MAINE AQUACULTURE

LOCALLY GROWN HEALTHY SEAFOOD

KEEPING WORKING WATERFRONTS WORKING!

MAINE AQUACULTURE

- >17 DIFFERENT SPECIES
- FRESH AND SALTWATER
- 120-140 FARMS
- $83-110 MILLION ANNUAL FARM GATE SALES
- $164 – 220 MILLION TOTAL ECONOMIC ACTIVITY
- T0TAL LEASED AREA 1300 ACRES <0.03% ME WATERS
  (31 FINFISH 69 SHELLFISH)
- LOBSTER GEAR 17-28,000 ACRES 5-8%
- RECREATIONAL MARINAS 4800 ACRES
- 2 MOST VALUABLE "CROPS" IN THE STATE ($/PER ACRE)
  - FINFISH $85,906 / ACRE
  - SHELLFISH $16,632 / ACRE

IT'S A SMALL LIFEBOAT AND WE ARE ALL ON IT TOGEATHER

PRINCIPLE CONCERNS REGARDING AQUACULTURE

- DISEASE
- NUTRIENTS
- ESCAPES AND INTERACTIONS
- FEED
- CHEMICALS
- SOCIAL CONFLICTS

NUTRIENT DISCHARGE CHARACTERISTICS IN AQUACULTURE

- ORGANIC DISCHARGE
- SOLUABLE (URINE N+)
- SOLID (FECES, FEED, BIOFOULING, N+P)
- POTENTIAL IMPACTS VARY WITH ECOSYSTEM AND LOCAL SITE CONDITIONS

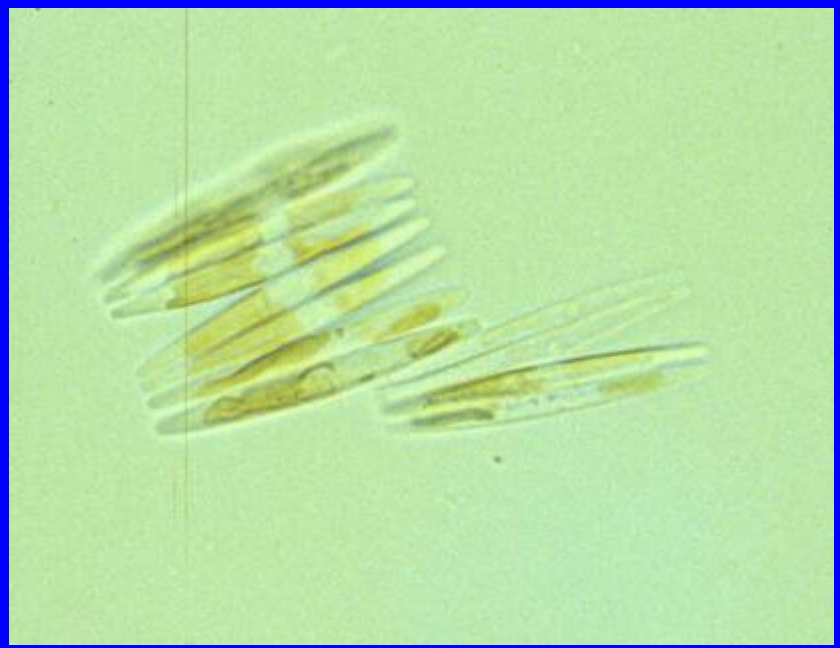
PRINCIPLE CONCERNS REGARDING NUTRIENTS

- TOO MUCH OF A GOOD THING
- IMPACTS WELL DOCUMENTED
- ACTUAL IMPACTS VARY WITH ECOSYSTEM TYPE
- FUNCTIONAL IMPACTS SAME

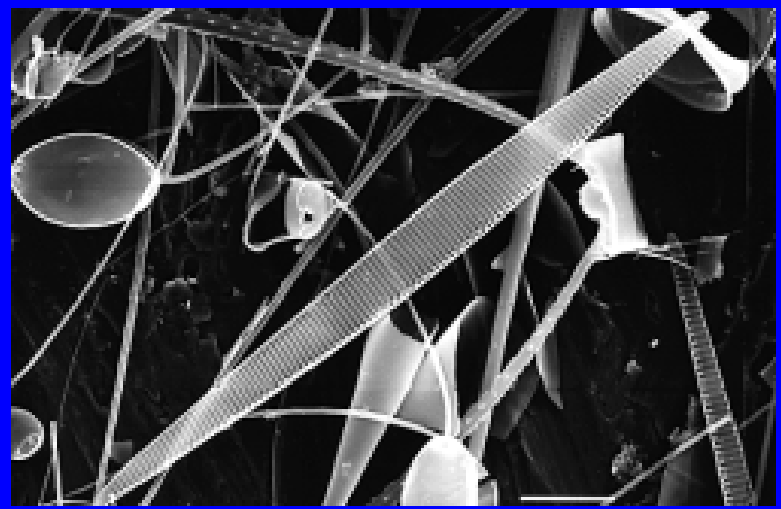
SOLUABLES
Dissolved nutrients and algae blooms

