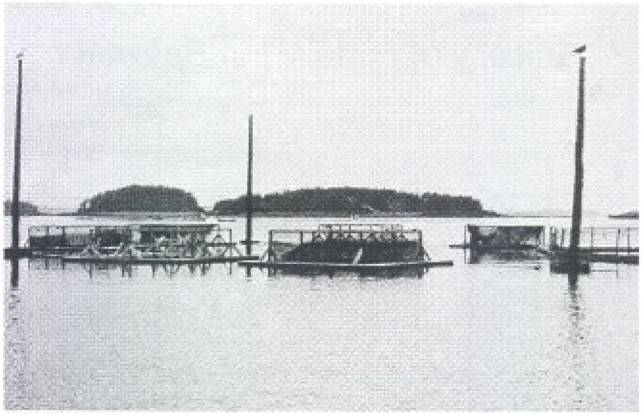
St. Andrews Biological Station



St. Andrews Biological Station · Station biologique de St. Andrews · Fisheries and Oceans Canada · Pêches et Océans Canada

Working together in support of Sustainable Aquaculture

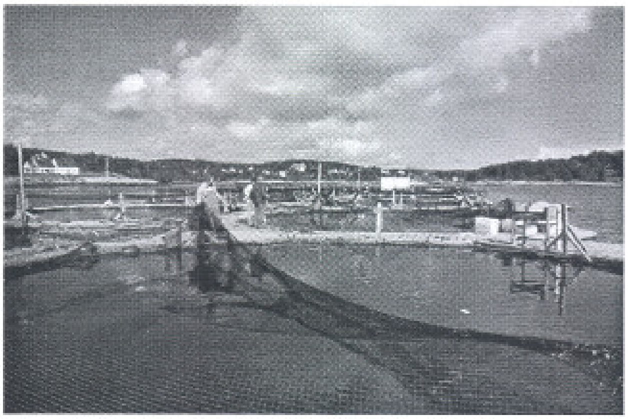
Science required for sustainable aquaculture

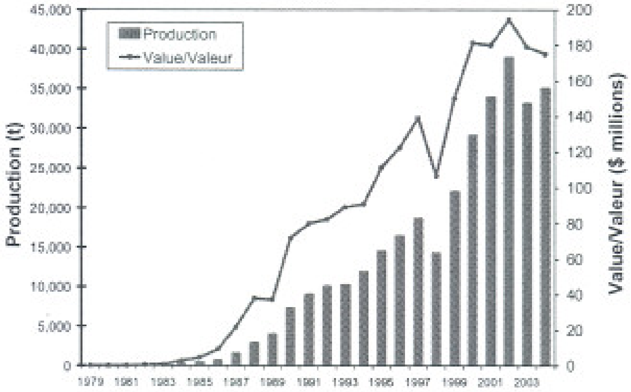


Atlantic Canada's first salmon farm, Lords Cove, Deer Island (c. 1978)

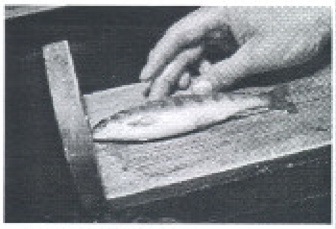
St. Andrews Biological Station — Station biologique de St. Andrews

