

A satellite-style map of North America, showing the United States and Canada. The map is overlaid with a grid of latitude and longitude lines. The text is in a bright yellow color, making it stand out against the darker background of the map. The title is at the top, the author's name and affiliation are in the middle, and the bullet points are at the bottom left. The date and event information are at the bottom right.

Environmental Monitoring of Marine Aquaculture in Canada

Toby Balch
Nova Scotia Fisheries & Aquaculture

- Aquaculture in Canada
- Environmental Monitoring Methods
- Applications to Management



Pacific

Canada

Atlantic

5050 km

Atlantic Canada

Newfoundland

Saint-Pierre

Gulf of St. Lawrence

Quebec

PEI

New Brunswick

Bay of Fundy

Nova Scotia

1100 km

Atlantic Ocean



Image © 2006 MDA EarthSat

© 2005 Google



Nova Scotia





Prince Edward Island



A scenic landscape view of Prince Edward Island, Canada. The foreground shows a green field with a white house and a barn. In the middle ground, there is a large body of water with several long, narrow structures extending into it, likely for aquaculture. The background features a forested coastline and a small town with buildings and a church spire. The sky is clear and blue.





New Brunswick



British Columbia

Vancouver Island

Pacific
Ocean



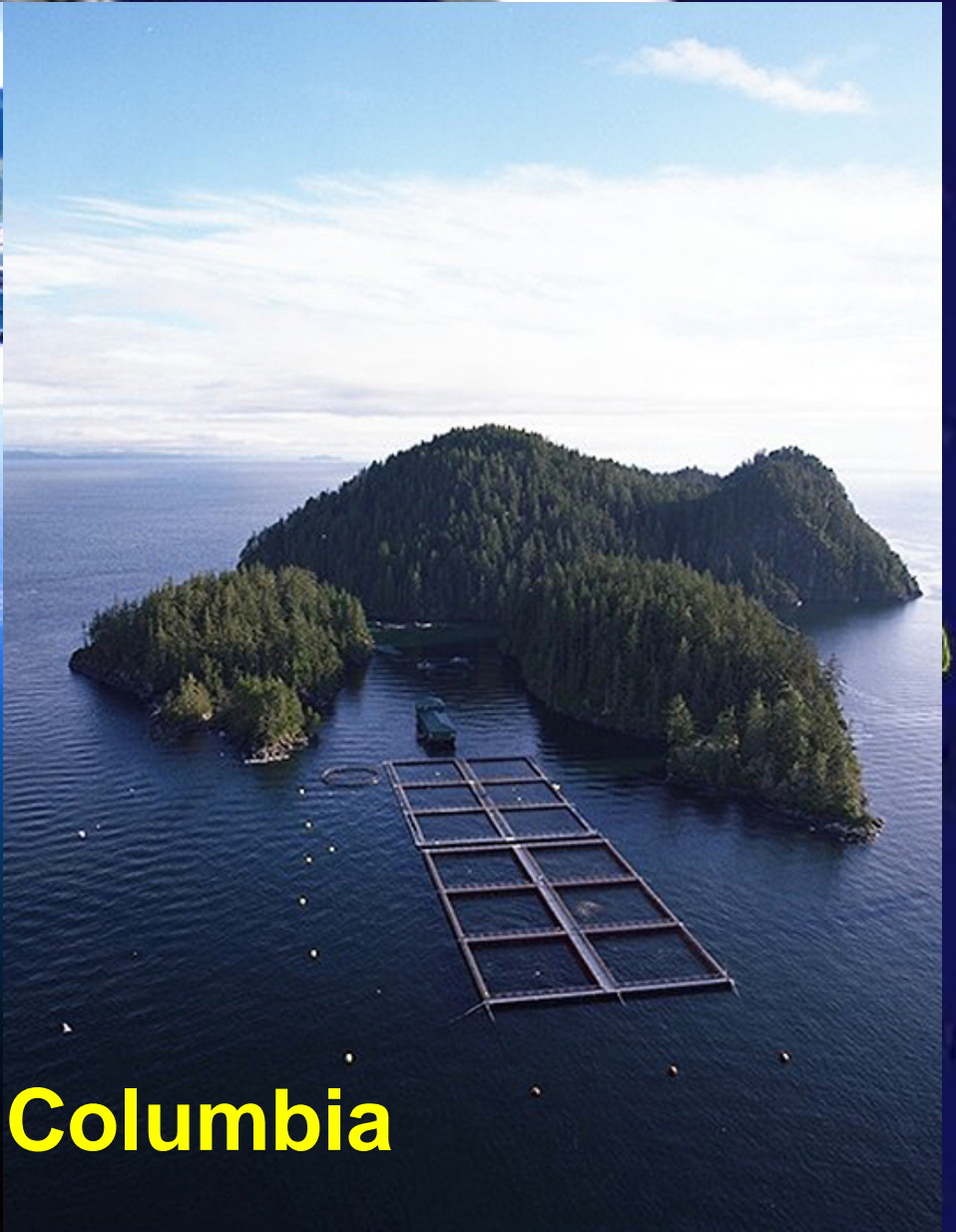
Image © 2006 MDA EarthSat

© 2006 Google

Pointer 49°50'44.37" N 125°47'15.13" W elev 1627 ft

Streaming ||||| 100%

Eye alt 239.03 mi



British Columbia

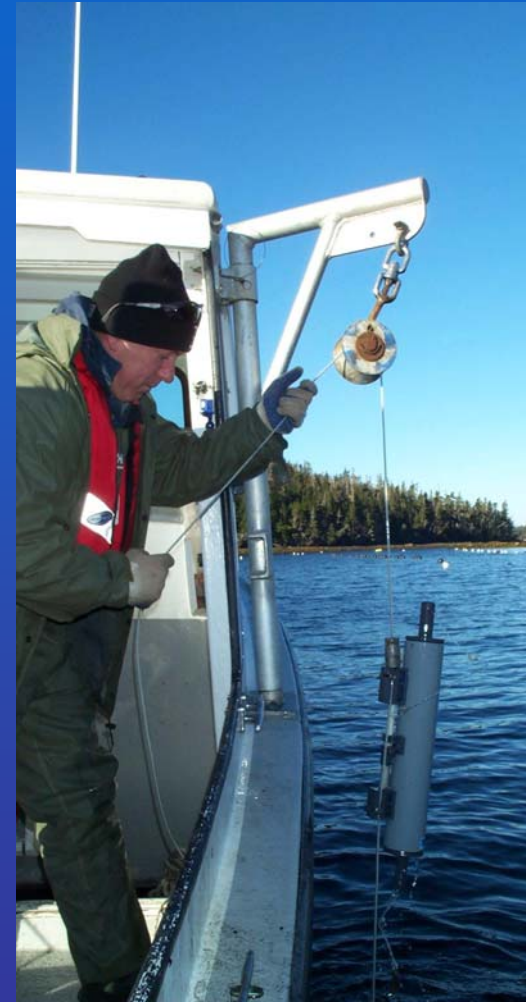
Environmental Monitoring Program Requirements

An aerial photograph of a salmon aquaculture farm. The water is dark blue with many circular pens made of metal frames. A small white boat with a cabin is in the center, surrounded by several pens. Yellow buoys are scattered throughout the water.

- **Risk-based**
 - Species and level of production
 - Ecosystem capacity / sensitivity
 - Latest science techniques
- **Responsive**
 - Address areas of concern
 - Delineate effect / reference sites
- **Accurate**
 - Appropriate parameters to detect effect
 - Qualitative & quantitative
- **Manageable**
 - Large data sets
 - Effective decision making
 - Cost Effective

Water Column Monitoring

- **Parameters**
 - Salinity, temperature, oxygen, Chlorophyll, SPM, organic content & nutrients
 - Secchi depth
- **Methods**
 - Surface & bottom vs profiles
- **Pros/Cons**
 - Far-field / ecosystem effects
 - Spatially & temporally variable
 - Costly