21 studies over 30 years

Japan, Scotland, Chile, Canada, Norway



Pseudonitzschia sp. diatom

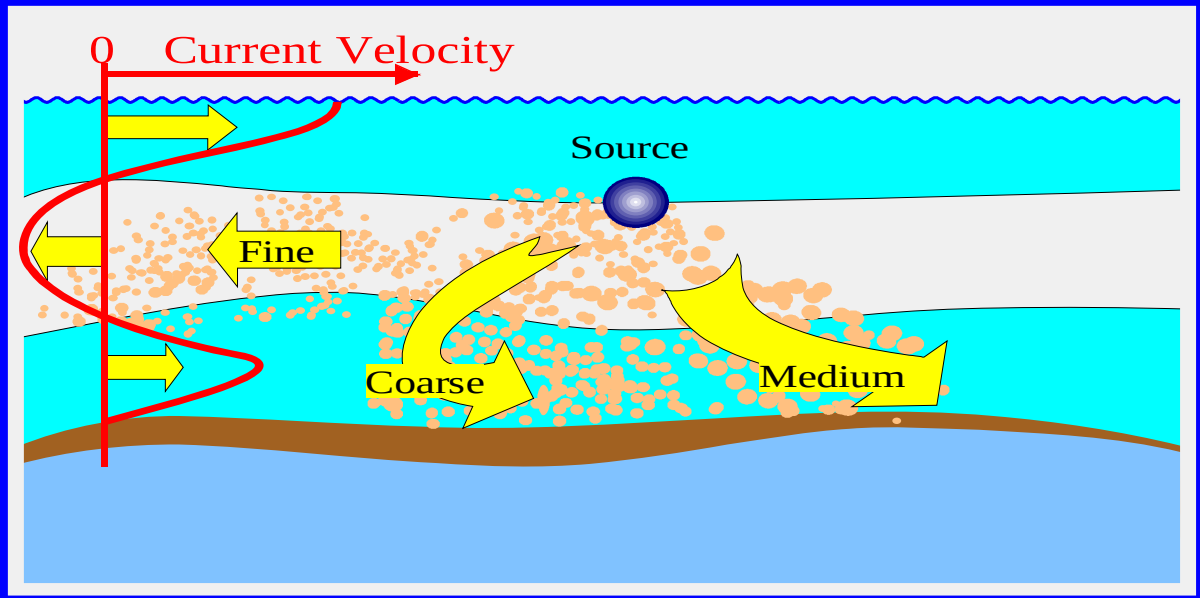


Dissolved Nutrients Conclusions

- 18 studies found no effect
- 3 studies found low correlation between presence of farm and algae levels
- In all 3 cases “loading” massive compared to receiving waters
- No studies definitively attributed increased algae production to farm discharges
-
- Except perhaps in a few enclosed waters, enrichment by fish farm nutrients is too little, relative to natural levels, to have the alleged effects.
- Farm waste has a ratio of N to P close to natural ratios.
- Even in enclosed waters algal production from fish farm nutrients is small relative to that generated by marine and terrestrial inputs.
- Production is often limited by light not nutrients.

SOLIDS
Particulates - transport

- Distribution of settling velocities from waste feed and faecal particulates
- Advection by currents variable in time and depth (shear)
- Particles on the bed can be resuspended and redistributed

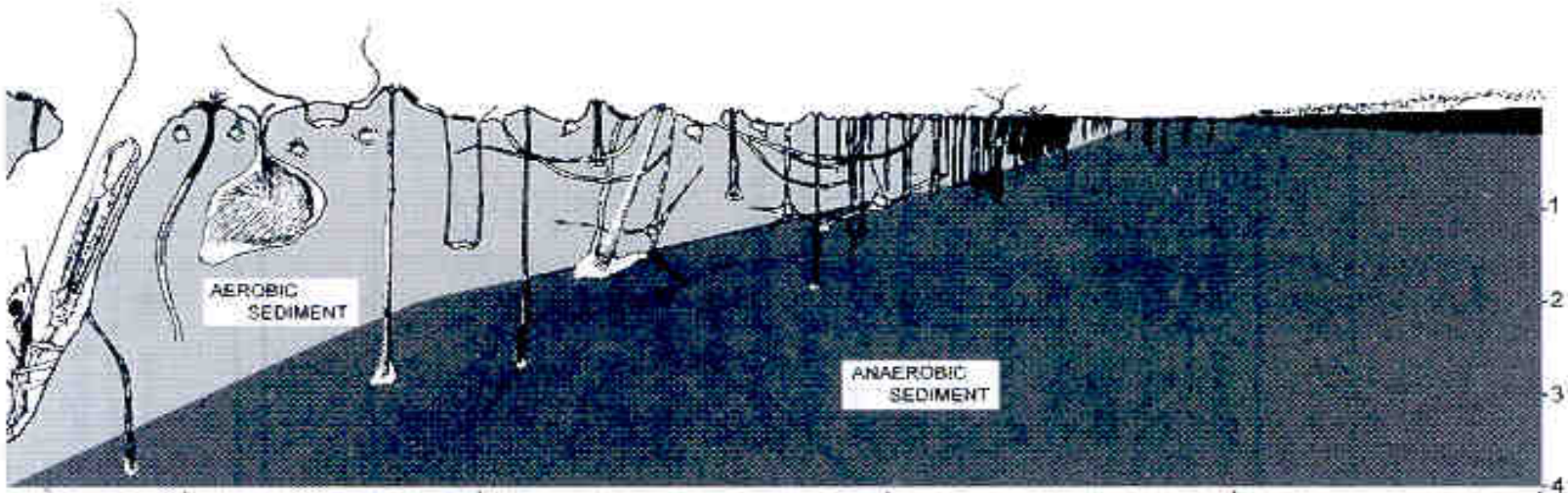


CLASSICAL PROGRESSION WITH INCREASED ORGANIC LOADING

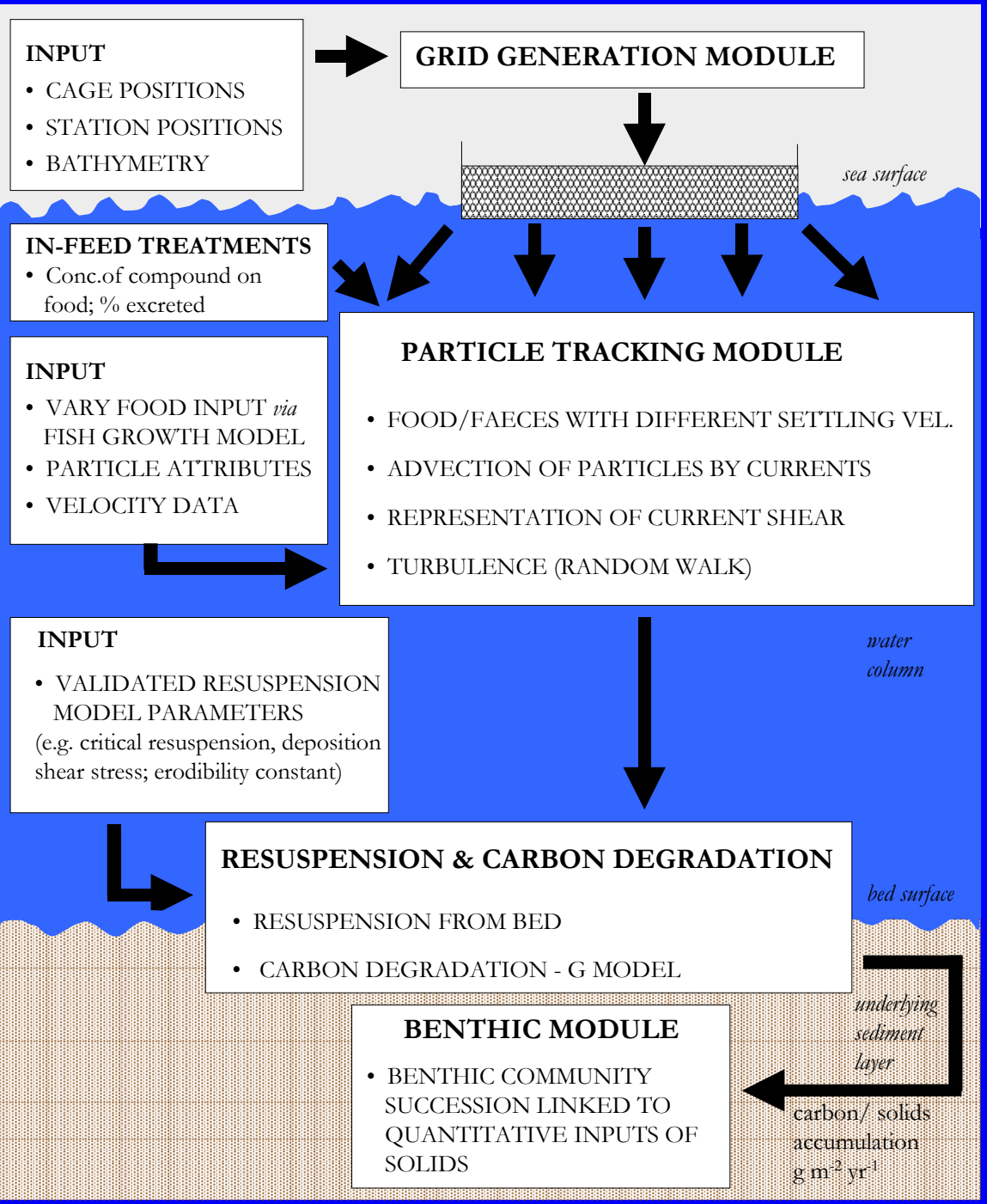
- ORGANIC LOADING ↑
- SPECIES DIVERSITY ↑ ↓
- BIOMASS ↑ ↓
- MACROFAUNA → MICROFAUNA
- AEROBIC → ANAEROBIC
- HYDROGEN SULPHIDE AND METHANE