Fisheries and Oceans Canada — Pêches et Océans Canada

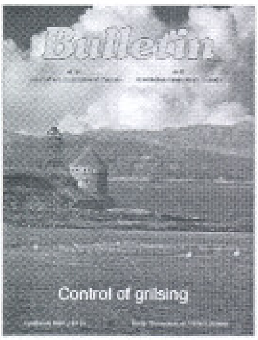




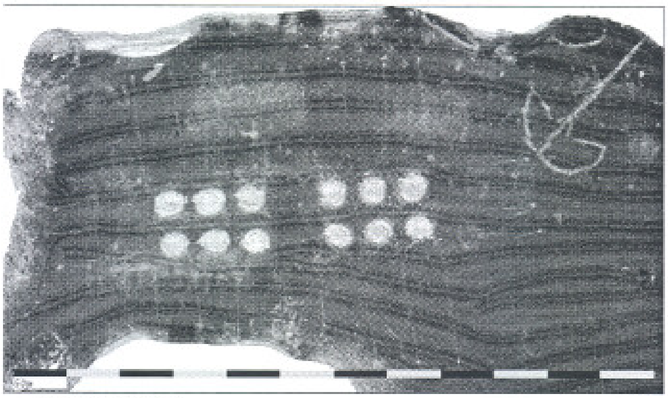
Smolt development, maturation



Saunders, Peterson et al

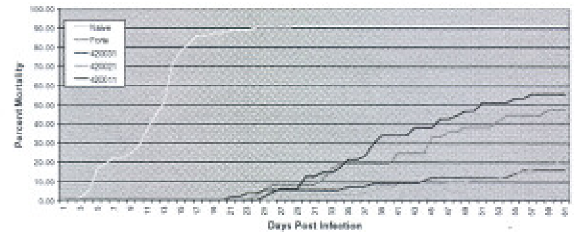


Benthic impacts



Wildish, Lawton et al

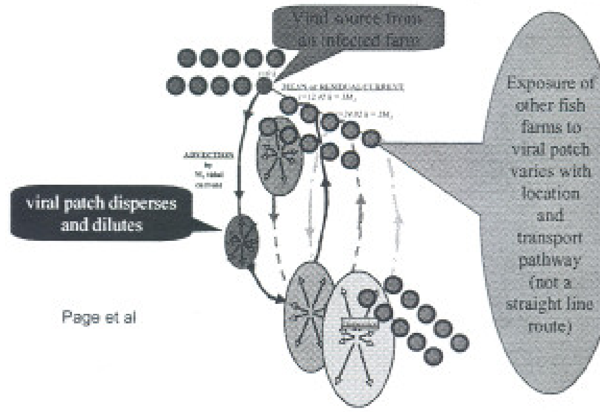
Efficacy of Forte V1 in Seawater



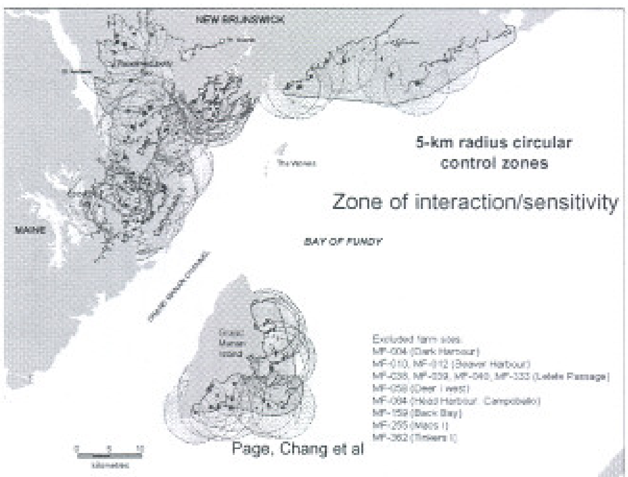
Glebe et al

9 naïve cohabitants (smolts) / 30 vaccinates
replicated n=30/tank

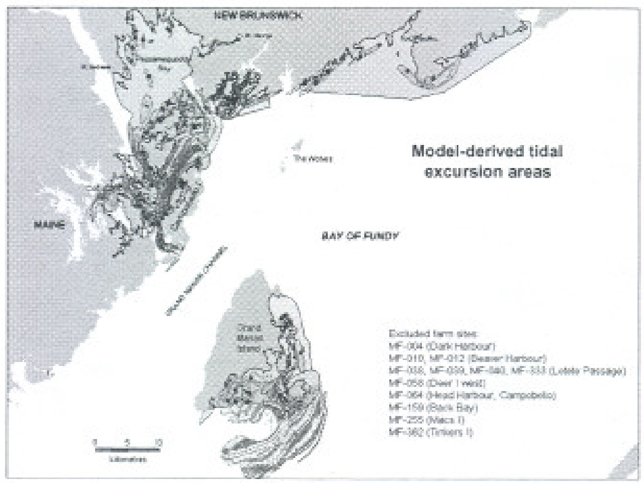
Conceptual Approach: Transport and Dispersal of ISA