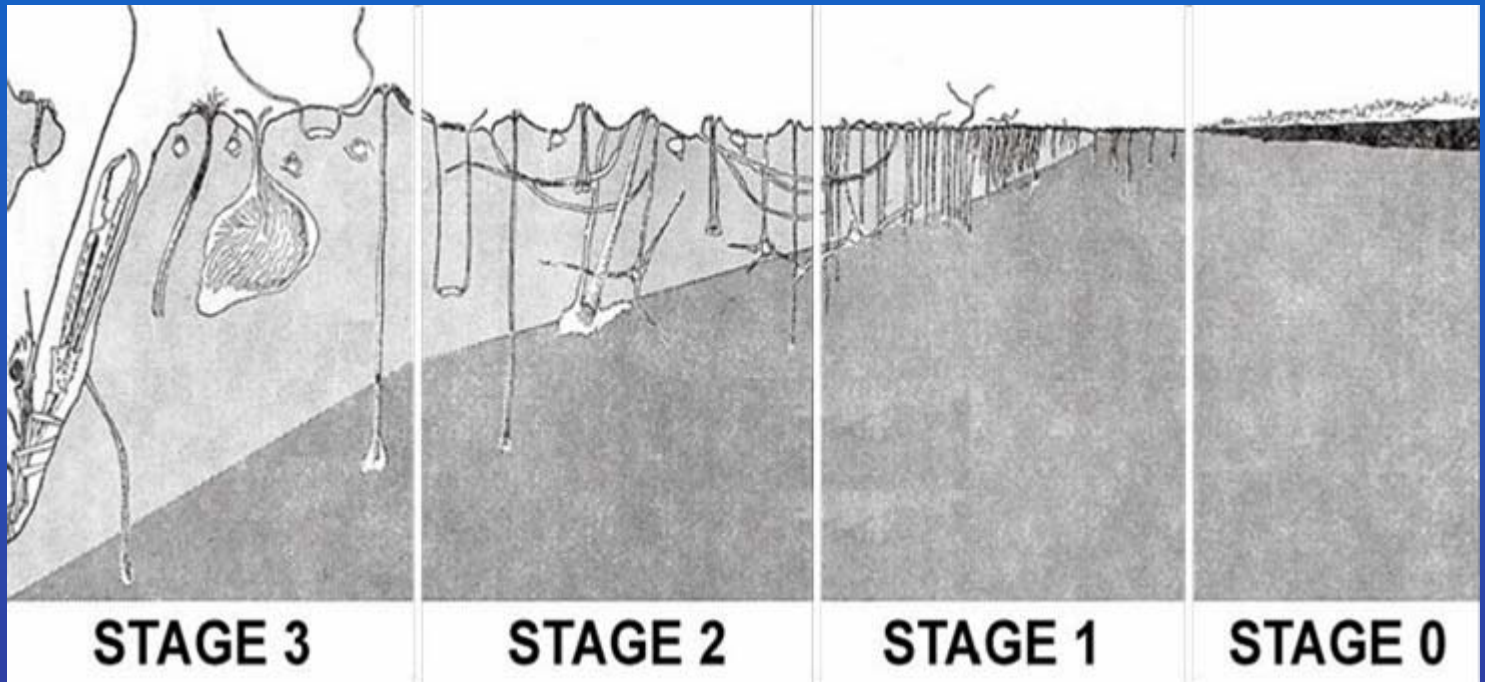
Sediment Monitoring

- **Parameters**
 - Redox (Eh), sulphides, porosity, organic content & grain size
 - Benthic classification methods
- **Methods**
 - Sediment cores (grab or diver)
 - Benthic Video
- **Pros/Cons**
 - Effects concentrated & persistent
 - Qualitative & quantitative
 - Site-specific (Near-field)