Pearson and Rosenberg (1978)

Seminal paper on macrofaunal response to organic pollution gradients



ZONE	NORMAL	TRANSITORY		POLLUTED	GROSSLY POLLUTED
TYPICAL MACROFAUNA	Nucula Amphiura Terebellides	Labidoplax Corbula Goniada	Chaetozone Anaitides Pectinaria	Capitella Scolelepis	No macrofauna Surface covered by fibre 'blanket'
DOMINANTS	Rhodine Echinocardium Nephrops	Thyasira Pholoe	Myriochele Ophiodromus		



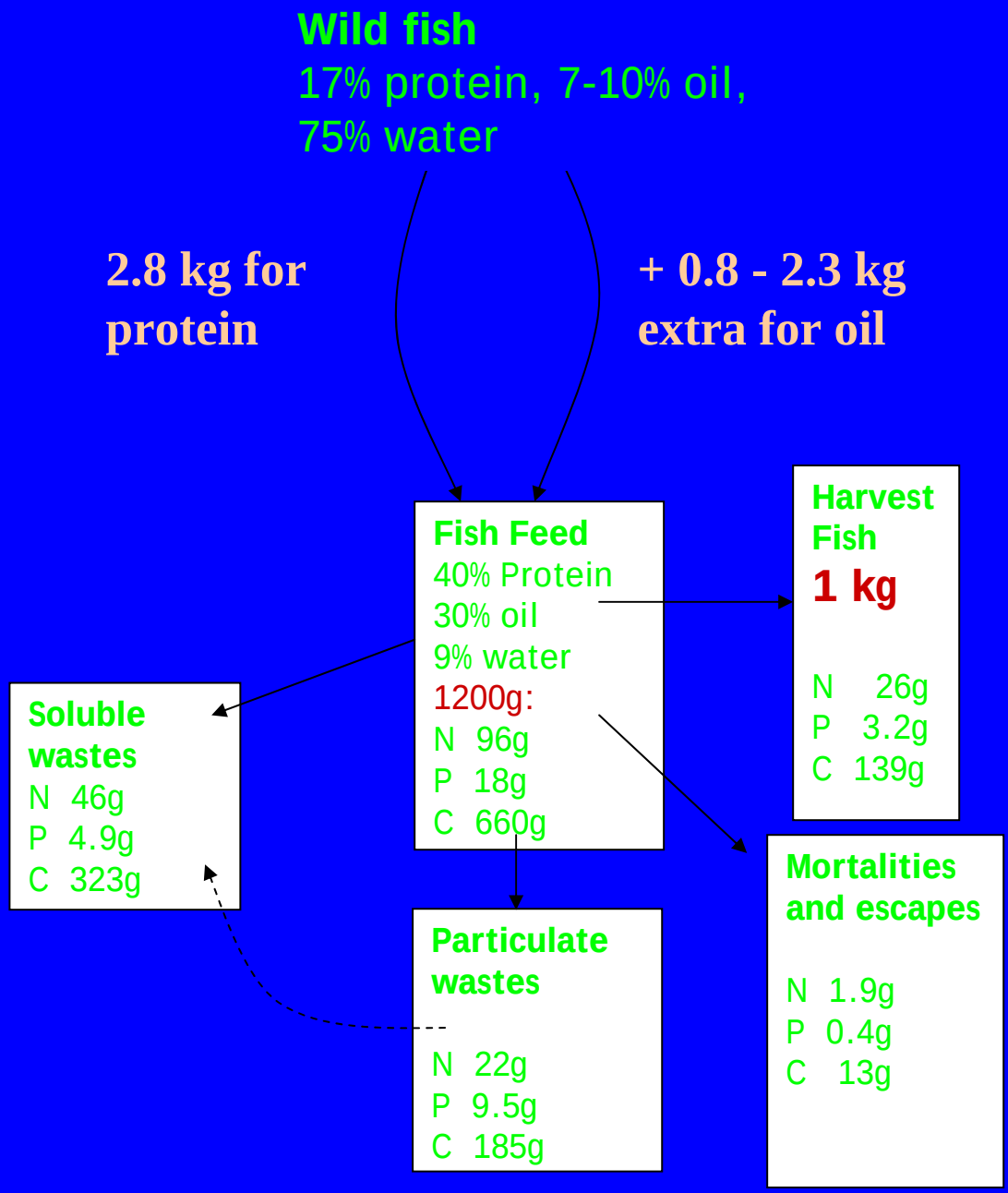
- This process is amenable to modelling and several such models exist

- DEPOMOD is used operationally by SEPA

Cromey, C. J., Black, K. D., Edwards, A. & Jack, I. A. (1998). Modelling the deposition and biological effects of organic carbon from marine sewage discharges. *Estuarine Coastal and Shelf Science* **47,** 295-308.

Cromey, C. J., Nickell, T. D. & Black, K. D. (2002a). DEPOMOD - modelling the deposition and biological effects of waste solids from marine cage farms. *Aquaculture* **214,** 211-239.