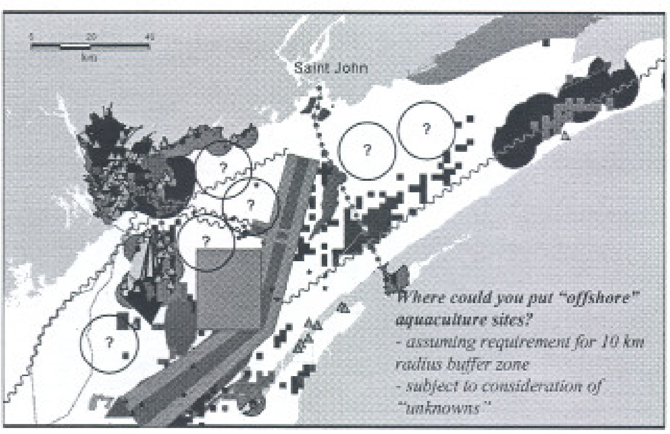


Page et al



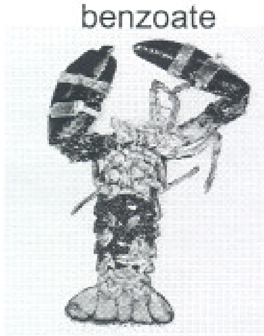
Page, Chang et al





SABS

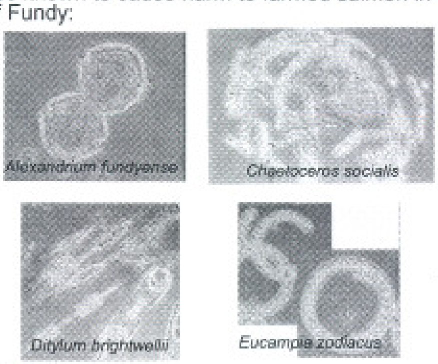
Sublethal effects of emamectin benzoate



Waddy, SL., Burridge, LE, Hamilton, MN and Mercer, SM, Aiken, DE, and Haya, K (2002) Can. J. Fish. Aquat. Sci. 59: 1096-1099

Toxic algae

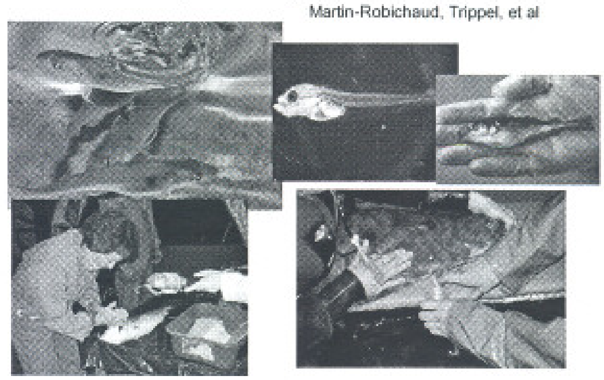
- Species known to cause harm to farmed salmon in the Bay of Fundy:



J. Martin et al

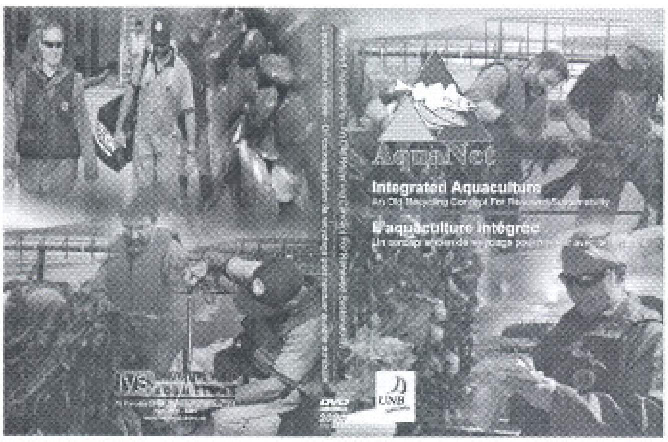
Alternate finfish species for aquaculture