Sediment Organic Enrichment

organic
flux



STAGE 3

STAGE 2

STAGE 1

STAGE 0

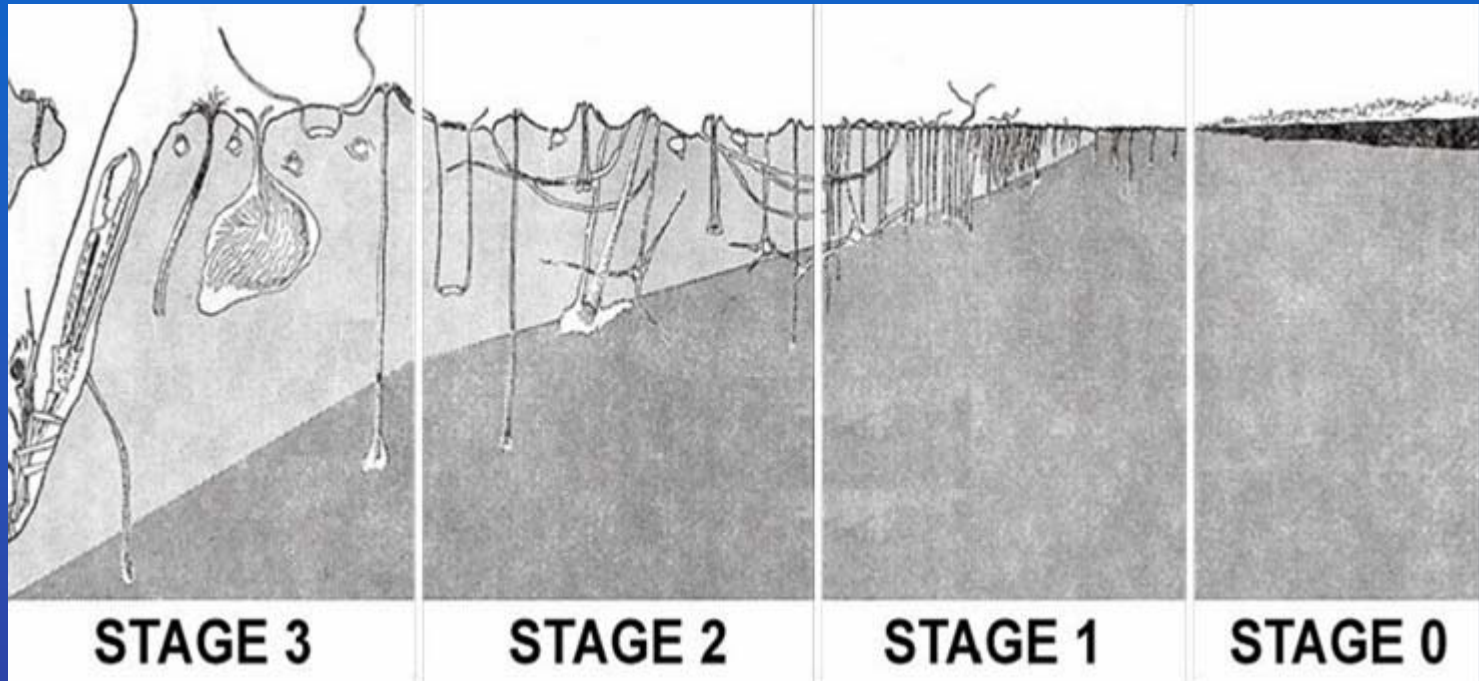
filter feeders

deposit feeders

bacteria

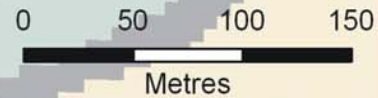
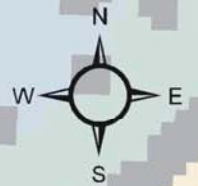
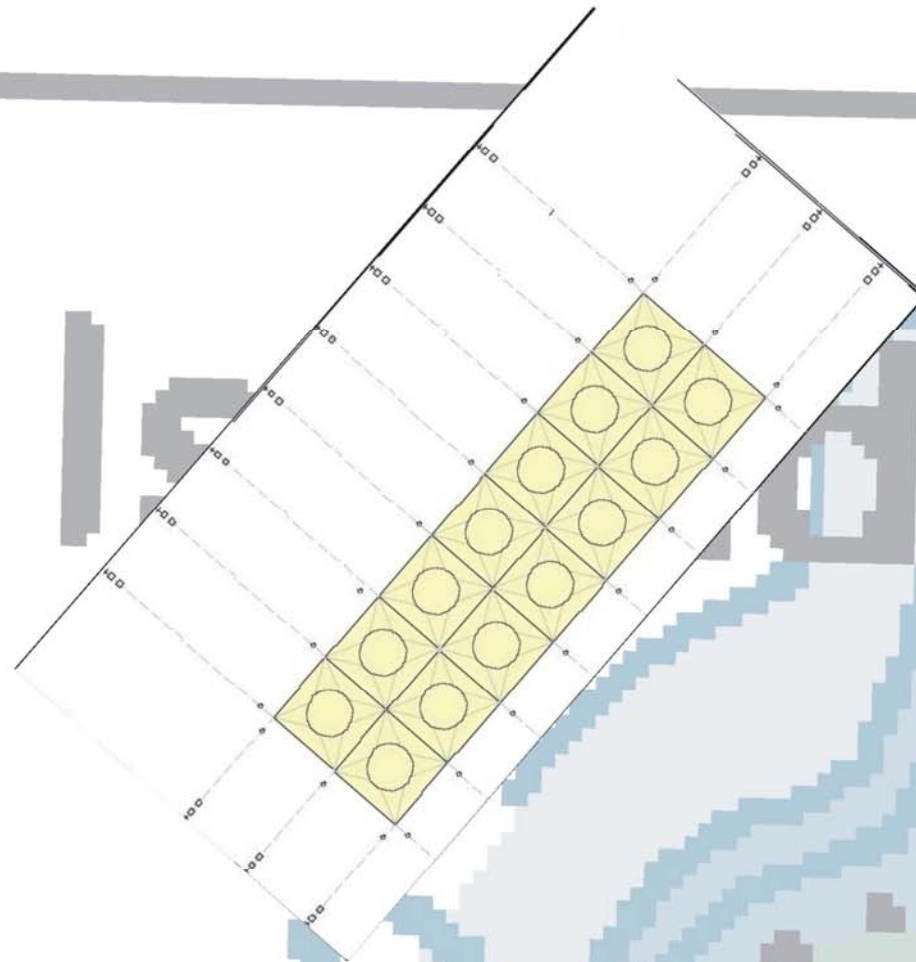
diversity