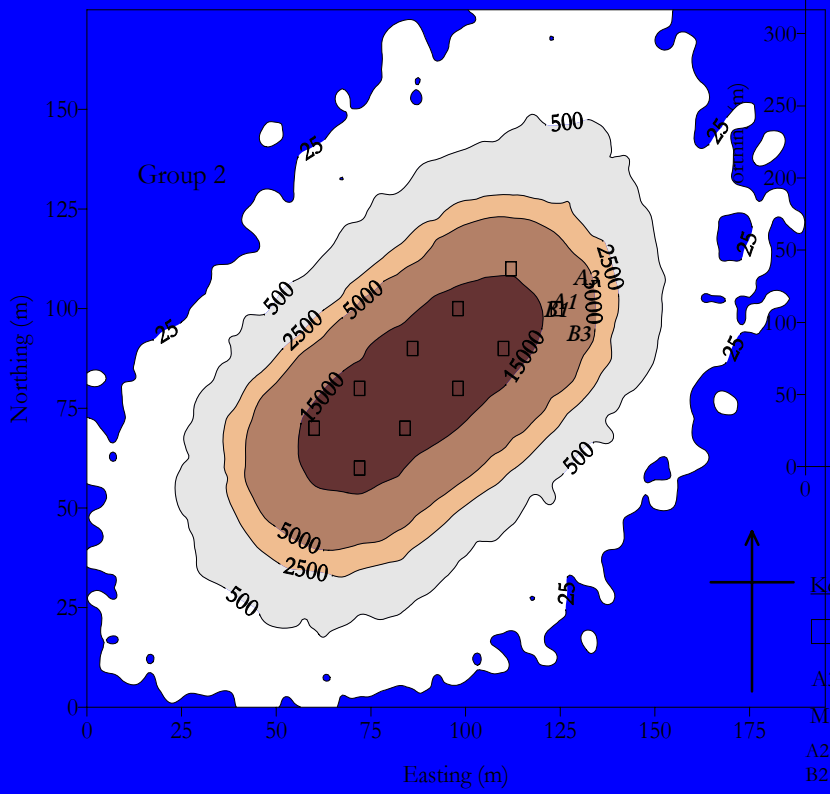
Cromey, C. J., Nickell, T. D., Black, K. D., Provost, P. G. & Griffiths, C. R. (2002b). Validation of a fish farm waste resuspension model by use of a particulate tracer discharged from a point source in a coastal environment. *Estuaries* **25,** 916-929.



Budget for the flow of nutrients from oceanic wild caught fish to the coastal environment for a harvest of 1 kg of farmed salmon assuming no substitution with vegetable protein or oil and a ratio of fish feed to product of 1.2:1