Martin-Robichaud, Trippel, et al

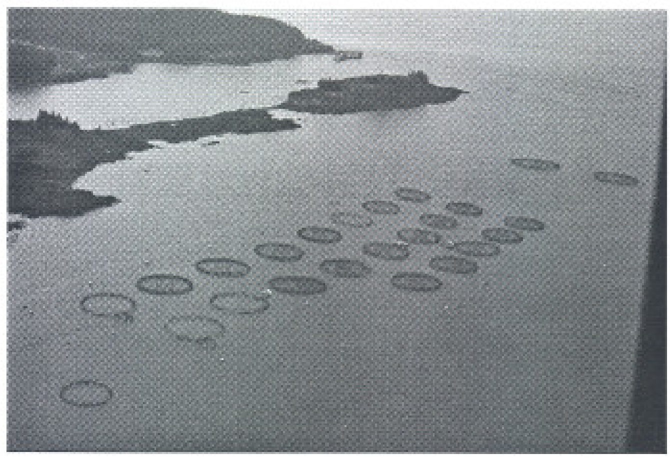


St. Andrews Biological Station · Station biologique de St. Andrews

Fisheries and Oceans Canada · Pêches et Océans Canada



Robinson, Chopin et al



Initiatives

Sustainable aquaculture

Precautionary Approach

Risk Management

Objectives Based Management

Performance-based management

Code of Practice

Ecosystem Approaches

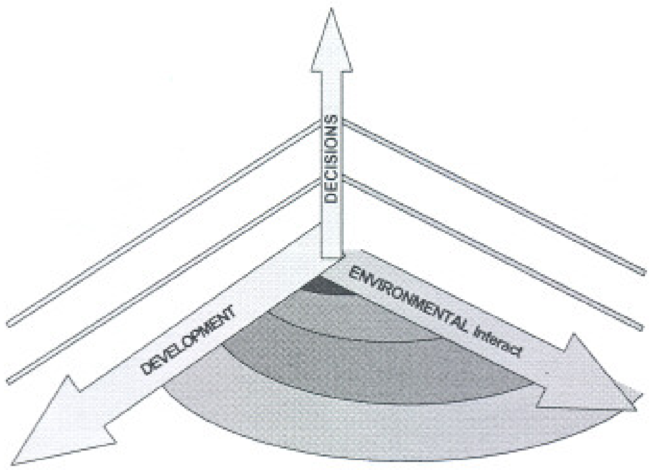
Oceans Action Plan

Bay Mgmt Areas

Co-Management Partnerships

Aquaculture Science

- Apparent elements
  - Aquaculture production
  - Environmental Interactions/Sustainability
  - Fish health
- 'Science in support of management of human activities'
- Targeted, relevant science within legitimate DFO mandate
  - Increasingly collaborative environment

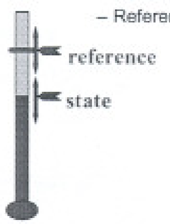


Managed Human Activities

- **Objectives**
  - Conservation
  - Social
  - Economic

Objectives => Operational Strategies

- **Objective**
  - Sub-objective
    - Strategy
      - Performance Indicator
      - Reference Point



- **Management Plans**
  - Groundfish
  - Large Pelagic
  - Lobster
  - Aquaculture
  - Species at Risk Recovery
  - Ballast Water Disposal
  - etc.

Conservation Objectives

- Productivity
  - maintain productivity of components (primary, community and population) to preserve function
- Biodiversity
  - maintain components (biotopes/seascapes, species and populations) to preserve the structure and natural resilience
- Habitat
  - maintain habitat to safeguard the 'container' (both physical and chemical properties)

Framework

Managed activities

Objectives/strategies

	fisheries	aquaculture	oil and gas
Conserv. Obj.			
Economic Obj			
Social Obj.			