Environmental Quality Definitions



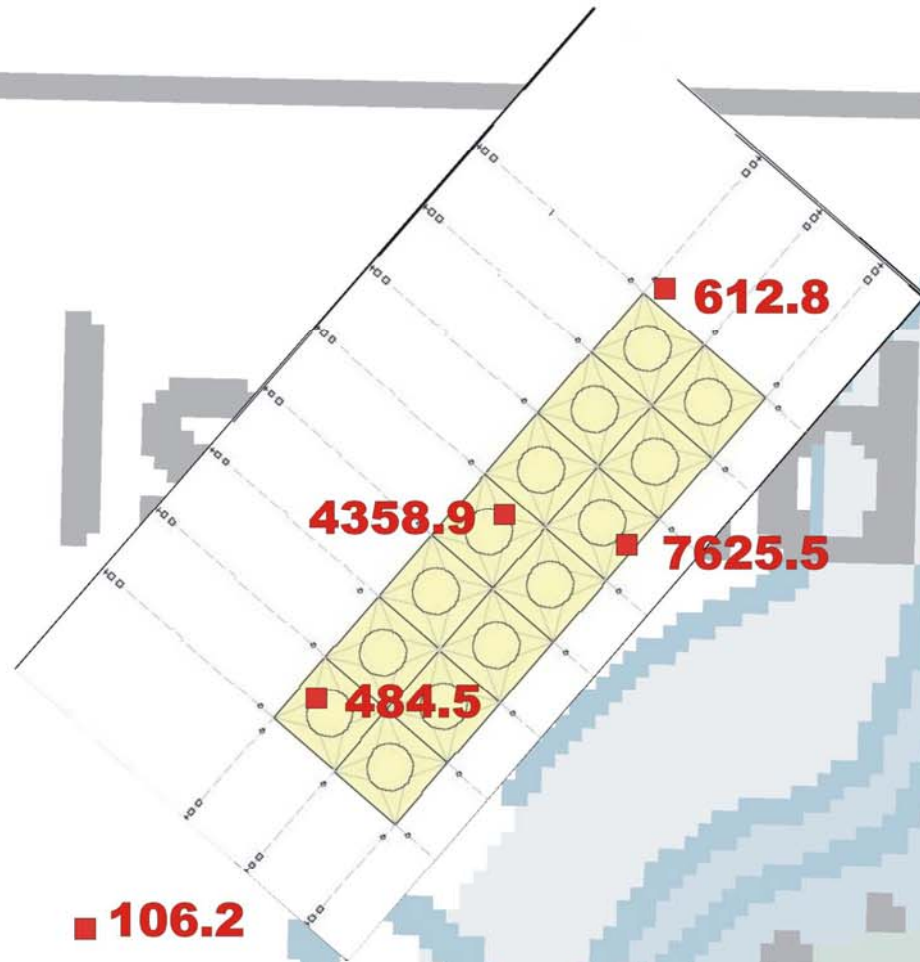
<u>Total Dissolved Sulphides</u>			
Oxic A/B	Hypoxic A	Hypoxic B	Anoxic
<1500	1500 - 3000	3000 - 6000	>6000 μM

Remediation Plan



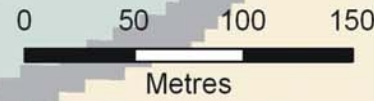
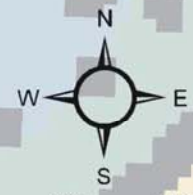
Remediation Plan

- 2004 Station
- Impacted Area



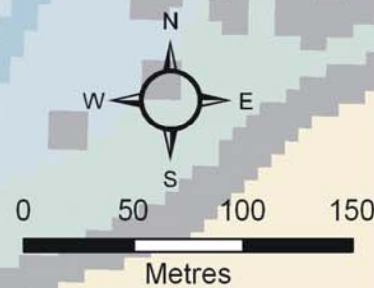
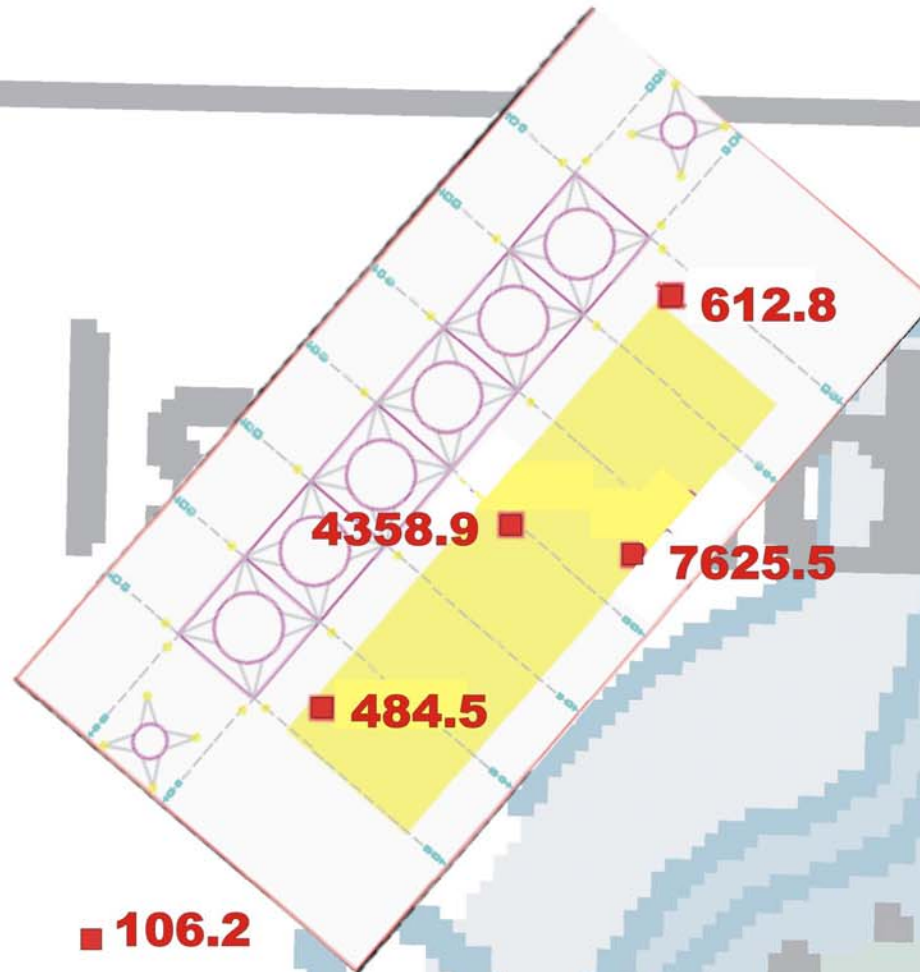
58.5 ■