DEPOMOD - Site C

Model predictions of solids deposition from a cage group



Key

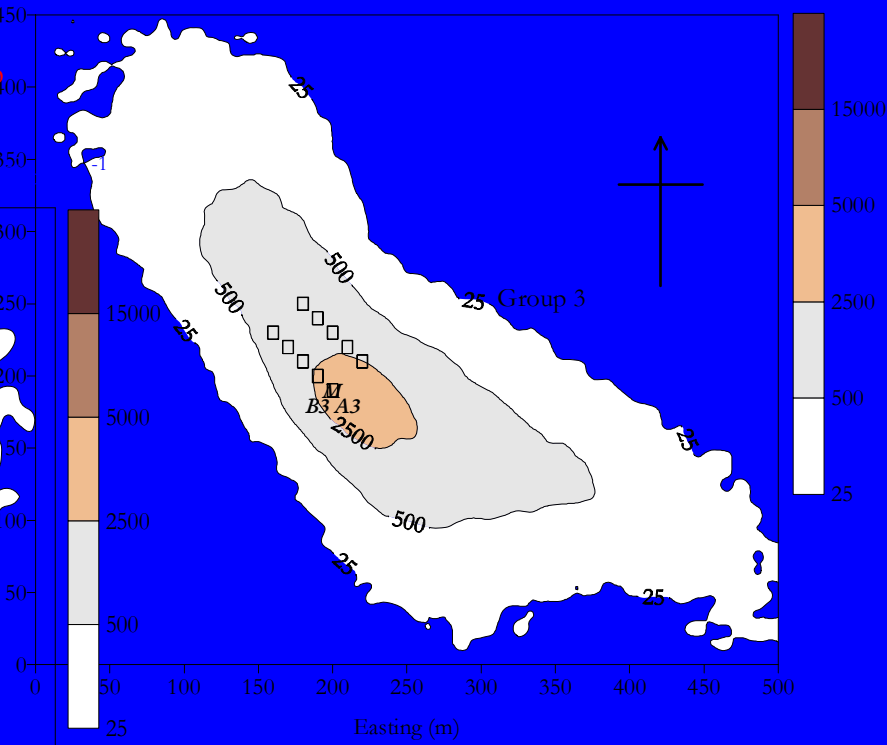
- cage centres

A1 A3 B1 B3 - sediment traps

A2 is positioned between A1 and A3

DEPOMOD - Site L

Model predictions of solids deposition from a cage group



Key

- cages

A3 B3 - sediment traps

M - position of traps A1 and B1

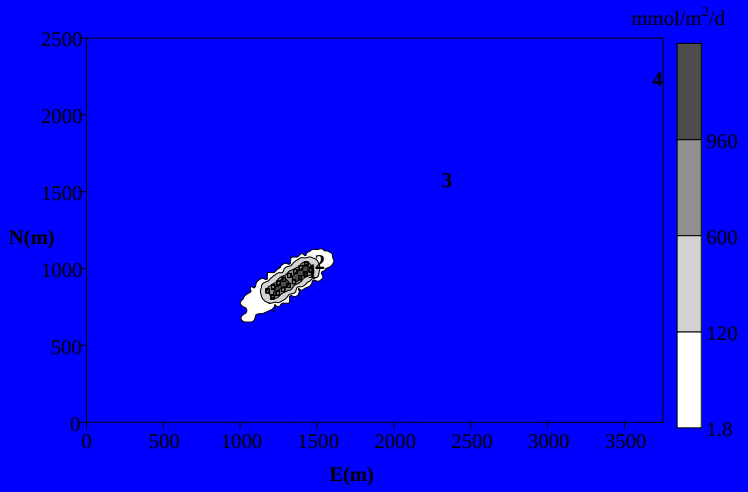
A2 is positioned between A1 and A3

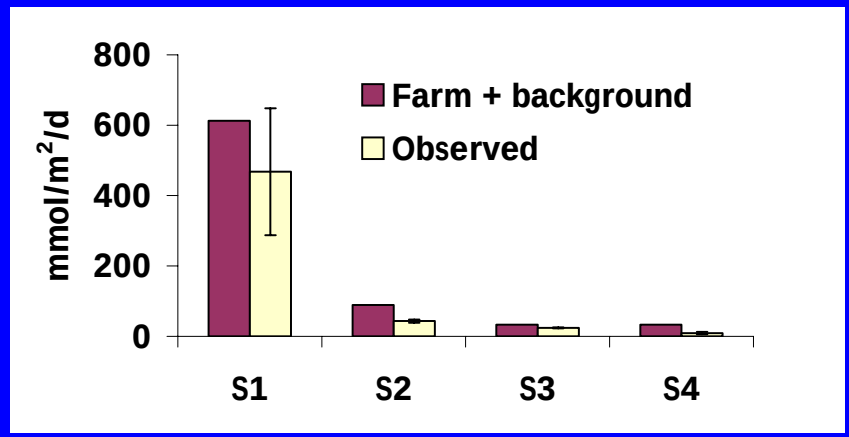
B2 is positioned between B1 and B3

INDIRECT IMPACTS ON OXYGEN BUDGETS

- Theoretical negative oxygen impacts (benthic and water column) due to BOD
- 18 studies over 28 years
- Japan, Scotland, Ireland, Canada, US, Norway

Oxygen flux in loch Creran





Summing flux rates for L Creran indicates that sediment oxygen demand is only about 3% of tidal supply

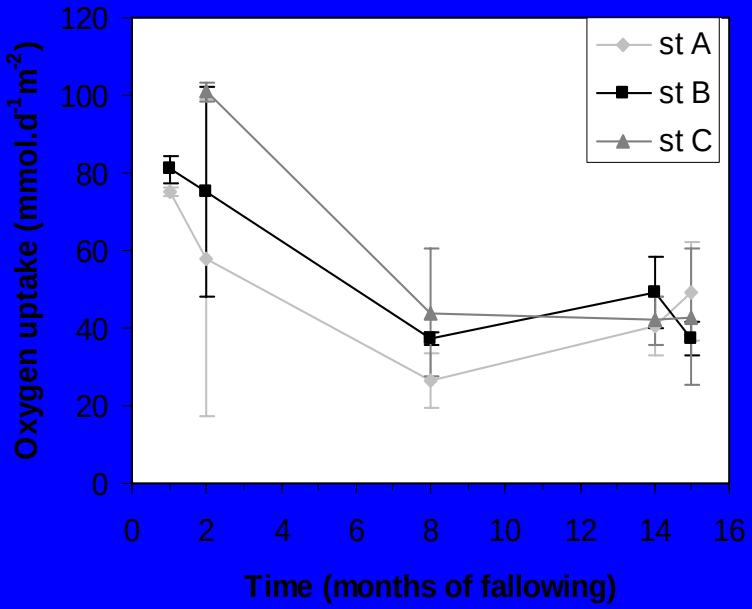
Fish farm contributes <10% of that demand

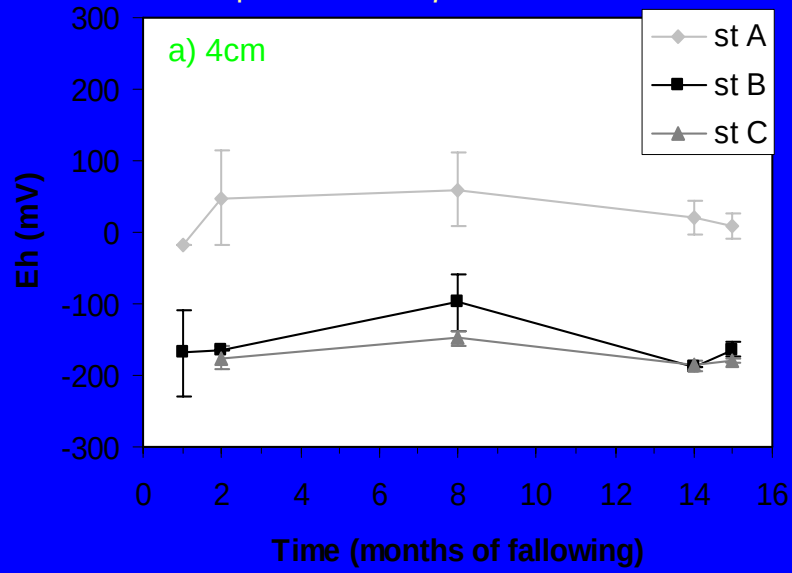
CLASSICAL PROGRESSION WITH INCREASED ORGANIC LOADING

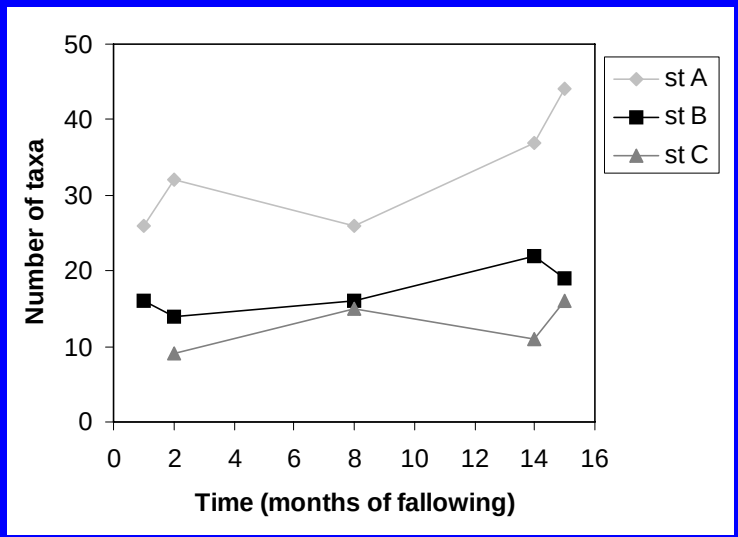
- ORGANIC LOADING ↑
- SPECIES DIVERSITY ↑ ↓
- BIOMASS ↑ ↓
- MACROFAUNA → MICROFAUNA
- AEROBIC → ANAEROBIC
- HYDROGEN SULPHIDE AND METHANE

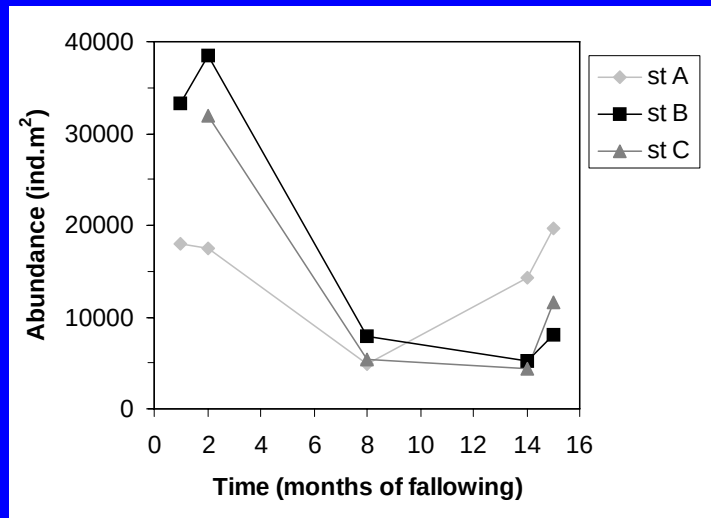
Benthic Recovery

Pereira, P. M. F., Black, K. D., Mclusky, D. S. and Nickell, T. D. (in press). Recovery of sediments after cessation of marine fish farm production. *Aquaculture*.