Aquaculture science products

- Targeted, Objective-based
- Tied to use in decision-making

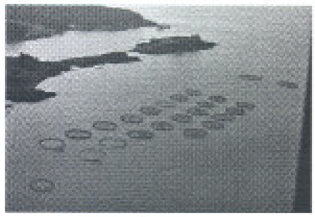
Need:

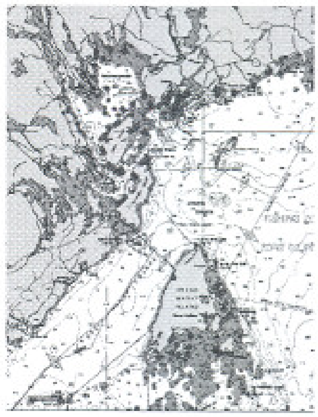
- Conceptual framework for aquaculture science activities
- Method of prioritization

Potential hot topics include

- Alternate species
- Poly/multi-trophic aqua
- Feed production
- Therapeutants
- Harmful algae
- Offshore culture
- Invasive species
- Economic sustainability
- Performance-based standards
- Integrated management
- Escapees
- Site evaluation

NBSGA





Code of Practice

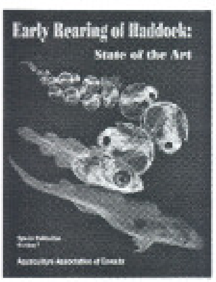
- *'...describes the practices to be followed to provide the maximum level of protection to the environment while allowing the salmon growers the flexibility to operate their sites to maximize productivity and cost effectiveness'*
- *NBSGA Draft COP in support of Performance Based Management - Oct 25/2005*

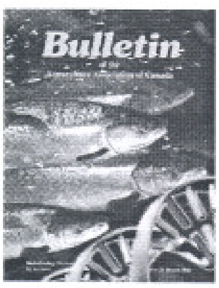
NBSGA Working together in support of sustainable Aquaculture SABS

St. Andrews Aquaculture Workshop series

Control of Grilsing (2002)

Haddock Culture (2003)





Biotechnology (2004)

ATTENDANCE LIST

Attendee	Company
Armstrong, Blake	Cooke Aquaculture Inc.
Backman, Steve	Skretting
Bacon, Bev	RDI Strategies
Beattie, Michael	DAFA
Benfey, Tillmann	UNB
Blanchard, Clarence	Future Nets
Brewer, Kathy	DAFA
Brown, Glen	Admiral Fish Farms
Chang, Blythe	DFO/SABS
Chopin, Thierry	UNBSJ
Combs, Karen	DAFA
Corey, Lee	Corey Feed Mills Ltd.
Craig, Aaron	MariCal
Daggatt, Tara	Sweeney International
Drost, Terry	Corey Feed Mills Ltd.
Dupuis, Helene	DFO/ACRDP
George, Sheldon	ShurGain
Halse, Nell	Cooke Aquaculture Inc.
Hanley, Jim	NBSGA
Hutchins, Lynn	DAFA
Ian Hamilton	Aqua Fish Farms
Jackson, Tim	NRC-IRAP
Joy, Denise	NBDELG
Kesselring, Mark	Marine Harvest
Kohler, Chris	DAFA
Lipsett, Kim	DAFA
Losier, Randy	DFO/SABS
Ludwig, Andrew	Marine Harvest

MacDonald, Linda	ACOA
MacFarlane, Mike	DAFA
Marcoux, Ernie	Marsh Canada
Martin-Robichaud, Debbie	DFO, St. Andrews
McGee, Doni	NBSGA
McKindsey, Chris	DFO, Quebec
McLaughlin, Melanie	NBSGA
Methe, Denise	DFO/ACRDP
Moran, Hugh	NBSGA
Nervette, Pascale	Centre of Aquatic Science
Nicholls, Kris	ShurGain
Page, Fred	DFO/SABS
Ritchie, Rachael	RPC
Robinson, Shawn	DFO, St. Andrews
Rouse, Mike	Enterprise Charlotte
Saulnier, Chris	Ocean Salmon Farms/Aqua Fish Farms
Smith, Gail	DAFA
Smith, Jamey	CoastalSmith/NBSGA
Smith, Sybil	NBSGA
Stephenson, Rob	DFO/ SABS
Streight, Howard	Corey Aquafeeds
Symonds, Jane	Huntsman Marine Science Centre
Szemerda, Mike	Cooke Aquaculture Inc.
Taylor, Gary	Skretting
Tucker, Rudy	Maritech Marine Inc.
Walker, Seumas	Huntsman Marine Science Centre
Were, Keith	Skretting