■ 361.7

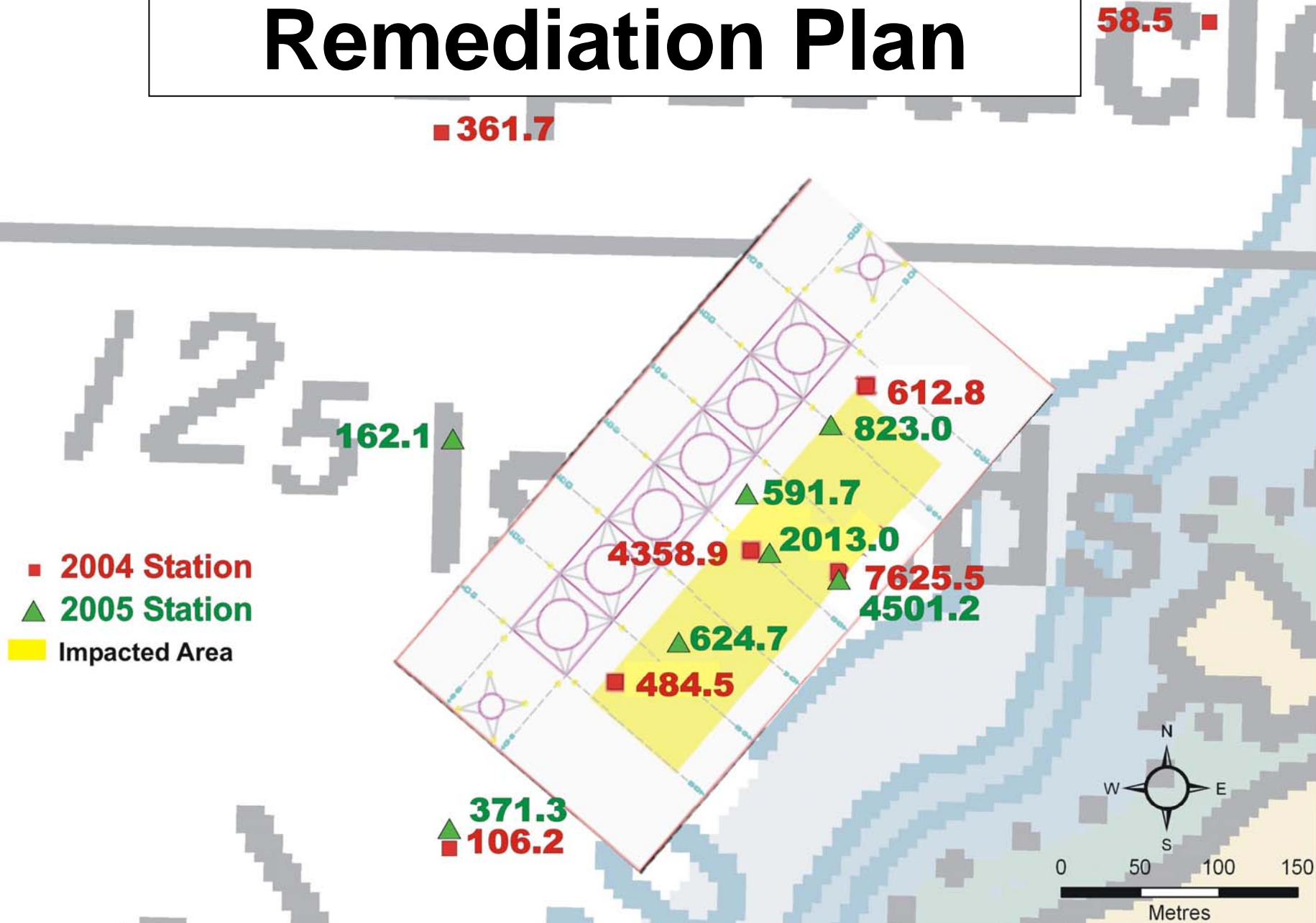


Remediation Plan

- 2004 Station
- Impacted Area



Remediation Plan



Bay Management

Station Year

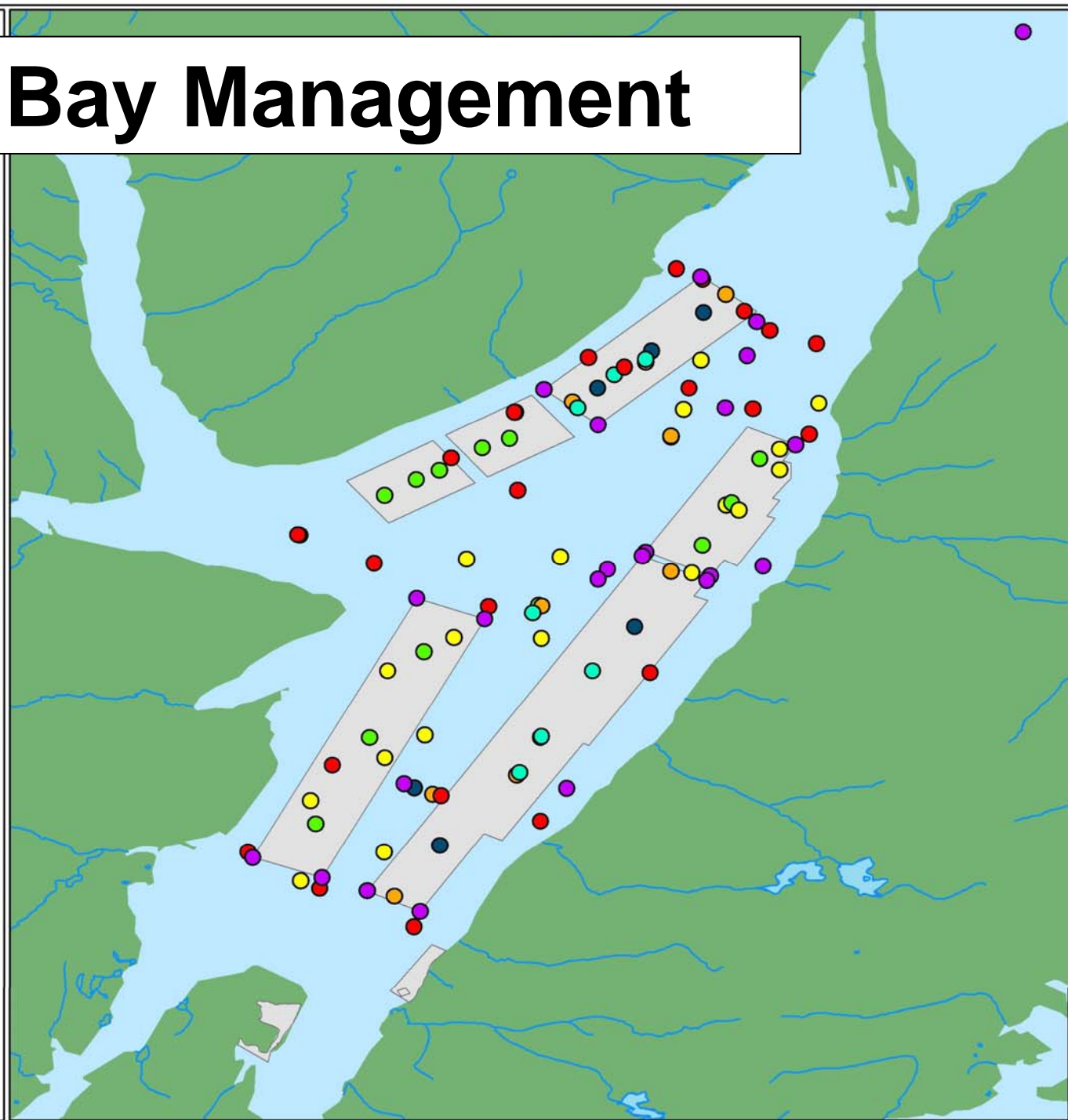
- December 2000
- May 2001
- December 2002
- June 2003
- October 2004
- September 2005
- November 2005



0 1 2 km

A horizontal scale bar with three segments. The first segment is black and labeled '0', the second is white with a black border and labeled '1', and the third is white with a black border and labeled '2 km'.