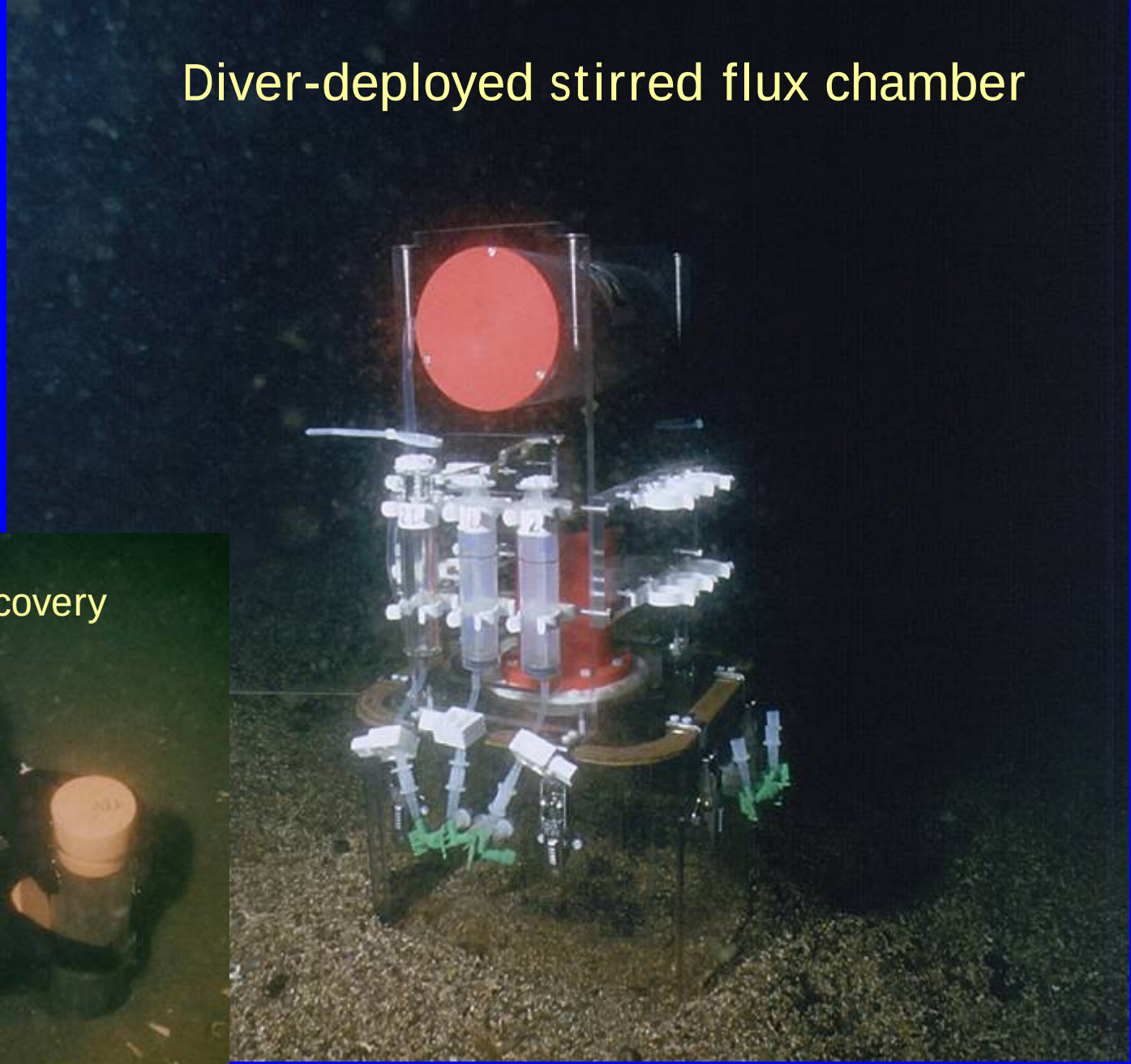
PRINCIPLE FACTORS INFLUENCING POTENTIAL ENVIROMENTAL IMPACTS OF NUTRIENTS DISCHARGED FROM A NET PEN

- DEPTH
- AVERAGE CURRENT SPEED
- SITE ENERGY CLASSIFICATION
- FEED FORMULATION
- FEEDING LEVELS AND METHODS
- FISH BIOMASS AND CONDITION
- LOCAL ECOSYSTEM
- BACKGROUND NUTRIENT LEVELS

NUTRIENT MANAGEMENT

- LOADING LEVELS AND ASSIMILATIVE CAPACITY
- SITE SPECIFIC CARRYING CAPACITY
- FARM MANAGEMENT MUST BE IN TUNE WITH SITE CHARACTERISTICS

Diver-deployed stirred flux chamber



KEY NUTRIENT MANAGEMENT METHODS

- SITE SELECTION
- FEED MANAGEMENT
- PRODUCTION PLANNING
- WASTE MANAGEMENT
- SITE ROTATION AND FALLOWING
- ANIMAL HEALTH MANAGEMENT
- SPECIES ROTATIONS AND INTERCROPPING
- SITE MONITORING PROGRAM

CORE MARINE FARM BMP CHARACTERISTICS

- DRIVEN BY ENVIRONMENTAL LINKAGE AND INABILITY TO CONTROL ENVIRONMENT
- RISK ANALYSIS BASED
- MUST ALLOW FOR ADAPTIVE MANAGEMENT
- SHOULD INCLUDE VERIFICATION

Annual aquaculture input of nitrogen and phosphorus in the coastal waters off North East North American Coast

Year	1994	2001
Salmon production (tons)	11,836[1]	35,000[2]
Nitrogen release rate (kg/ton/year)	78.0[3]	35.0[4]
Phosphorus release rate (kg/ton/year)	9.5[3]	7.0[4]
Nitrogen input in the Bay (tons/year)	923	1,225
Phosphorus input in the Bay (tons/year)	112	245

[1]DFO: http://www.dfo-mpo.gc.ca/communic/statistics/stat_e.htm

[2]Canadian Aquaculture Industry Alliance, pers. comm.