RESEARCH REQUIREMENTS TO SUPPORT IMPLEMENTATION OF THE SUSTAINABILITY PLAN – NB PERSPECTIVE

Draft prepared July 6 2005 and updated July 19, 2005 following meetings with NBSGA Science Committee and F. Page

Explanatory notes for the following table:

1. The column headings represent key components of the sustainability plan. It has been identified that each of these components must be addressed for the plan to be successful. It has also been recognized that addressing these components at a management-regulatory level must be done on a best-available- knowledge or risk-based process. Therefore, research requirements must also be identified to continuously improve knowledge and confidence in decisions.

2. The row heading represent levels of research requirements for each component:
   - Applied science includes work that requires application of valid results from previous research in order to provide advice or answer a specific management/regulatory question. It is considered to be work that must be done in the near term to overcome a specific issue, and to continue to through implementation of the plan.
   - Short term new science includes priority research that is required to increase the knowledge base and provide confidence in risk-based decisions.
   - Long term new science includes priority research that may have a long time requirement, or may be of a lesser priority.

3. Blue text represents fish health related issues, red text represents genetic, and green text represents environment. Black text is not assignable to one of these categories. Underlining in these colours represents a connection with other categories (for example ISA Distribution indicates that this issue has both a fish health and genetic component).

Science Component	Sustainability Plan Component							
	Fish Health	PBS	Codes of Practice	New Sites	BMA System	Site Consolidation	Alternate Species	Stakeholde Interactions
Applied Science – Near Term/Ongoing	ISA Distribution BKD issues Other pathogen screening • Techniques • Infrastructure Effects of • Stress • Smolt transfer • Supersmolt Biosecurity protocols	Plume delineation – actual footprint of sites on: • Water • Bottom • System Better information on background conditions What are best indicators based on present knowledge? Spatial/temporal variability	SOPS need to be developed that consider auditing and Reporting Data analysis to improve understanding of cause-effect relationships and to provide confidence to a PBS program Issues related to implementation	Mapping and conflicts determination and resolution What are appropriate monitoring programs	Best effective site separation distance What are appropriate scales • BMA level • Sites level Need to establish criteria • Health • Environment • Conflicts • Dynamic system How to incorporate alternate species • Crop rotation • Integrated What are appropriate monitoring programs	Consider as part of the BMA system work Conflict resolution PBS Scale Fish health What are appropriate monitoring programs	Consider to diversify salmon industry Criteria to fit into BMAs? Economic factors and assessment Fish health interactions and management Infrastructure requirements	Wild/farmer interactions Mapping and conflict determinat. and resolution

New Science	Short Term	ISA strain pathogenesis Stress/wellness Smolt transfer Supersmolt Fish health - environmental quality connection	New parameters • Oxygen • Hard bottom Genetic strain – effects of escapes on wild populations Carrying capacity related issues: • Models • Far field effects • Cumulative effects • Better feed/waste generation information Better indicators ?	Data analysis regarding cause-effect – what are best responses?	Implement projects related to the 5 concepts developed for the Offshore Project • Ocean / engineer. • Mapping and conflict resolution • Enviro. compat. • Fish health and husbandry • Economic			Cod – nodavirus Salmon – alternate species fish health interactions	Wild/farmer interactions Mapping and conflict determinat. and resolution
	Long Term	Other concerns – non ISA Vaccines	Carrying capacity related issues as described above Bacterial resistance						Wild/farmer interactions