March 2006



Bay Management

Station Year

- December 2000
- May 2001
- December 2002
- June 2003
- October 2004
- September 2005
- November 2005

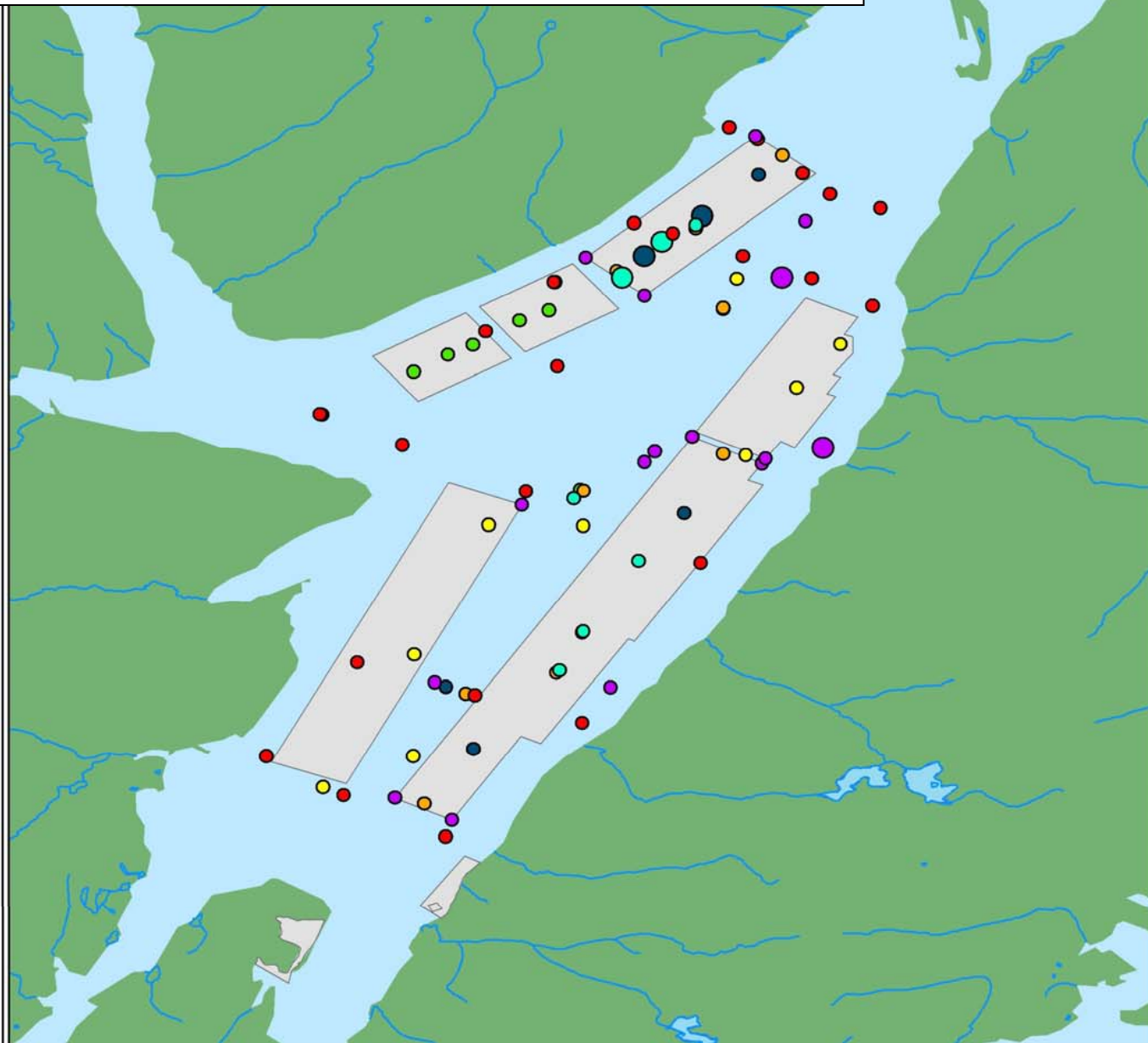
Sulphides Levels (uM)

- <750 Oxic A
- 751 - 1500 Oxic B
- 1501 - 3000 Hypoxic A
- 3001 - 6000 Hypoxic B
- >6000 Anoxic



0 1 2 km

March 2006



Summary

- Aquaculture is varied in scale and effect
- Requires risk-based approach
- Sulfides most effective indicator
- Remediation planning and action
- Bay management