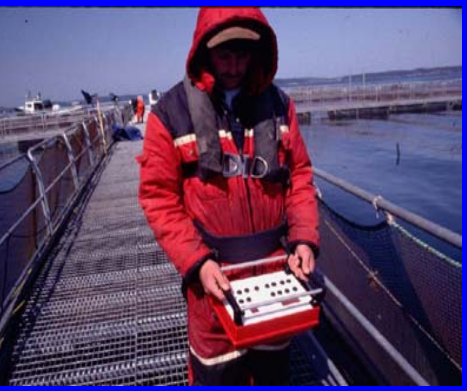
[3]Ackefors and Enell (1994)

[4]ICES (1996)
DFO (1997)
Chopin *et al.* (2001)

MULTITROPHIC AQUACULTURE

YOU CAN'T BEAT MOTHER NATURE

MAINE AQUACULTURE
KEEPING WORKING WATERFRONTS WORKING
FEEDING AMERICA SUSTAINABLY



MAINE AQUACULTURE

GROWING MAINES FUTURE

GOOD JOBS - RESPONSIBLE STEWARDSHIP - HEALTHY FOOD

Thanks

Contact Me

Sebastian Belle

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Hallowell, ME 04347

207 622 0136

MALNUTRITION
is still the number one killer and cause of suffering on earth;
causing more deaths than HIV/AIDS, warfare, genocide, terrorism, or any other ailment.

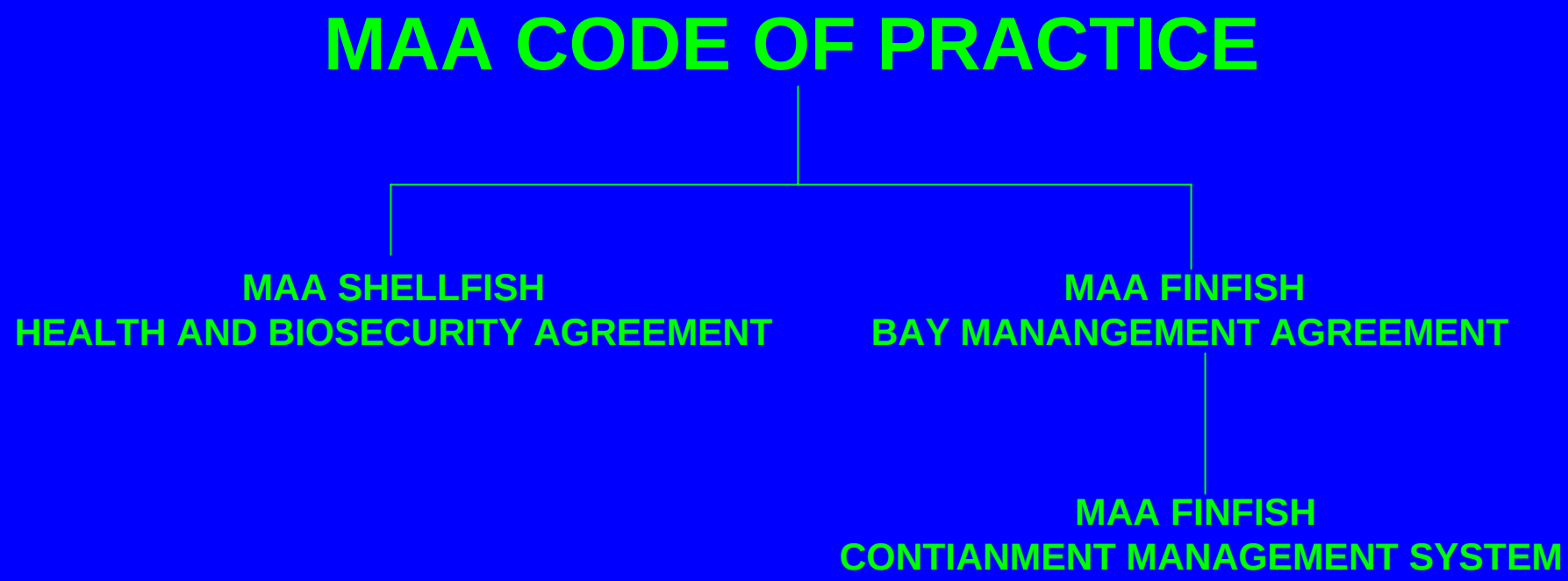
Date	Treatment	Organism	Therapeutants							
			EMA	CYP	IVR	OTC	TC	CHL	ROM	TRI
08-05-01		*Mytilus*	ND	ND	ND	ND	ND	ND	ND	ND
06-06-01		*Mytilus*	ND	ND	ND	ND	ND	ND	ND	ND
21-06-01		*Laminaria*	ND		ND	ND	ND	ND	ND	ND
22/28-06-01	EMA									
11-07-01		*Mytilus*	ND	ND	ND	ND	ND	ND	ND	ND
27-07-01		*Laminaria*	ND		ND	ND	ND	ND	ND	ND
11/17-08-01	EMA									
15-08-01		*Mytilus*	ND	ND	ND	ND	ND	ND	ND	ND
05-09-01		*Mytilus*	ND	ND	ND	ND	ND	ND	ND	ND
07-09-01		*Laminaria*	ND		ND	ND	ND	ND	ND	ND
20/30-09-01	OTC									
10-10-01		*Mytilus*	ND	ND	ND	ND	ND	ND	ND	ND
15/23-10-01	EMA									
19-10-01		*Laminaria*	ND		ND	ND	ND	ND	ND	ND
07/16-11-01	OTC									
4-12-01		*Mytilus*	ND	ND	ND	ND	ND	ND	ND	ND
12-12-01		*Laminaria*	ND		ND	ND	ND	ND	ND	ND
09-01-02		*Mytilus*	ND	ND	ND	ND	ND	ND	ND	ND
02-02-02		*Laminaria*	ND	ND	ND	ND	ND	ND	ND	ND
04-04-02		*Laminaria*	ND	ND	ND	ND	ND	ND	ND	ND
06-05-02		*Mytilus*	ND	ND	ND	ND	ND	ND	ND	ND
05-06-02		*Mytilus*	ND	ND	ND	ND	ND	ND	ND	ND
27-06-02		*Laminaria*	ND	ND	ND	ND	ND	ND	ND	ND
03-07-02		*Mytilus*	ND	ND	ND	ND	ND	ND	ND	ND
19/25-07-02	EMA									
22-07-02		*Mytilus*	ND	ND	ND	ND	ND	ND	ND	ND
30-07-02		*Laminaria*	ND	ND	ND	ND	ND	ND	ND	ND
31-07-02		*Mytilus*	ND	ND	ND	ND	ND	ND	ND	ND
07-08-02		*Mytilus*	ND	ND	ND	ND	ND	ND	ND	ND
13-08-02		*Mytilus*	ND	ND	ND	ND	ND	ND	ND	ND
26-08-02		*Mytilus*	ND	ND	ND	ND	ND	ND	ND	ND
27-08-02		*Laminaria*	ND	ND	ND	ND	ND	ND	ND	ND
15-10-02		*Laminaria*	ND	ND	ND	ND	ND	ND	ND	ND
28-10-02		*Mytilus*	ND	ND	ND	ND	ND	ND	ND	ND


ENVIRONMENTAL POLICY
GUIDING PRINCIPLES
CODE OF PRACTICE
ENVIRONMENTAL MANAGEMENT SYSTEM
COMPREHENSIVE MANAGEMENT SYSTEM INVOLVING PLANNING, IMPLEMENTATION AND ONGOING REVIEW AND CORRECTIVE ACTIONS
BEST MANAGEMENT PRACTICES
SPECIFIC SET OF OPERATIONAL STANDARDS

MAA COOPERATIVE MANAGEMENT PROGRAMS

- PATHOGEN SPECIFIC ACTION PLANS
- INTERGRATED PEST MANAGEMENT PLAN
- CONTIANMENT MANAGEMENT SYSTEM
- FINFISH BAY MANAGEMENT AGREEMENT
- COMPREHENSIVE CODE OF PRACTICE
- SHELLFISH HEALTH AND BIOSECURITY MANAGEMENT PLAN
- BIOSECURITY AUDITS

MAA COOPERATIVE MANAGEMENT PROGRAMS



MAA COOPERATIVE MANAGEMENT PROGRAMS

- PATHOGEN SPECIFIC ACTION PLANS
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Use of Plant Proteins – Major constraints

- Protein content lower than animal proteins
- Imbalanced amino acids in plant protein
- High amount of carbohydrates
  - Indigestible polysaccharides and sugars
- Inherent antinutritional factors, e. g.
  - Protease inhibitors
  - Goitrous glucosinolates
  - Agglutinating lectins
  - Antigenic proteins
  - Toxic gossypols
  - Phytic acid

MAINE AQUACULTURE

GROWING MAINES FUTURE THROUGH THE RESPONSIBLE STEWARDSHIP OF AQUATIC RESOURCES

- MAINE FISH FARMERS ARE ENVIRONMENTALISTS
  - FISHFARMERS ARE ON AND IN THE ENVIRONMENT EVERYDAY
    - MANY ARE TRAINED BIOLOGISTS
    - DAILY OBSERVERS OF ENVIROMENTAL CONDITIONS
  - FISHFARMERS KNOWLEDGE AND FAMILARITY WITH STOCK IS POWERFULL ENVIRONMENTAL INDICATOR
    - CANARY IN THE MINE SHAFT
    - STUDENTS OF ANIMAL BEHAVIOR AND PHYSIOLOGICAL PERFORMANCE
  - LINKAGES BETWEEN ENVIRONMENT AND ECONOMIC PERFOMANCE ARE MANY AND STRONG
    - SUBLEATHAL IMPACTS ON ANIMAL PERFORMANCE DIRECTLY REFLECTED IN ECONOMIC PERFORMANCE OF FARM
      - CONVERSION RATIO
      - GROWTH RATES
  - EXTERNALITIES ARE FEW AND EMPIRICAL DATA TO SUPPORT LINKAGES ARE WEAK

CURRENT REGULATORY AUTHORITIES FOR MAINE AQUACULTURE INDUSTRY

NATIONAL AUTHORITIES

- National Marine Fisheries Service
- U.S. Fish and Wildlife Service
- Army Corps of Engineers
- Environmental Protection Agency
- Department of Agriculture
- U.S. Department of Commerce
- U.S. Coast Guard
- U.S Department of Labor
- FDA
- ISSC

REGIONAL AUTHORITIES

- New England Fisheries Management Council
- Atlantic States Marine Fisheries Commission

STATE AUTHORITIES

- Department of Environmental Protection
- Department of Marine Resources
- Inland Fish and Wildlife
- Department of Agriculture
- Department of Health and Human Services

FEDERAL REGULATORY OVERSIGHT

- Clean Water Act
- National Environmental Policy Act
- Coastal Zone Management Act
- Rivers and Harbors Act
- Endangered Species Act
- Lacey Act
- Migratory Bird Treaty Act
- Marine Mammal Protection Act
- Magnuson-Stevens Fisheries & Conservation Act
- Sustainable Fisheries Act
- Food Drug & Cosmetic Act
- Nonindigenous Aquatic Nuisance Prevention & Control Act
- Federal Insecticide, Fungicide and Rodenticide Act
- Virus-Serum-Toxin Act
- Federal Sanitation Standards (HACCP) Regulations
- National Marine Sanctuary Act.

MAINE STATE AQUACULTURE MANAGEMENT PROGRAM

- AQUACULTURE LEASING PROGRAM
- DEP/DMR ENVIRONMENTAL MONITORING PROGRAM
- AQUACULTURE PRODUCTION MONITORING (FAMP)
- FISH HEALTH SURVELLIANCE AND CERTIFICATION PROGRAM (USDA, IFW,DMR)
- BIOSECURITY AUDITING PROGRAM
- CONTIANMENT MANAGEMENT SYSTEM AUDITING PROGRAM
- WATER CERTIFICATION PROGRAM
- MARINE BIOTOXINS MONITORING PROGRAM
- PUBLIC HEALTH / SEAFOOD SAFETY INSPECTION PROGRAM

COASTAL COMMUNITY TRENDS

- TRADITIONAL RESOURCE BASES SIGNIFICANTLY DEPLETED
- DRAMATIC INCREASES IN PROPERTY VALUES AND TAXES
- SIGNIFICANT POPULATION GROWTH WITH INCREASING % SENIORS
- COMMUNITIES INCREASINGLY BASED ON NON EXTRACTION RESOURCE USE (LIFESTYLE/TOURISM)
- NON-EXTRACTIVE RESOURCE USE SHIFTING FROM SUMMER ACTIVITY TO YEAR ROUND
- REDUCTION AND DISPLACEMENT OF TRADITIONAL SOCIO-ECONOMIC GROUPS BASED ON NATURAL RESOURCE EXPLOITATION

MAINE AQUACULTURE

SUSTAINABLE SOLUTIONS FOR MAINE'S GROWING FUTURE